NPS-AM-24-203

ACQUISITION RESEARCH PROGRAM
SPONSORED REPORT SERIES

Attrition in the Air Wing: An Empirical Study on Flight Hours and Marine Pilot Retention

March 2024

Maj Benjamin P. Huggins, USMC

Thesis Advisors: Dr. Maxim Massenkoff, Assistant Professor
Jacob L. Reynolds, Lecturer

Department of Defense Management

Naval Postgraduate School

The research presented in this report was supported by the Acquisition Research Program of the Department of Defense Management at the Naval Postgraduate School.

To request defense acquisition research, to become a research sponsor, or to print additional copies of reports, please contact the Acquisition Research Program (ARP) via email, arp@nps.edu or at 831-656-3793.

ABSTRACT

The retention of Marine Corps pilots is challenged by civilian sector demand, aging fleets, and work-life balance issues. Despite extensive qualitative research on retention factors, the quantitative link between pilots' flight hours and their retention decisions remains underexplored. This study investigates the correlation between individual flight hours and Marine pilots' decisions to stay or leave the Service, aiming to offer insights into future retention strategies. Findings reveal that aircraft type, years of experience, and level of qualification own most of the contribution toward flight hour variance among pilots. Models also suggest that pilots who fly more frequently are more likely to separate, as they may be more marketable or more acutely experiencing burnout. Finally, the study suggests that the timing of flight hours is more critical than the average monthly hours for retention, with different patterns observed among rotary-wing (RW), fixed-wing (FW), and tiltrotor (TR) pilots. The research recommends a tailored approach to retention strategies specific to each aircraft community, emphasizing the timing of milestone-driven aviation bonuses and the need for non-monetary incentives. Future studies should expand the dataset and observation period for a more comprehensive understanding of retention dynamics.

THIS PAGE INTENTIONALLY LEFT BLANK

ACKNOWLEDGMENTS

This journey would not have been possible without the guidance and support of many, and I take this moment to express my deepest gratitude to those who have been instrumental in the completion of this endeavor.

I would like to express my appreciation to my research advisor, Dr. Maxim Massenkoff, for his support over the past six months. His advice, availability, and advanced statistical acumen were beneficial in navigating the challenges of my research. His contributions played an important role in the progression and completion of my work.

I am also immensely grateful to my second reader, Jake, and the various service professionals who have contributed significantly to my project. Their insightful feedback and constructive criticism have been crucial in validating my findings and ensuring that my research passed the “sniff test” of the common Marine pilot experience. Their contributions have provided me with the necessary direction and refinement needed to bring my work to fruition.

A special thanks goes to my wife, Danielle, for her unwavering support and patience through what was, at times, a tumultuous period. Her ability to distill complex topics into digestible pieces not only advanced my research but also provided a sense of calm and clarity amidst the storm. Danielle’s understanding and resilience as a sounding board to my muse made her contribution to my journey not just supportive, but indispensable.

THIS PAGE INTENTIONALLY LEFT BLANK

NPS-AM-24-203

ACQUISITION RESEARCH PROGRAM
SPONSORED REPORT SERIES

Attrition in the Air Wing: An Empirical Study on Flight Hours and Marine Pilot Retention

March 2024

Maj Benjamin P. Huggins, USMC

Thesis Advisors: Dr. Maxim Massenkoff, Assistant Professor
Jacob L. Reynolds, Lecturer

Department of Defense Management

Naval Postgraduate School

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF ACRONYMS AND ABBREVIATIONS

ALR	Additional Likelihood of Retention
AMOS	Additional Military Occupational Specialty
ATP	Airline Transport Pilot
Avb	Aviation Bonus
AVPLAN	Aviation Plan
BLS	Bureau Of Labor Statistics
CCRM	Core Competency Resource Model
CPG	Commandant's Planning Guidance
DCA	Deputy Commandant for Aviation
DOD	Department of Defense
DPG	Defense Planning Guidance
DON	Department of The Navy
EPAR	Electronic Personnel Administrative Request
FAA	Federal Aviation Administration
FAC	Forward Air Controller
FHP	Flight Hour Program
FRS	Fleet Replacement Squadron
FW	Fixed Wing
FY	Fiscal Year
FYDP	Future Years Defense Plan
GAO	Government Accountability Office
HQMC	Headquarters Marine Corps
LPM	Linear Probability Model
M&RA	Manpower And Reserve Affairs
MC	Mission Capable
M-SHARP	Marine Sierra Hotel Aviation Readiness Program
NAVFLIR	Naval Flight Record

NDAA	National Defense Authorization Act
OLS	Ordinary Least Squares
PCS	Permanent Change of Station
RW	Rotary Wing
SBTP	Sortie Based Training Model
T/M/S	Type/Model/Series
TFDW	Total Force Data Warehouse
TMR	Total Mission Requirement
TPT	Total Pilot Time
TR	Tiltrotor
T&R	Training and Readiness
USMC	United States Marine Corps
WTI	Weapons and Tactics Instructor

I. INTRODUCTION

Following two decades of war, personnel recruiting and retention shortfalls have emerged as one of the greatest modern threats to the U. S. Marine Corps (Berger, 2021). Former Marine Commandant General David Berger suggests in his communique of vision, Talent Management 2030, that retention poses a significant challenge to the future success of the United States Marine Corps (USMC) and needs to be balanced against current recruiting efforts (Berger, 2021). While the retention of the overall force remains an ongoing battle and a prevalent topic of discussion, the retention of Marine pilots presents a festering microcosm with a potentially unique problem set. The external hiring environment pulls Marine pilots away from continued service as an insatiable airline industry is actively hiring for lucrative positions. Meanwhile, the Marine Corps has an aging and maintenance-stricken fleet of aircraft coupled with numerous work-life difficulties inherent to the Air Wing's status quo that further push Marines to search for greener pastures (Bernthal, 2022). As a result, pilots are leaving the service branches faster than they can be replaced (Mattock et al., 2016).

Illustrating the historic and forecast pilot inventories in the Marine Corps, Figure 1 displays pilot community health in terms of manpower. This graphic indicates that the current USMC pilot inventory is below the target pilot inventory and will not reach its target if adjustments are not made. Pilot inventories suffer mostly at the company-grade level to the extent that field-grade pilots cannot fill the void. Leaders find pilot retention rates alarming because generating more pilots proves to be particularly challenging. Studies have shown that historically, the actual time required to train new pilots has exceeded the programmed training time by as much as two years per pilot, thus slowing down the arrival of replacement pilots (Griffin et al., 2018). The Marine Corps does not accept lateral entry of pilots from the civilian sector, leading to a backlog in pilot accession during the early training phase. Discussions about expanding flight schools to expedite training time have taken place; however, flight schools rely on instructor-pilots drawn from the current pilot inventory. Operational squadrons would need to allocate pilot manpower to support the training squadrons as instructor-pilots, but many operational squadrons already face shortages within their current pilot rosters. With accessions reaching the current production cap, the Air Wing has shifted its focus to retention to sustain its future manpower.

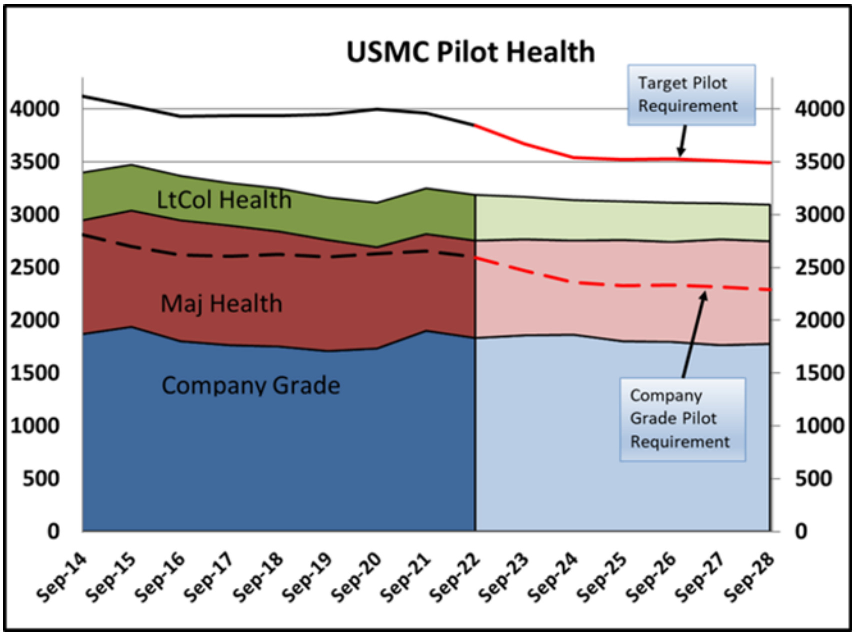


Figure 1. Historic and Forecast Marine Corps Pilot Inventory. Source: Manpower Plans and Policy (2023).

Prior to his retirement in 2017, Lieutenant General Jon "Dog" Davis, then Deputy Commandant for Aviation, advocated for enhancing squadron readiness during a period of low flight hours and piecemealed aircraft following fifteen years of war (*Aviation Readiness*, 2016). The term readiness, when used in the Air Wing, encompasses such items as preparedness for combat, operationally capable aircraft, and qualified personnel (*Aviation Readiness*, 2016). Davis suggested that a manpower retention problem was on the horizon but fixing readiness would help thwart it (Davis, 2017). A key metric in aviation readiness is flight hour averages held by the pilots. Increased flight hours correlate to increased proficiency, whereas dips in flight hours have been correlated with increased risk. This corollary posits a question; if pilots were to fly more, would they be more apt to remain in service? When we analyze readiness by examining flight hours, we observe a continuous decline over the years. The Marine Corps' tactical squadron average, encompassing all major types, models, and series (T/M/S) aircraft, reached its peak in 2011, with an estimated average of 170 flight hours per pilot per fiscal year (United States Marines Corps [USMC], 2023). However, by 2022, that average had plummeted to an all-time low of approximately 83 flight hours per pilot per fiscal year. Contextually speaking, the 2nd Marine Aircraft Wing has historically established a minimum monthly goal of 15 flight hours per pilot to maintain full proficiency, equivalent to 180 flight hours per year (2D Marine Aircraft Wing, 2023). This widening disparity between actual flight hours and defined proficiency-level flight hours was one of the trends that Lieutenant General Davis referred to in his discussions on readiness. However, few studies have attempted to measure empirical correlations between individual flight hours and retention.

A. PROBLEM STATEMENT

The retention of pilots in the Marine Corps is a critical challenge exacerbated by high demand in the civilian airline industry, an aging aircraft fleet, and work-life balance difficulties. This issue has been highlighted by leaders in the Marine Corps, and while extensive research exists on qualitative factors impacting retention, there's a gap in understanding the quantitative relationship between individual pilot flight hours and pilots' decision to stay or leave the service. Investigating this correlation is pivotal in comprehensively addressing the pilot retention crisis and enhancing strategies to sustain an adequate pilot force within the Marine Corps.

B. RESEARCH QUESTIONS

1. Do the quantity and quality of individual flight hours have an impact on pilot retention rates?

2. What is the extent of the variation of flight hours across the Marine Corps, and can it be explained by aircraft type, location, and individual pilot quality?

THIS PAGE INTENTIONALLY LEFT BLANK

II. BACKGROUND

Pilots have kept logs of flight hours since the dawn of flight (LeCompte, 2009). For over a century, pilots have logged these flight hours in physical logbooks, but with the advent of technology, electronic logging has been embedded in the process. Marine Corps pilots accomplish this using the Marine Sierra Hotel Aviation Readiness Program (M-SHARP) database. M-SHARP serves as one of the largest repositories of Marine Corps flight information in the database inventory. Its integration with other data systems is currently limited but still expanding. Extracting the wealth of data hosted by this system and empirically quantifying the role of individual flight hours in retention could contribute to advancing the conversation and refining future tools for pilot retention. Using the logs kept in M-SHARP, the individual flight experiences of each pilot can be examined and compared.

To frame the relationship between flight experience (referring to both the number of flight hours and their quality) and retention outcomes, the constraints surrounding flight hours must first be discussed. First, flight hours are costly and, therefore, are finite. Furthermore, outside influences such as weather and aircraft readiness can impact the accomplishment of the hours allotted. Second, not all flight hours are created equally—some flights inherently have more training value than others and thus need to be categorized. Third, pilot training progression must be discussed to highlight pilot eligibility for increased flying opportunities. Finally, because flight hours and training opportunities are constrained resources and cannot be equally distributed, their allocation amongst pilots must be explored.

A. FLIGHT HOURS ARE FINITE

The Marine Corps Aviation Plan (AVPLAN) is routinely put forth by the Deputy Commandant for Aviation (DCA) and discusses the outlook of Marine Aviation and its alignment with higher planning guidance, such as the Defense Planning Guidance (DPG) and Commandant's Planning Guidance (CPG). The most recent AVPLAN (published in 2022) describes how Marine Aviation is moving forward to support of the most recent

CPG (Headquarters United States Marine Corps [HQMC], 2022). Depicted in Tables 1 and 2, the DCA provides both the funding levels for the current and Future Years Defense Plan (FYDP), as well as the flight hours purchased and allocated to each aircraft Type/Model/Series (T/M/S) to fly in Fiscal Year 2022 (FY22).

Table 1. Flight Hour Program Funding (in millions of dollars) for FYDPs 2022–2027. Source: HQMC (2022).

FYDP FHP Funding							
Schedule	FY22*	FY23	FY24	FY25	FY26	FY27	FYDP
TACAIR	2168.33	2345.58	1975.89	1840.202	1860.733	1882.923	12073.66
Fleet Air Training	415.922	358.477	271.224	269.371	287.44	247.207	1849.641
Fleet Air Support	90.241	98.585	113.685	116.444	122.973	123.486	665.414
Reserves	183.282	182.04	167.261	177.149	182.481	178.035	1070.248
CNATRA	286.402	277.014	282.545	299.481	310.239	316.972	1772.653
Flight Other	344.917	423.91	424.105	456.384	506.611	506.666	2662.593
UAS	14.479	99.97	182.597	287.133	93.588	98.025	775.792
Total ($M)	3503.58	3785.57	3417.31	3446.164	3364.065	3353.314	20870
*FY22 Numbers are from Enacted Budget, FY23 and out are PB-23 Controls							

Table 2. Flight Hour Requirements by T/M/S for FY22. Source: HQMC (2022).

AH-1Z	22,275.0
AV-8B	9,647.0
CH-53E	19,450.0
CH-53K	800.0
F-35B	13,900.0
F-35C	2,800.0
FA-18C	12,533.0
FA-18D	6,667.0
KC-130J	20,100.0
MV-22B	36,390.0
UH-1Y	19,170.0
Total	163,732.0

The funding and flight hour allocations describe the first constraint in the flight hour assessment—flight hours are finite at the service level. Flight hours are a byproduct of funding and must be planned for and purchased via the budget. Based on roughly 60 squadrons in the Marine Corps and a planning factor of 30 pilots per squadron (though this varies dramatically by aircraft community and manning levels), monthly allocations would offer a target flight hour average in the vicinity of 15 hours per pilot per month. The number of flight hours purchased may appear to be arbitrary, but they are not. They are products of the Flying Hour Program and its primary unit-level inputs.

1. Flight Hour Planning

The Flying Hour Program (FHP) is purchased through the Navy's allocation of funds for fiscal year flight hours, which are then allotted to the Marine Corps to operate and maintain their aircraft (Headquarters United States Marine Corps, 2009). The FHP connects unit-level inputs based on training and operational needs to a request for the purchase of flight hours. The operational and training needs forwarded by individual squadrons for flight hour procurement are estimated via two primary methods: the Core Competency Resource Model (CCRM) and the Sortie-Based Training Program (SBTP).

The CCRM is a generic tool that estimates the number of flight hours per year a squadron might need based on inputs such as number of crews, number of aircraft, and training requirements outlined in each community's Training and Readiness Manual (T&R) (HQMC, 2009). Every aircraft community has a unique T&R that outlines the core competencies and training structure required to make proficient pilots and aircrews. Each respective T&R dictates which skills are required to fulfill each mission set and breaks up the skills into unique flight events with definable outcomes and required training resources. By applying the required resources outlined in the T&R and multiplying them by the number of pilots and qualifications required in a squadron, a general number of flight hours can be estimated in the CCRM.

SBTP was established as a mechanism by which units could forecast and quantify their training requirements in a standardized manner (HQMC, 2009). Where the CCRM estimates what resources a squadron might require in a given year, SBTP estimates when the squadron will need them and how many it will specifically need at each point. SBTP is intended to be a customized training plan submitted by each squadron that aligns the training requirements in the T&R with a planned training schedule (considering items such as deployments, training exercises, and leave periods). Units are responsible for creating an SBTP estimate for annual submission which is considered in conjunction with the CCRM for the flight hour requirement to be submitted in the FHP. Once the FHP submission is approved within the Navy budget, the SBTP for each squadron is adjusted to the target number of flight hours allocated.

2. Limitations on Flight Hours

While SBTP is a plan to accomplish training and flight hours throughout the year, it is subject to constraints. Foremost among them is aircraft readiness. Pilots cannot record flight hours if their aircraft are not suitable for flight. Squadrons are given custody of a designated number of aircraft, much as they are the pilots that fly them. A squadron might have 12 aircraft on its roster; however, rarely does that translate to 12 aircraft being available for flight. Between routine, planned, and incidental maintenance requirements, a squadron might only have a small fraction of its aircraft operational at any given time. The capability to pick an aircraft and fly at least one assigned mission is the Mission Capable (MC) rate, as outlined in the Government Accountability Office's report on aircraft readiness (Government Accountability Office [GAO], 2022).

The 2022 GAO study was performed on all major aircraft platforms flown across the services and found that between FY11 and FY21, 26 aircraft communities were could not achieve their MC annual goals throughout the entire period. Figure 2 compares each aircraft across the 11 fiscal years and indicates the number of years (size of the corresponding bar) that the community reached its MC goal. The Marine Corps never reached their annual goal in any single year during the observation period, on any single aircraft platform. The GAO report acknowledged that due to the sensitivity of the specific MC goals of each aircraft community and the MC deficits experienced, the specific numbers and rates could not be published in their findings.

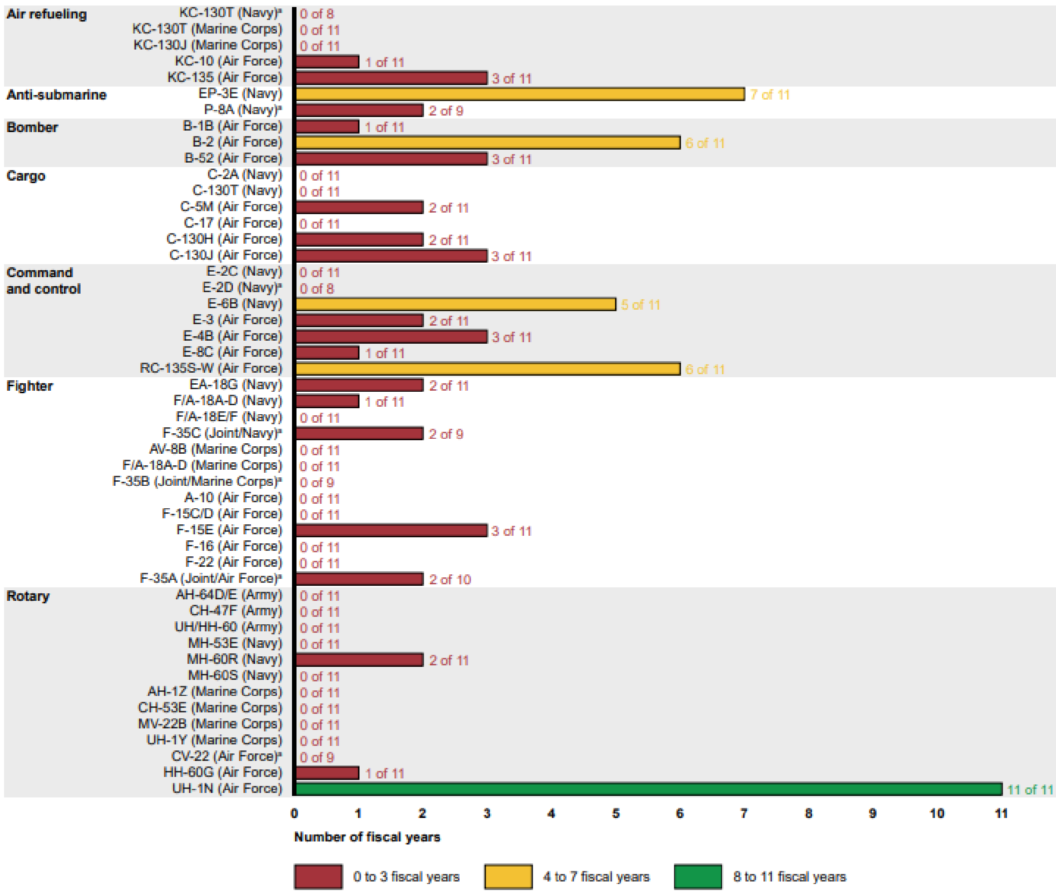


Figure 2. Readiness Levels of U.S. Military Aircraft.
Source: GAO (2022).

In conjunction with aircraft readiness, weather plays a role in flight hour achievement. The Federal Aviation Administration (FAA), service-level policies, and local command policies dictate the minimum conditions for weather in support of flight operations based on perceived risk. Suppose the weather degrades beyond the defined minimums (such as the clouds being too low or visibility being too poor). In that case, flights are likely to be canceled, and the forfeited flight hours cannot always be recovered, as they will be subject to time availability and future aircraft readiness rates. Simultaneously, certain types of training require various weather minimums. Should the weather be good enough to meet the requirements for a general flight but insufficient to meet the requirements for the specified intended training, then the quality of the training is reduced to meet a quality supported by the weather conditions.

Regional differences play a role in the weather experienced and the training days lost or truncated. For example, Marines flying out of North Carolina may see precipitation 118 days out of the year, whereas Marines flying out of Southern California may only see precipitation 38 days during the same timeframe (Best Places, n.d.). These regional differences indicate that climate variation could play a role in aircraft storage and maintenance requirements, quality, and quantity of training. While MC rates and weather patterns will not be directly observed in this data, controls for location and aircraft type will provide some collinearity with these variables, assuming that similar aircraft stationed in close regional proximity will exhibit similar aggregate MC rates and be exposed to the same average weather patterns.

B. FLIGHT HOURS HAVE DIFFERENT ATTRIBUTES

Every flight logged contains at least one Total Mission Requirement (TMR) code defined in the CNAF M-3710.7 instruction (Office of the Chief of Naval Operations, 2022). TMR codes represent the overall mission of a flight event, though there can be multiple TMRs assigned to a single event if the flight event encompasses different types of training or tasking. TMR codes consist of three characters: the flight purpose code (numbered 1–7), a general-purpose code (lettered A-Z), and a specific purpose code (numbered 1–10). For example, a routine familiarization training flight for a student pilot might be given a TMR code of "1D1." The "1" in the first position of the TMR would represent a training flight, the "D" in the second position would indicate that it was for a student pilot, and the last "1" would indicate that the focus was on fundamentals (Office of the Chief of Naval Operations, 2022). While 485 possible TMR codes are outlined in the CNAF 3710.7, most flights are categorized inside roughly 50 TMR codes (U.S. Marine Corps, 2023).

TMR codes are used to indicate a flight's primary mission but can also indicate the flight quality. By looking at a pilot's logbook, a pilot's level of experience cannot holistically be deduced simply by looking at their aggregate flight hours. The TMRs help break out pilots' experiences by indicating the types of flights and environments pilots are exposed to. For example, if two pilots were compared, each with the same qualifications and 500 flight hours, they might both appear of equal quality to a third party. However, if one pilot achieved the 500 flight hours through a mix of training and tasking hours, whereas the other received most of their hours through ferry flights (administrative flights with the sole intent to relocate an aircraft from one location to another) and maintenance flights, the two pilots would possess different skillsets, experiences, and perspectives on flying. Explicit T&R codes logged can provide more fidelity to flight quality than TMR codes. However, T&R codes have different meanings across different T/M/S and cannot be directly compared. Therefore, TMR codes are advantageous when assessing the whole population.

The seven flight purpose codes associated with the first position of a TMR code are intended to bin the missions into like categories such as training, support, and combat (Office of the Chief of Naval Operations, 2022). However, these bins categorize flights into similar categories based on what the flight is in support of rather than the characteristics of the flight profile itself. To perform an analysis of the common pilot experience, TMRs will be binned into three categories that address the common characteristics of a flight as seen by the pilots. This approach will both simplify and better address the common Marine pilot experience.

C. PILOT PROGRESSION AFFECTS ELIGIBILITY FOR INCREASED OPPORTUNITY

Student pilots select an aircraft type to train for and fly in the future while in flight school, based on the Marine Corps' needs, their perceived abilities, and personal preference. After making this selection, they complete their flight school training and receive their wings, signifying their graduation. This "winging" date also triggers the beginning of their flying contract. Pilots don't immediately join a Fleet tactical squadron, though. Instead, they are sent to their aircraft-specific Fleet Replacement Squadron (FRS) to master the basics of the aircraft they intend to fly. Upon completing their training at the FRS, they then proceed to join a Fleet tactical squadron. Tiltrotor (TR), rotary wing (RW), and multi-engine fixed wing (FW) pilots begin as copilots and spend their first few years building flight hours and experience to be qualified as aircraft commanders. Once a copilot is designated as an aircraft commander (they are now in charge of their aircraft), they can begin working on subsequent qualifications.[1] Because FW jets are primarily single-piloted, they spend extra time in flight training before arriving at the FRS to fly their T/M/S.

Every aircraft has its own progression timeline denoted in its respective T&R, but they all are structured similarly. Figure 3 illustrates the planning guidance for progression within the MV-22B training pipeline. Once a pilot graduates from flight school and arrives at the FRS, their training begins in their specific aircraft as denoted by month 0. They progress through the 1000 series of training codes in the FRS before proceeding to their designated Fleet Squadron where they will continue their training in the 2000 series and beyond. The box widths in Figure 3 correspond to the planned minimum and maximum time to train at the bottom of the figure. Pilots are intended to be designated as aircraft commanders within two years of beginning training on their aircraft (occurs within the 4000-code phase). At this point, they transition to learning how to lead and teach in the aircraft. If a pilot were to meet the suggested timeline below, they would reach their most qualified state within 48 months following their designation as a pilot.

[1] The Marine Air Wing distinguishes between *designations* and *qualifications* in the Aviation Training and Readiness Program Manual; however, for simplicity in this discussion, the term *qualifications* will be used in interchangeably for both (Headquarters United States Marine Corps, 2020).

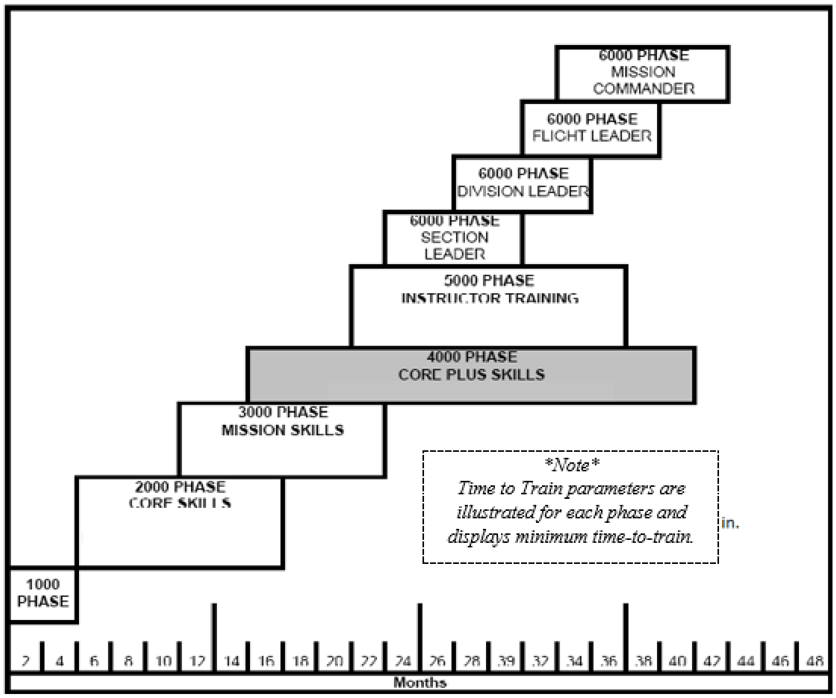


Figure 3. MV-22B T&R Progression. Source: HQMC (2023).

While each T/M/S has varying qualifications and suggested timelines associated with them, a few permeate all aircraft types and are given additional military occupational (AMOS) codes. These codes, corresponding to qualifications such as Section Leader and Division Leader, are submitted to a Marine's official record for selection boards to see. Using these AMOS as binning criteria, pilots can be sorted into categories based on training received and compared across the different T/M/S.

D. FLIGHT HOUR VARIATIONS THROUGH EXPERIENCE

Based on the structure of the Air Wing, there are observable patterns in monthly flight hours that correspond to rank and years of flying experience. Monthly flight time is not traditionally linear by rank but instead has an upside-down U-shape. Typically, flight time allocations increase in the first few years of flying while a pilot gains qualifications before peaking as a senior flight instructor. As pilots are promoted from the rank of O-3 to O-4, flight hour averages occasionally dip to allow new pilots the opportunity to progress and new instructors the opportunity to learn how to teach. Meanwhile, senior pilots are routinely asked to fill leadership roles outside of the cockpit, corresponding to increased responsibility levels.

Figure 4 depicts a notional monthly flight hour average distribution by rank. When new pilots arrive at a squadron, they are often senior O-2s or junior O-3s. While they are new and unqualified, their flight hour averages remain low. As they progress, their monthly flight time average increases to a maximum point as a senior O-3 when they have likely reached their most qualified state before leaving their first unit. When the pilot returns to flying as an O-4, they often maintain their qualified status but act as department heads in the squadron and fly less than they did as senior O-3s due to competing time commitments and allocation requirements. As a pilot is promoted to O-5 and above, they act in the capacity of a commander or senior staff member and fly just enough to keep above currency minimums.

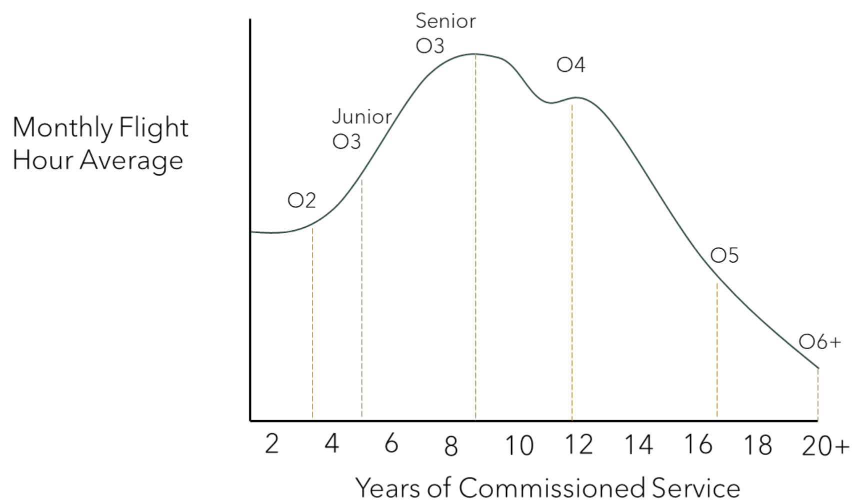


Figure 4. Notional Depiction of Monthly Flight Hours by Rank in RW and TW Communities. Adapted from HQMC (2023).

The second relationship between experience and flight hours is found in qualifications, which are somewhat more linear. Most pilot progression occurs within the first squadron assignment and drives some of the variation in flight hours for O-3s. Once a pilot is designated an aircraft commander, they are eligible to pursue instructor-level and flight leadership qualifications. These qualifications are earned in iterative waves, so there are instructorship and flight leadership tiers. Based on the finite training hours available to progress pilots, a cohort may be prioritized to advance in qualifications at different rates, with only a fraction reaching the most qualified state. Figure 5 illustrates the relationship between experience and opportunity amongst O-3s; the more experience a pilot has, the more opportunity they have to fly. The pool of competing peer pilots is smaller, and they are qualified to fly and teach a broader range of missions. Conversely, inexperienced pilots are qualified for the least number of missions and are in competition with the greatest number of pilots for flight hours.

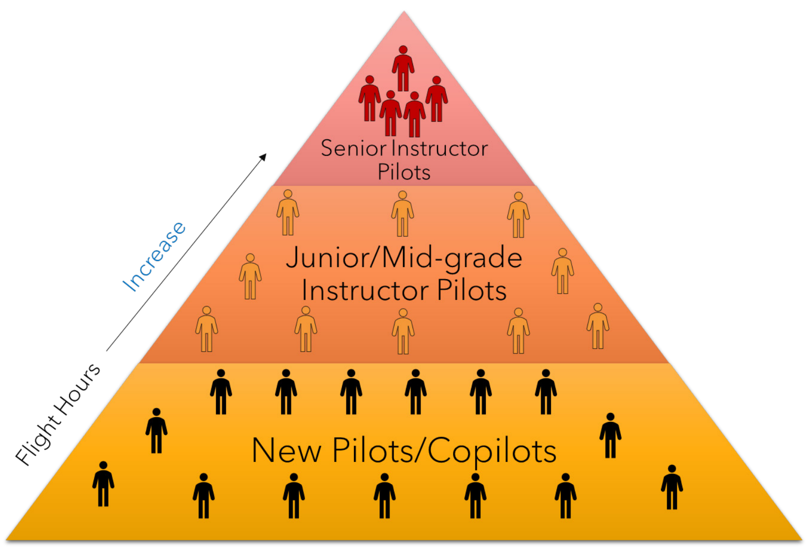


Figure 5. Pilot Distribution by Qualification. Adapted from HQMC (2023).

For example, a TR squadron might have 28 pilots, but they are comprised of varying levels of experience that might look like 12 copilots, ten junior and mid-grade instructors, and six senior instructors. The 12 copilots would spend most of their early flying hours paired with the six senior instructors. Meanwhile, the ten junior instructors would compete amongst each other for the remaining flight time, where some of them will pursue increased qualifications and climb toward senior instructorship. It takes squadron resources and flight hours to progress pilots to senior roles, so these pilots will inherently begin to outpace their peers in monthly flight time. Pilots who do not pursue advanced qualifications (either by choice or through lack of selection) then find themselves relegated to administrative flights and routine training flights. With the remaining squadron flight hours feeding their progressing peers, they watch as their flight hour averages and the quality of flights begin to diverge. The pool of instructors shrinks with the level of qualification because there is not enough time or resources available in a single tour of duty to make all pilots senior instructors. Should a pilot choose to continue to fly after their first squadron tour, however, there is some opportunity to continue to progress.

For pilots selected to progress toward senior qualifications, however, it does not come without personal cost. The Marine Air Wing views pilots with advanced qualifications as expensive human capital. Thus, an additional 24-month active duty obligation is appended to a pilot’s contract if they attend the Weapons and Tactics Instructor (WTI) Course (HQMC, 2019b). Pursuit of a WTI qualification is highly encouraged by squadrons due to requirements to have a minimum quantity on their roster; however, they cannot generally force an unwilling pilot to attend the school due to the increased contractual obligation that is tied to it. Therefore, there is some selection bias when looking at Marines who choose to retain or separate following their first contract—holding individual quality equal, Marines who intend to retain are more likely to accept the WTI nomination than Marines who intend on separating. Therefore, one could intuit that the intention of retention influences the decision to go to WTI, just as the experience gained through attendance of WTI could influence the decision to retain.

III. RELATED LITERATURE

In this chapter, I survey the literature on factors influencing pilot retention in the Marine Corps and the broader United States Military. Both research and policy shifts highlight the growing challenge of pilot shortages across all service branches. Given the substantial expense of pilot production, retaining existing pilots emerges as the more cost-effective option compared to training new ones. While preserving pilot quantities serves as the primary strategy for stabilizing the pilot inventory, the real hurdle lies in devising incentives—both monetary and non-monetary—that can effectively compete with the attractive opportunities available in civilian markets.

While a promising civilian career holds its own allure, it doesn't singularly drive the issue of retention. The perceived rigors of military life can significantly influence service members, sometimes prompting them to seek more favorable opportunities elsewhere. Incentives implemented should consider the diverse preferences of service members, addressing both the allure of external opportunities and the internal challenges within the organization.

A. RETENTION VERSUS ACCESSION

Scholars have compared the cost-effectiveness of accessing (training new pilots) to retaining pilots to manage the pilot inventory due to the high cost involved in training pilots to fly aircraft. To estimate the cost of training a pilot, one must first calculate the expenses. Mattock et al. (2019) used Air Force data on major aircraft types to undertake this task. They aggregated the fixed and variable costs of aircraft ownership and maintenance, determining the cost per flight hour in each aircraft. By multiplying this cost by the number of flight hours necessary to progress an initial pilot through all training phases, they found that training a single pilot ranged from $1.1 million (C-17 transport pilot) to $10.9 million (F-22 jet pilots).

Mattock et al. (2019) further modeled Air Force pilot retention against possible yearly Aviation Bonus (AvB) values, shedding light on the elasticity of pilot retention regarding these incentives. They predicted that increasing AvB values would result in increased retention. Although costly, this rise in retention would diminish the demand for pilot accession, consequently reducing the total pilot per capita cost to the service. Focusing on the most expensive and least expensive fighter pilot communities for modeling (Figure 6; red and blue lines, respectively), they estimated the effects of varying AvB amounts on retention and per capita cost. Their findings concluded that increasing the AvB amount proved more cost-effective for maintaining the pilot pool compared to increasing accessions.

Figure 6. AvB values applied to Fighter Pilots.
Source: Mattock et al. (2019).

Initially, the data unveiled an elastic response: raising the AvB resulted in a substantial upsurge in retention rates across all pilots, showcasing the highest marginal retention benefit up to $40,000 per year. However, as the AvB values exceeded this threshold, the pace of retention increase decelerated, signaling a transition towards inelasticity. Despite successive increments in the AvB, its impact on retention weakened, indicating diminishing returns beyond the $40,000 mark. Apart from the retention response, Mattock et al. (2019) pushed the boundaries, testing AvB values as high as $100,000 a year for cost-effectiveness. Surprisingly, retaining a fighter pilot remained more cost-effective than recruiting a new one, even with this elevated incentive value. The authors noted that their findings are a function of the existing high costs of training; a substantial reduction in training expenses in the future might alter these conclusions. Presently, however, the authors concluded that AvB values reaching $100,000 or higher per year could decrease the per capita cost of pilots. Nevertheless, as of 2023, Congressional bonus limitations remain capped at $50,000 a year (Gordon, 2023).

Although it may be more cost-effective to provide larger AvB amounts to pilots to promote retention, the value of the AvB provided and its uptake is heavily correlated with the external hiring environment. In their previous study, Mattock et al. (2016) analyzed the commercial airline industry and forecasted its future demand. They suggested that retaining military pilots could face external challenges due to the anticipated increase in demand for civilian pilots in the coming years. Mattock et al. (2016) argued that major airlines would need to ramp up their hiring efforts significantly from 1,200 new pilots a year in 2014 to over 2,800 new pilots a year by 2024 (accounting only for replacement, not expansion), owing to the upcoming retirements of pilots from the baby-boomer generation. Mattock et al. (2016) concluded that aviation retention bonuses must increase to as much as $62,500 a year to compensate for an anticipated 14% increase in civilian pilot wages (relative to wages in 2014).

Yet, Mattock et al. (2016) estimates did not accurately predict the rapid growth of the airline industry. The twelve major U.S. airlines hired more than 13,000 pilots in 2022 alone (FAPA.aero, n.d.). Furthermore, CNBC reported that American Airlines pilots received a 21% pay increase just in 2023, indicating that the estimates put forth by Mattock et al. (2016) have already been far surpassed (Josephs, 2023). Mattock et al. (2016) estimated that a first-year captain flying wide-body aircraft for American Airlines in 2014 would make approximately $193 an hour. Today, pay charts indicate that the same first-year airline captain makes a starting wage of $402 an hour (Schlappig, 2023).

Marine pilots earn far less. At the end of their first contract, an East Coast-stationed Marine Captain (O3) who works 50 hours a week makes approximately $50 an hour (with housing and flight pay included). Although a Marine pilot cannot directly transition to becoming an airline captain without prior experience as an airline first officer, the allure of future pay remains ever-present. Even the starting wage for a first officer on the smallest commercial aircraft stands at $108 an hour while promising a minimum of 75 flight hours a month (Schlappig, 2023). This value may represent a decrease in gross annual income to a Marine pilot based on the hours cap, but it also represents a doubling of income at the hourly rate with staggering potential for future growth. The swift escalation of pay and job opportunities in the civilian sector, coupled with unforeseen economic inflation, suggests that the cost of retention could far exceed previous forecasts. While the Mattock et al. (2016, 2019) studies focused on Air Force pilots rather than Marine Corps pilots, it is reasonable to assume that the costs and external impacts on retention would be similar.

Mattock et al. (2019) presents a model for a pilot's cost threshold to remain in the Service in the current environment but does not explore the cost or relative effectiveness of altering other factors affecting pilot retention. While there is a ceiling on the total number of flight hours purchased by the Marine Corps each year, variations in individual pilot flight hours may reveal additional cost-effective measures toward pilot retention (HQMC, 2022). By exploring the impact of flight hours on retention, I aim to uncover the relationship between the two and determine if flight hour allocation can be used as a tool to selectively curb retention.

Retention efforts extend well beyond pilots in the Marine Corps. The Marine Corps has been directed to balance retention with recruiting at the service level through Talent Management 2030 (Berger, 2021). Seeking ideas for non-monetary incentives in 2021, the Marine Corps received over 700 suggestions from Marines and civilian employees. While prior strategies focused on assignments, leave policies, promotions, living conditions, and career development, new suggestions emphasized professional opportunities and increased Permanent Change of Station (PCS) flexibility (*Military and Civilian Personnel Overview*, 2022). While these broad incentives might not comprehensively address the unique preferences of pilots, I will next review the literature concerning these topics and their pertinence to the specific pilot-retention problem.

B. NON-MONETARY RETENTION TOOLS

Referencing the Marine Corps crowdsource feedback regarding PCS flexibility, one can infer that location significantly influences retention decisions. In a study conducted by Williams (2021), over 6,000 fighter pilots' individual decision points were analyzed explicitly for this purpose. The author highlighted Air Force pilots' stronger tendency to stay in service when stationed in a preferred location that supports a unique or exciting mission. Figure 7 illustrates how Williams (2021) categorized Air Force bases into four bins: training, operational, foreign, and unique mission, then compared their additional likelihood of retention (ALR). For the purposes of this study, 'unique' refers to a subset of missions and pilots that do not directly fit into the other three categories (such as drone pilots, Test Pilot School, or pilots stationed at the Pentagon). The findings indicated a 7.6% lower probability of retention for pilots stationed at a training base (e.g., Columbus) compared to those at an average retention base (e.g., Seymour Johnson). Conversely, pilots stationed at foreign bases or involved in unique missions demonstrated a 9.3% higher likelihood of making a positive retention decision compared to those at an average retention location.

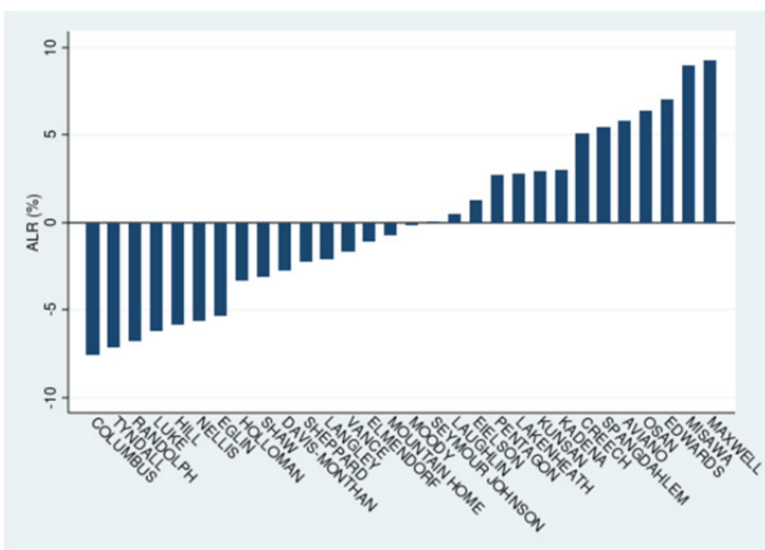


Figure 7. Pilot ALR by Location. Source: Williams (2021).

Williams (2021) somewhat controversially concluded that quality of life indicators had no significant correlation with retention and even found a weak negative correlation between the quality of schools and ALR (Figure 8). The author resultantly suggests that policies targeting such elements should undergo more careful examination for their desired effects. Furthermore, a limitation within the Williams (2021) study surrounds the treatment of flight hours within the analysis. It discusses the challenges pilots encounter in achieving their desired flight hours, but this discussion is generalized and presented in the form of aggregate service-level flight hour accounting rather than at a person-level experience. Additionally, the quality of flight hours and pilots are assumed to be the same across all locations. However, not all pilots are eligible for all basing locations, and not all locations have the same training opportunities or levels of funding. This variation in personnel and flight experience could influence pilots' overall experience that is tied to a base but is not caused by it.

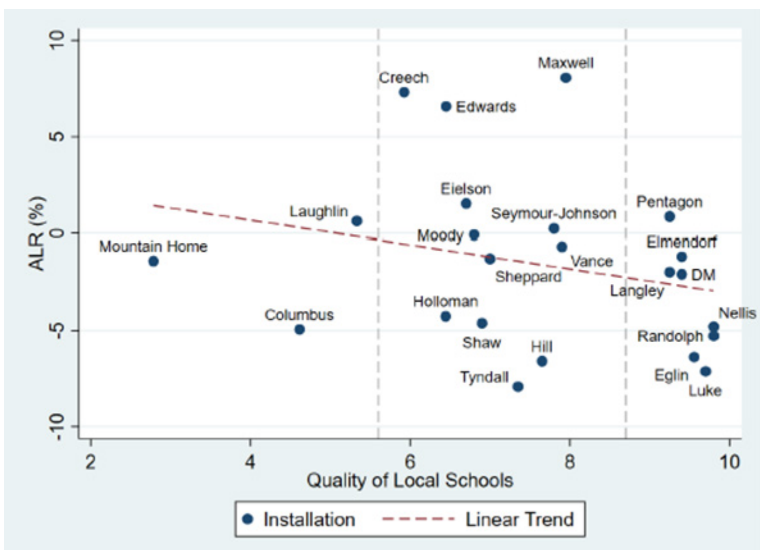


Figure 8. Correlation Between School Quality and ALR.
Source: Williams (2021).

My study builds on these findings regarding motivations to stay in the Service and may shed light on flight hour variations by location with the potential to offer an alternative interpretation of the results presented by Williams (2021). One possible interpretation is that well-qualified pilots are often assigned to locations to support unique missions, and their decision to remain in Service is possibly more highly correlated with their quality or personal motivations than their assigned base or mission. For example, Williams (2021) concluded that bases engaged in unique and strategic missions exhibited higher retention rates as compared to those supporting routine missions. The study addressed the variance of rank across different bases but did not delve into pilot quality within each rank. It did not explore the associations between flight hours, pilot quality, and retention, potentially leaving them as omitted variables in the equation when discussing the effects of basing on retention outcomes.

The other main theme produced by the Marine Corps crowdsourcing retention survey focused on professional opportunities, which happened to be the focus of Griffin et al. (2018). Griffin et al. (2018) found that a pilot's experience played a critical role in their retention, as seen in Table 3. The researchers highlighted that the quality of a Marine aviator's experience significantly correlated with increased pilot retention when they possessed a Weapons and Tactics Instructor (WTI) or Forward Air Controller (FAC) qualification. As opposed to Marines who did not possess such qualifications, Marines with WTI or FAC ratings were more likely to make a positive retention decision beyond their original commitment by as much as 13.5 percentage points (Griffin et al., 2018).

Table 3. Relationships Between Aviator Retention and Retention-Affecting Factors. Source: Griffin et al. (2018).

Factor	Percentage-point change in retention for a one-unit factor change
MV-22 pilot (relative to rotary-wing)	+6.7
Have dependents (relative to no dependents)	+5.0
FAC experience (relative to no FAC experience)	+9.8
WTI experience (relative to no WTI experience)	+13.5
Cumulative combat deployment experience	+1.6 for every additional 100 days
O-4 (relative to O-3)	+13.0

However, three major limitations exist in this study. Firstly, the researchers lacked access to individual pilot flight data, necessitating the use of aggregate service-level data and estimation to create monthly approximations per pilot, resulting in generalizable claims. Secondly, while the study observed a significant correlation between WTI/FAC rating and retention, it did not address the additional contractual obligations incurred by attending a Marine formal school—a policy that requires pilots to serve longer than their initial contract in exchange for education received which could potentially explain the observed correlation (HQMC, 2019b). Lastly, the study did not consider possible omitted variable bias related to pilots' timing between deployment cycles, eligibility for advanced training (there are many qualifications required prior to WTI, all of which represent a significant flight-hour investment in a pilot), or unit-level experiences and their corresponding retention rates. My research aims to expand on the correlations observed here to enhance the collective understanding of individual pilots' experiences and qualifications, while carefully accounting for the nuances of the Marine Air Wing.

C. PERCEPTIONS AND RETENTION

The discussion thus far suggests that Marine pilots either require more money or improved intangible benefits in the form of a desirable location or advanced professional opportunities to remain in the Marine Corps. However, there is a third possible factor that could affect retention: organizational hardship. Bernthal (2022) discovered through a dozen personal interviews and surveys of 30 Marine Corps pilots leaving the service that the size of the aviation incentive bonus was among the least significant factors influencing pilots' decisions to leave. Meanwhile, job-related themes surrounding poor leadership, culture, and heavy workload ranked as the top three drivers of separation (Bernthal, 2022).

Either cosmically or consequentially, Bernthal's (2022) results resemble a Gallup poll performed in 2018 concerning employee burnout. Wigert and Agrawal (2018) looked at the dominant contributors to employee burnout, and their findings nearly matched the top three grievances illustrated by Marine Corps pilots (Table 4), suggesting that Marine Corps pilots may also be suffering from burnout. Furthermore, the researchers concluded that employees experiencing burnout are 2.6 times more likely to seek alternate employment (Wigert & Agrawal, 2018).

Table 4. Relating Pilot Attrition to Burnout. Adapted from Bernthal (2022), Wigert and Agrawal (2018).

Pilots' Reasons for Leaving the USMC	Top 5 Causes of Employee Burnout
1. Leadership (poor)	1. Unfair treatment at work
2. Culture (poor)	2. Unmanageable workload
3. Workload (too much)	3. Lack of role clarity
4. Readiness (having capable/flyable aircraft)	4. Lack of communication and support from managers
5. Flight Hours (too few)	5. Unreasonable time pressure

Mattock (2016) examined a robust external hiring environment within the airlines and its influence on the military pilot population, but the report did not discuss burnout as a key contributor to military pilot poaching, as it focused more on the demand for pilots than on pilots' demand for a new job. While the airlines offer a strong incentive to leave the service through a higher salary, the promise of abundant flight hours without assigning additional duties truly assuages burnout. Marines work an average of 51.9 hours per week, or 200+ hours per month (Data USA, n.d.). Marines, specifically in the Air Wing, likely work even more due to daily shift-based maintenance cycles. Looking at the pilot average of sub-15 flight hours per month hosted by the Marine Corps, however, we can reasonably conclude that a large majority of the monthly 200+ hours must be spent in auxiliary and support duties rather than flying (U.S. Marine Corps, 2023).

All pilots, both civilian and military, are capped at 100 hours of flying a month by the Federal Aviation Regulations (14 CFR 121.471, 2023). Civilian airline pilots have few additional duties outside of flying, so the time spent flying encompasses the overwhelming majority of their labor. According to the Bureau of Labor, the commercial pilot average in 2023 was 75 hours per month (U.S. Bureau of Labor Statistics, 2023). Effectively, an airline pilot flying for a major national carrier could fly as few as three international trips in a month to reach their flight hour quota (it takes approximately 17 hours, one way, to fly from San Francisco to Singapore). In so doing, they would work half as many hours as Marine pilots in that same month while making as much or more monthly pay. Meanwhile, the flight hours achieved over the course of those three trips would be commensurate with a junior Marine pilot's yearly total.

The hours Marine pilots spend on non-flying duties at work suggests a potential misalignment of roles within the larger organization. Marine pilots may struggle in part because they are designed to operate as Peripheral Specialists within the larger organization—a distinct role discussed in Cross and Prusak (2002). The primary role of a Peripheral Specialist is to provide the organization with specialized knowledge. While organizations often seek to better integrate these specialized members and foster interconnectivity, such as through increased meeting attendance, this inevitably diverts their focus and detracts from their primary role as organizational experts. This pull on the expert members' time alienates them in two ways: they feel that they are no longer at the top of their field because they are burdened with competing duties, and their responsibilities and time commitments have increased as a result of their own success. Ultimately, these outcomes may influence their decision to leave (Cross & Prusak, 2002).

As Marine pilots progress, the organization endeavors to transition them from specialized roles to larger managerial positions, often leading to reduced time in the cockpit (Bernthal, 2022). Applying the findings of Cross and Prusak (2002), the Marine Corps structural layout might impact pilot retention, especially if pilots are primarily motivated by their expertise in flying and flying-related tasks rather than managerial or staff roles. While specific motivations are not the focus here, exploring whether pilots are influenced by their flight experiences proves relevant. This study aims to assess the correlations between flight hours and pilots' decisions to remain in service, filling a gap in the empirical research and expanding upon pilots' qualitative discussions regarding Marine Corps pilot separation.

D. CONCLUSIONS

Exploring pilot retention in the Marine Corps and the broader U.S. Military reveals a myriad of factors that influence pilots' decisions to remain in service. The research highlights the cost-effectiveness of retention strategies despite challenges from external market forces and the expanding opportunities in the civilian sector. Both monetary and non-monetary incentives play a pivotal role in retention efforts, underlining the necessity for tailoring a custom approach that suits pilots' motivations and adapts to the changing external landscape. Additionally, these studies highlight how location, career prospects, and burnout affect retention among Marine Corps pilots. These insights stress the importance of reevaluating organizational structures and roles, ensuring a delicate balance between pilots' technical expertise and their transition into managerial roles within the military framework. While existing literature covers aspects of the retention issue, few studies delve into the empirical significance of flight hours due to a lack of individual-level data. My study seeks to broaden prior research by investigating the correlation between individual-level flight hour experiences and retention outcomes.

THIS PAGE INTENTIONALLY LEFT BLANK

IV. DATA

A. DATA SOURCES

The data used in this study came from two primary sources: Marine Sierra Hotel Aviation Readiness Program (M-SHARP) and Total Force Data Warehouse (TFDW). Figure 9 illustrates the existing relationships between the data with common pilot and aircraft indicators. M-SHARP data comprises the flight logs between 2018 and 2022 for every Marine pilot in observation, whereas the TFDW repository provides the demographics, qualifications, and retention decisions of each pilot. All data would be merged by pilot indicators and aircraft indicators common to the datasets.

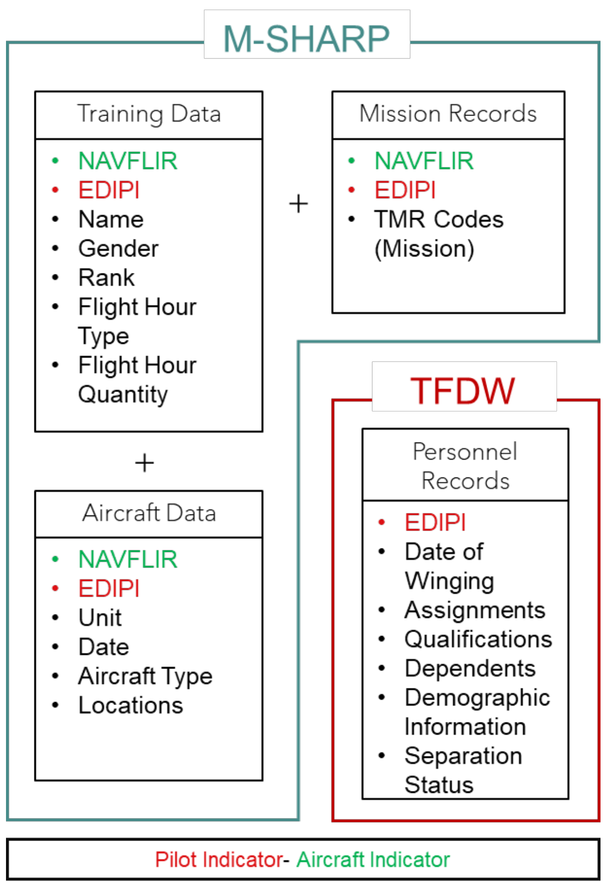


Figure 9. Data Design and Relationships

1. M-SHARP

M-SHARP data formed the nucleus of the research by providing individual pilot flight records across the Marine Corps between 2018 and 2022. M-SHARP is the primary flight hour logging tool pilots use to track flight hours, missions, and aircrew qualifications across all type/model/series (T/M/S) aircraft in the Fleet. Every time an aircraft flies, a Naval Flight Record (NAVFLIR) is logged in M-SHARP by the aircrew following their return. On it, it has information such as the aircrews' identification, the duration of flight, ordnance expended, and missions flown. That information is cataloged in the M-SHARP database and is used for tracking and evaluation purposes. It is used by individual aircrew members to maintain their personal logbooks, by each unit to track personnel flight currency and mission proficiency, and by higher command echelons to monitor trends in unit readiness. The repository is expansive with millions of flight records; however, the analysis capabilities organic to M-SHARP are limited. An interactive visualization tool has been implemented for selective use to look at aggregate data and to track trends. The trends observed do not inherently tie to secondary analysis, however. Additionally, the raw data used in the output cannot be screened for accuracy, so it is susceptible to erroneous output based on misidentified inputs.

With special permissions, all individual-level data can be accessed through an ad-hoc query where the user can define the sorting criteria and generate a comma-separated value (CSV) file report. There are two limitations within the ad-hoc query, however. Based on the common access card (CAC) time-out restrictions on the website, the size of the CSV requested must be small enough to fully generate and download before the user times out from inactivity. Secondly, two sub-databases found in the ad-hoc query: Training and Aircraft. The two datasets capture different metrics from NAVFLIR submissions and do not have a crosstalk capability. Therefore, all data pulled must be entirely from one database or the other—a user cannot request data from both simultaneously.

The Training dataset captures aircrew-specific factors such as training codes and flight hours logged in different aircraft positions or environments (aircraft commander versus copilot; night versus day). The Aircraft database contains aircraft-specific data, such as the takeoff and landing times, flight locations, the aircraft's overall mission, and total flight hours logged by the aircraft. The only overlap between the two databases is found in the identity of the pilots and the NAVFLIR document number. Due to these restrictions, reports were generated in three waves for each aircraft type: a distinct data pull for Training records and two separate data pulls for Aircraft records that partitioned the missions and aircraft data. This resulted in 21 separate files that would be imported and merged inside of the R software by Electronic Data Interchange Personal Identifier (EDIPI) number and NAVFLIR document number.

2. TFDW

Information provided by the Marine Information Data Branch from the TFDW database consisted of nine CSV files that each represented data pulled from different tables embedded in the TFDW data structure. The data came primarily in the form of panel data, with each observation correlating to an individual at non-standard intervals (in the vicinity of annual). No dates were provided on the observation lines, so matching a pilot's dynamic variables (such as rank and number of dependents) to a specific year proved untenable. Static demographic information, however, could be easily gathered for import into R.

Separation data came from two variables: Application for Separation or Retirement and a Separation Code. While screening the data, however, disparities in logging were noted and would need to be adjusted to determine separation status. Firstly, not all Marines who have separated have an Application for Separation or Retirement entry. Marines who have been separated unexpectedly (such as due to disability, death, or poor conduct) never applied for separation and thus do not have a date associated. Meanwhile, other pilots who applied for separation but later canceled their request are not captured here (an option that was occasionally exercised during the COVID-19 pandemic when airline hiring froze) (Josephs, 2020). Secondly, not all separated Marines have a published separation code, and of the ones that do, the codes used are inconsistently applied based on the type of separation. Once the data from TFDW was merged with that of M-SHARP, a combination of variables between the two repositories would have to be used to determine a conservative approximation of the Marines that voluntarily separated.

B. DATA CLEANING

All data from M-SHARP and TFDW was imported into R for merging, compilation, and cleaning. Upon the initial merger of the data, there were 936,623 flight observations with 47 variables. The data had to be paired down to ensure that flight observations were limited only to the aircraft (not the simulator), only manned tactical-use aircraft types were in observation, and all pilots in the pool were Active-Duty Marines (other U.S. and foreign services have sent pilots to train on Marine Corps aircraft in the past and are mixed into the data). Lastly, observations capturing aircrew that were logged as pilots when they only were on an aircraft but were acting only in a passenger capacity had to be removed from the sample. Once the data had been sifted, the dataset was reduced to 606,295 observations, with each observation representing a single flight performed by a unique pilot. If two pilots flew together on a given flight (common to multi-piloted aircraft), there would resultantly be two observations logged—one for each pilot, but both with the same assigned NAVFLIR.

Subsequently, the 18 T/M/S that populated that data were then relabeled to omit their series letters and combine aircraft types that exhibit similar characteristics, as seen in Figure 10. All aircraft fall into one of three groups based on wing type: Fixed Wing (FW), Rotary Wing (RW), or Tiltrotor (TR). Inside the three groups, seven aircraft designations remained and would be used as a binning tool for all analysis and statistical descriptions. While there are multiple units and possible basing locations for pilots that fly each of the seven aircraft types, pilots were then binned into a general region based on their observed flight records. Each Marine Corps squadron was binned into one of five regions, and then all pilots' flight hours were aggregated by unit to determine which unit they spent the majority of their time flying with during the observation period. If a pilot spent all their time at a single unit, then they would be assigned a location commensurate with that squadron. Conversely, if a pilot transferred units during the period of observation, the unit they flew more at was the location they were assigned.

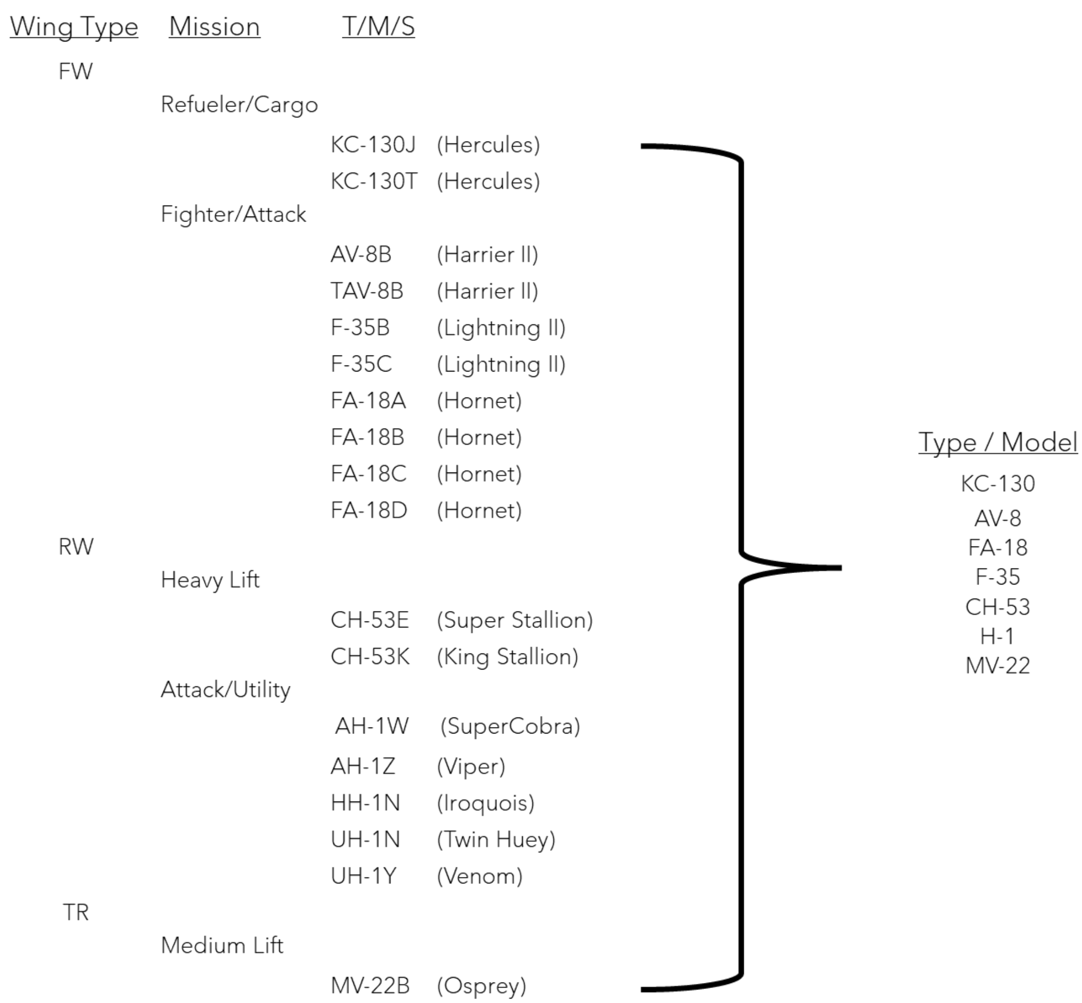


Figure 10. Consolidation of Aircraft T/M/S. Adapted from USMC (2023).

Once all data was imported, cleaned, and merged, the final dataset contained 582,557 observations with 74 variables. Among the variables were indicators for pilot qualification level (based on AMOS), indicators for mission (based on logged TMRs), and indicators for separation. The separation indicator was derived using two variables: an M-SHARP deactivation variable and the TFDW Application for

Separation or Retirement variable. Because the purpose of this study is to capture the effects of flight hours and quality on retention, it was determined that the separation status of all Marine pilots was not necessary– just those that voluntarily left. Therefore, voluntary separation was defined through two criteria. Pilots who have an Application for Separation or Retirement date and are deactivated in M-SHARP were the first category, indicating that a pilot demonstrated intent to depart, and their deactivation status in M-SHARP shows that they have stopped flying for the Marine Corps. The second criterion included for separation binning was an active Application for Separation that was posted after September 2022 (within the last 14 months of the data pull) and a presumed intent to separate. By confining our labeling of separation to these observations, I can omit observations pertaining to non-voluntary departures from service and minimize erroneous labeling of pilots that are deactivated from M-SHARP but are simply in a non-flying tour of duty (operating as a Marine in other capacities, such as a staff officer). There is a small niche of pilots who cannot be accounted for under this logical structure pertaining to pilots that applied for separation, revoked their request, and are now serving in a non-flying role (such as the Naval Postgraduate School). The pool of aviators matching this description is few, so it is surmised that this assumption shortfall would not alter the overarching conclusions drawn from this study.

C. OTHER DATA LIMITATIONS

All data logged within M-SHARP is user-provided and, therefore, susceptible to error. M-SHARP requires certain fields to be filled out mandatorily when submitting a NAVFLIR. However, it will permit aircrew to make erroneous submissions such as assigning a pilot an incorrect role (like designating a pilot as a flight engineer) or recording a value for hours flown at night when the total pilot time (TPT) reflects a value of zero (commonly seen when a pilot rides as a passenger but still dons night vision goggles). The prevalence of passengers logging zero hours on NAVFLIRS was pervasive and biased the population's monthly flight hour average down by nearly two hours per month. While time spent riding in the aircraft may still contribute to a pilot's retention decision and can have beneficial training outcomes, it is outside the scope of this research and its presence suppresses the reality of the average pilot's experience. Therefore, only observations that had a TPT greater than zero were kept.

The second limitation was found in the records kept internal to M-SHARP. A NAVFLIR document number is assigned to every submission. However, the data produced a series of inconsistencies where the NAVFLIR document numbers were different between the Training database and the Aircraft database, though they represented the same flight event. The misalignment of NAVFLIR document numbers between the two databases was investigated, and it was determined that 6,819 flight hours would be unaccounted for in the data following the merger. While the missing data represents a quantifiably significant number of flight hours, it contextually only represents 0.34% of the data and appears to affect the population somewhat homogeneously.

Thirdly, the status of a pilot as Active Duty or Reservist was not clearly defined. The M-SHARP ad-hoc pull has a variable accounting for status; however, it does not show historical data—it only indicates the present day. While a flight record that was flown five years ago may have all correct information pertaining to the flight itself, the status of the pilot tied to the observation would only reflect their present-day unit assignment and status, not their status at the time of the flight. The data provided by TFDW indicated status but did not tie switching points between Active and Reserve to specific dates or years. Therefore, status was estimated using the same method as regional assignment—all flight hours were evaluated by the unit that owned the aircraft that was flown. If a pilot flew most of their flight hours from aircraft belonging to reserve units, they were dubbed as reservists and removed from the pool.

Lastly, the commissioning and separations data found in the TFDW data was inconsistent and observations had no established period between them. Not all pilots had a commissioning date or a winging date present in their record, though both items are prerequisites to fly in the Marine Air Wing. Meanwhile, each observation did not perfectly correspond to an annual cycle, giving the appearance that new observations are triggered by a change in some variable (such as moving to another squadron) rather than a monthly or annual report. Because dates could not be tied to observations, controlling for person-fixed effects in my analysis would not be possible since I cannot monitor dynamic variables over time. To compensate for this lack of capability, each pilot was assigned their most senior rank and a binary indication for dependents (indicating if they ever had dependents or not) for descriptive statistics only. This would skew all data to the right (such as assigning hours to an O4 when they were truly flown when the pilot was an O3) but would affect the population similarly. Time-dependent variables that could not be accurately tracked would be omitted during the regression analysis to avoid skewing the data against pilots who had less opportunity, in the form of fewer years, to acquire dependents or additional rank. All pilots who did not have a logged winging date (pilot designation date) would have to be dropped prior to analysis (about a 7% loss).

D. DESCRIPTIVE STATISTICS

1. The Population

Looking at the Marine pilot population between 2018 and 2022, I compared the experiences of 3,820 pilots across five primary regions and seven types of aircraft. Table 5 shows the cursory breakdown of the population.

Table 5. Population Descriptive Statistics. Adapted from USMC (2023).

Number of Pilots:	3,820
Male:	3,646
Female:	174
Rank:	
01-02:	47
03:	2,083
04:	1,115
05:	482
06+:	93
Race:	
White:	3,338
Asian:	117
Black:	94
American Indian:	42
Hawaiian/Pacific Islander:	19
Declined to Respond:	210
Dependents:	
Has Dependents:	2,628
Does Not Have Dependents:	1,154
Unknown:	39
Observation Period (months):	60
Number of Flight Events:	338,393
Number of Individual Flight Hours Logged:	1,531,735
Number of Basing Regions:	7
Number of Aircraft Type:	7
Number of Units:	78
Number of Departure/Arrival Locations:	848

Observation Period refers to the number of months being evaluated between 2018 and 2022 to determine monthly averages.

Number of Flight Events refers to the number of distinct NAVFLIRs logged in M-SHARP. A flight event is defined as a flight, or series of flights, flown by an aircraft commander in a specific aircraft. The flight event is complete when the aircraft commander signs the aircraft over to another pilot or turns the aircraft in for maintenance.

Number of Individual Flight Hours Logged is a sum of all flight hours logged by each pilot across all aircraft NAVFLIRS. Whereas two pilots can fly on the same NAVFLIR (in the role of an aircraft commander and a copilot), they would both log their own distinct flight hours. For example, a NAVFLIR may indicate that an aircraft was airborne for 3 hours, but the logged pilot time on the NAVFLIR would reflect 6 hours if there were two pilots.

Number of Basing Regions indicates the number of possible geographic regions that a pilot could be stationed as binned into West Coast, East Coast, Hawaii, Japan, Arizona, Reserve, or Other. Reserve and Other categories will later be removed to focus on Active-Duty tactical units.

Number of Units refers to the number of Marine Corps squadrons that supported flight operations with aircraft during this observation period.

Number of Departure/Arrival locations refers to the distinct number of registered landing zones, airfields, or vessels that Marine Corps aircraft either departed from or landed to during this course of observation.

Individual pilot monthly means were calculated before taking a monthly average across the population to determine the population mean. By doing so, the true pilot experience could be more accurately depicted vice an aggregate average. The observations revealed a monthly pilot flight time average of 12.79 hours per month, as seen in Figure 11. The first and third quantiles are labeled on the histogram, indicating that 25% of all pilots have a monthly flight hour average of fewer than 9.3 hours per month, and 75% of the population has a flight hour average of less than 15.9 hours per month. In other words, the average pilot saw a monthly total of about 13 hours of flight during their active months, and less than a quarter of all pilots ever reached an average above 16 hours per month.

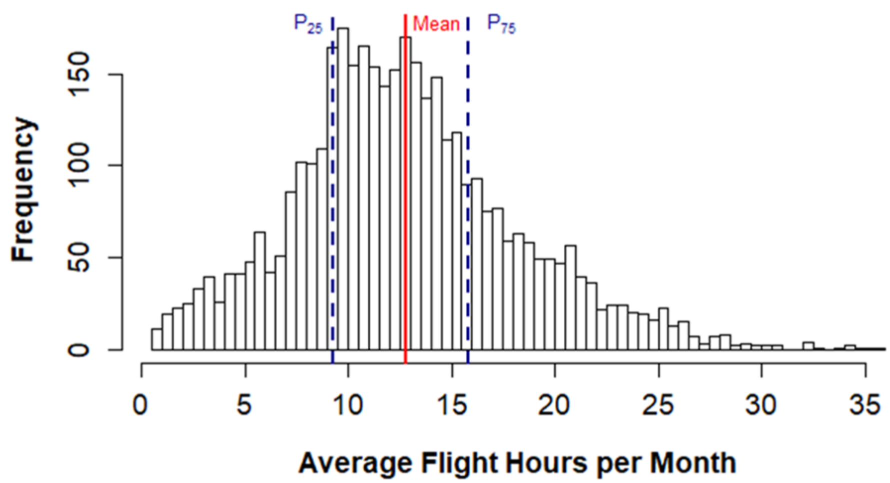


Figure 11. Histogram of Monthly Flight Hour Averages. Adapted from USMC (2023).

2. Flight Hours

Each aircraft type has substantially different requirements and capabilities; taking a population average provides limited value other than an anchoring point for the subsequent analysis. Referencing Table 6, the number of pilots associated with each aircraft type varies dramatically as a function of the number of squadrons that fly each respective aircraft, the number of aircraft that belong to each squadron, and the number of pilots required to fly a specific aircraft (single pilot or multi-pilot). The jets used by the Marine Corps are primarily single-seat aircraft, whereas rotary wing and tiltrotor aircraft are multi-piloted aircraft. This difference is demonstrated in the CH-53 and FA-18 communities which sustain similar sized aircraft complements. The CH-53 pilot count of 672 is just more than double the FA-18 pilot count of 304 in the sample as a result of the number of pilots required to fly a single aircraft. While KC-130s are also multi-piloted aircraft, the 2022 Aviation Plan indicated that there were only 63 KC-130s in the inventory compared to 296 MV-22s, thus driving a differential in the pilot inventory (HQMC, 2022).

Table 6. Flight Hour Breakdown by Aircraft Type. Adapted from USMC (2023).

	Fixed Wing				**Rotary Wing**		**Tilt Rotor**	
	AV-8	**FA-18**	**F-35**	**KC-130**	**H-1**	**CH-53**	**MV-22**	**All T/M/S**
Number of Pilots	252	304	345	399	1,162	672	1,079	3,820
Mean Flight Hours/month	11.35	11.51	8.11	18.38	12.01	11.42	11.29	12.79
Standard Deviation	4.14	6.01	3.09	7.45	6.51	5.56	4.27	5.43
Median Flight Hours/Month	11.26	10.97	8.26	20.25	12.75	12.23	11.14	12.3
Min Monthly Hours	0.5	1.1	0.8	0.1	0.2	0.3	0.5	0.5
Max Monthly Hours	22.75	37.78	18.36	35.2	33.52	27.71	26.85	35.61
Standard Error	0.26	0.34	0.17	0.37	0.19	0.21	0.13	0.09
IQR	4.95	5.85	4.5	8.47	7.79	6.83	5.21	6.57
1st Quantile	8.99	8.19	5.69	14.91	8.31	8.33	8.7	9.31
3rd Quantile	13.94	14.04	10.19	23.37	16.1	15.16	13.9	15.88

Figure 12 graphically depicts the disparity between average monthly flight hours across aircraft platforms. Pilots who fly KC-130s expectantly receive the most flight time—they are closest to a civilian airline and perform support tasks for all other aircraft. They carry more fuel than any other aircraft and can, therefore, stay aloft for greater periods of time. They are also in high demand, as they support logistic requirements as well as tactical ones. If a CH-53 were to fly from the East Coast to the West Coast, a KC-

130 might accompany them to carry their support personnel or to provide aerial refueling en route. Meanwhile, the F-35 is the Marine Corps' newest fighter jet and is still working to acquire aircraft and personnel for the established units that fly them. As a result, we would expect their community flight hours to be low while they continue to grow toward their full complement.

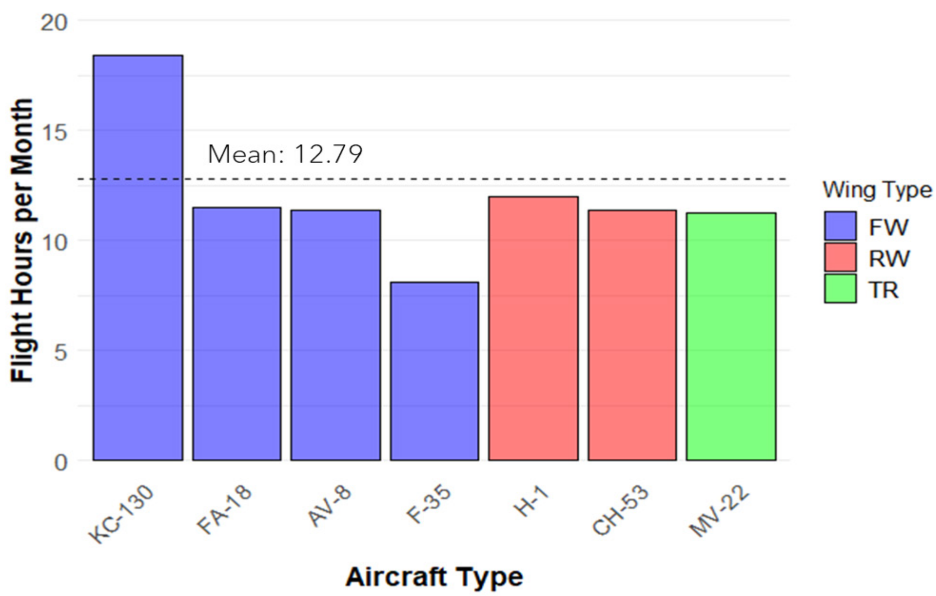


Figure 12. Average Monthly Flight time per Pilot. Adapted from USMC (2023).

Average flight time varies not only by aircraft but also over time and location. Figure 13 displays the variation of monthly averages by aircraft type over the five-year observation period. For example, H-1 pilots saw a monthly average of 14.6 hours in 2019, whereas FA-18 pilots took a period low of 8.0 hours per month in 2021. Factors such as budgetary constraints, geo-political events, expansion and contraction of the Marine Corps, and deployment cycles affect the number of hours targeted to be flown each year under the Flight Hours Program (HQMC, 2022). Meanwhile, unforeseen factors such as weather, increased maintenance requirements, and supply chain limitations further curtail the actual number of hours flown by the squadrons. While in a non-deployed status, squadrons traditionally fly significantly more over the spring and summer months than over the fall and winter due to routine weather and the placement of federal holidays. To limit the known seasonality of the data, monthly averages have been annualized to dampen the oscillatory patterns.

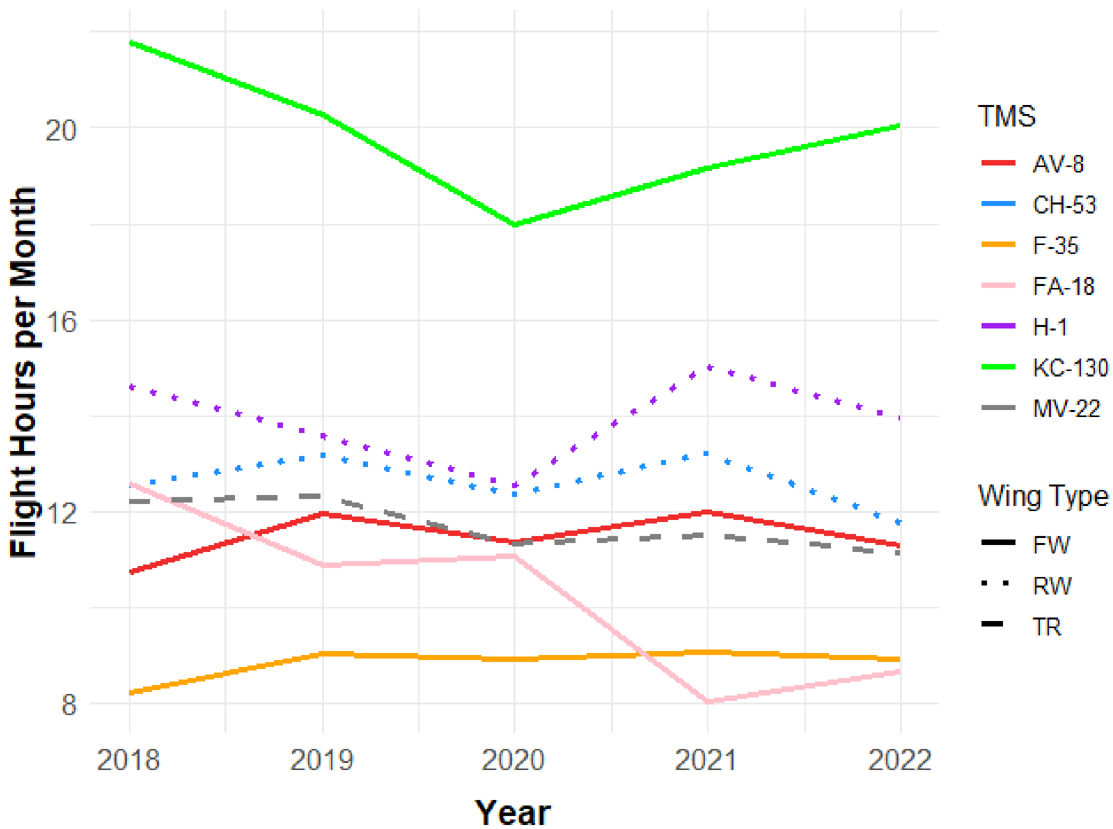


Figure 13. Pilot Monthly Flight Hour Average by Aircraft. Adapted from USMC (2023).

Likewise, region affects flight hours flown through climate differences and supply chain logistics. Figure 14 illustrates variation in monthly flight hour averages across the five binned regional locations. Squadrons that share similar training areas and have comparable living experiences were binned together. For example, squadrons that operate out of North Carolina and South Carolina are both considered East Coast, whereas squadrons that operate out of Iwakuni and Futenma were both binned under Japan. While squadrons that operate in Arizona share the same training opportunities as those on the West Coast, they have been binned separately due to the differences in weather patterns and living environments. Additionally, bins were created to capture Reserve and Other units (a small niche of Active-Duty pilots that fly for non-standard units, such as the Blue Angels and the Fleet Readiness Center), but observations relating to these bins were subsequently removed from the data once identified to avoid skewing the results on Active-Duty tactical units.

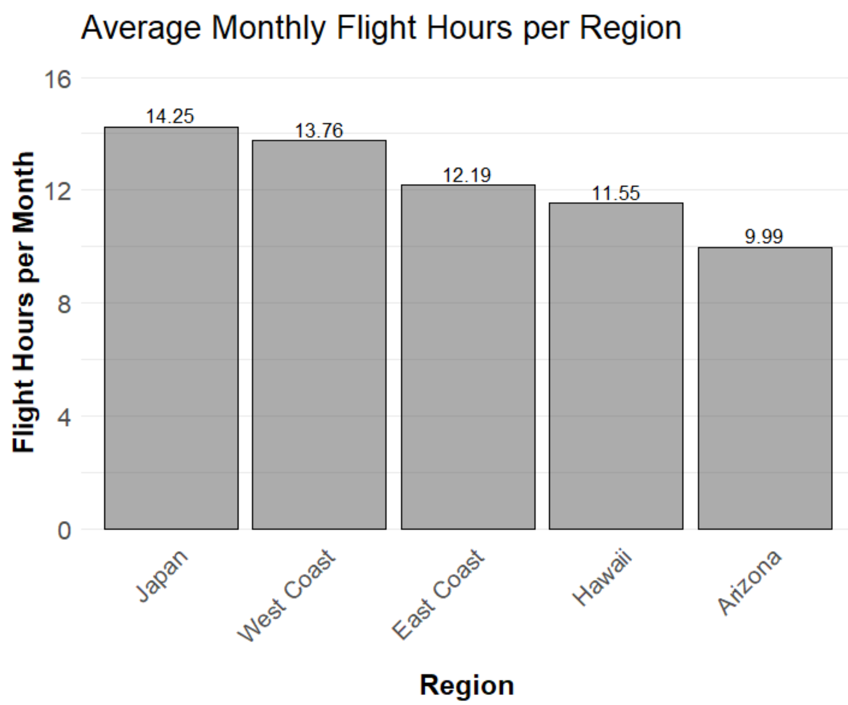


Figure 14. Average Monthly Flight Hours by Region.
Adapted from USMC (2023).

Japan maintains the largest flight hour average at 14.2 hours per month, compared to Arizona, where the average is 9.8 hours per month. Arizona's low average can be attributed in part to the constituency of the units that are stationed there; outside of specialty units such as VMX-1 and MAWTS-1, Arizona is home only to jet squadrons (which notably fly less than non-jet squadrons).

Lastly, flight hours vary with pilot quality and level of qualification. Certain missions can only be flown or taught by pilots with more senior qualifications. Because squadrons must maintain a pre-defined number of combat-capable crews for the purposes of readiness, experienced pilots tend to fly more than junior pilots. Experience alone does not dictate flight hour averages though. Higher ranked pilots tend to fly less than junior ranked pilots due to competing ground job requirements and their designated roles as leaders. Narrowing the focus of the population to only O3s (where most qualifications are earned and employed), the flight hour average sees its greatest range in Figure 15.

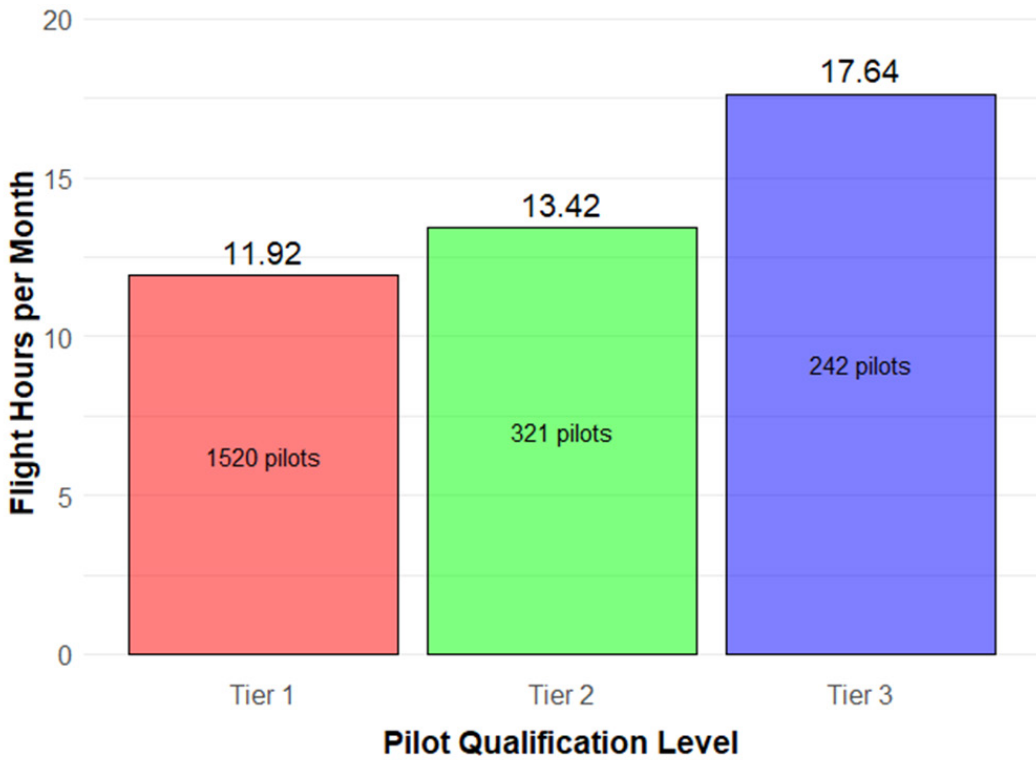


Figure 15. Pilot Qualification Levels and Their Respective Monthly Flight Hour Averages. Adapted from USMC (2023).

For this study, pilots have been binned into three tiers based on their qualifications. Pilots who maintain the AMOSs corresponding to Night Systems Instructor (NSI), Weapons and Tactics Instructor (WTI), or Flight Lead are binned into the most qualified category of Tier 3. Pilots who are noted as either Section Leaders or Division Leaders are categorized as Tier 2. Lastly, all remaining pilots are binned as Tier 1—the broadest category that captures all new copilots, aircraft commanders, and junior instructors. While there are numerous other qualifications that pilots can earn, these specific criteria represent a chronological progression in flight experience. The Table of Organization for a squadron dictates that pilots described as Tier 1 would make up most of the population, whereas there would be fewer Tier 2 pilots, and the least number of Tier 3 pilots (USMC, 2023). From the snapshot provided, however, it is apparent that with a smaller population, Tier 3 pilots maintain the strongest monthly flight average across the observation period. Because qualifications are recorded statically, the averages seen are pilot averages throughout the period grouped by their final qualification level, not the qualification they maintained at the time of a specific flight. Therefore, what is unclear from this depiction is whether they have a strong flight hour average because of their qualifications or if they possess higher qualifications and higher flight hour averages because of their individual quality or career timing.

Of note, additional military occupational specialty (AMOS) data is found in TFDW but is not automatically cataloged. Members who earn qualifications must submit their earned AMOSs via Electronic Personnel Administrative Request (EPAR) through the Marine Online Portal. While it is standard practice, it is at the discretion of local commanders to ensure that their personnel comply with the task. As a result, there can be significant delays between receipt of qualification and input of the corresponding AMOS in MOL, if it is ever logged at all. Well-qualified Marines with the intention to be promoted and remain in service may be more likely to submit for AMOS addition than Marines who intend to separate. In so doing, this disparity could translate to an inflation of the impacts of Tier 1 pilots and an underestimate of Tiers 2 and Tier 3 pilots.

3. Flight Quality

Three categorical bins were used to consolidate the 200+ distinct TMR codes logged in the data and are displayed in Table 7. All flights were categorized as either Administrative, Training, or Tasking and displayed along with their flown frequency amongst the population. Administrative flights encompass all flights that are in a maintenance testing or ferry flight capacity. When used en masse to build a copilot's hours toward a fixed flight hour requirement (often required for subsequent qualifications), these are referred to as 'hollow' hours—as the training value is normally limited. Training flights are categorized as all routine flights that are intended to fulfill requirements set forth in the Sortie-Based Training Program and Training and Readiness Manuals and are not in support of another unit or in response to official tasks. Training flights are valuable for pilots in the learning process and constitute most of their flying experience. While they are qualitatively more beneficial than Admin hours, they are potentially less beneficial than Tasking. Tasking flights capture all remaining flights that are in a support or combat capacity. Flight hours spent fulfilling Tasking missions are regarded qualitatively as the most valuable, as they test tasks learned in training. The median pilot in this population sees five flights a month, of which three and a half are dedicated to training, and less than one each is spent in admin or tasking capacities.

Table 7. TMR Binning for Mission Quality. Adapted from USMC (2023).

Mission Category	**TMRs Logged**
Admin Flights	85,728
Tasking Flights	103,395
Training Flights	393,339

Just as with flight hours, missions substantially vary by aircraft type, and therefore, the individual pilot's experience can vary dramatically across the aircraft inventory. Figure 16 shows the mission proportion averages flown by each aircraft during the observation period. Notably, KC-130 pilots appear to perform the most Tasking and the least Admin in their career, whereas CH-53 pilots perform the most Admin and least Tasking. These results are as expected in the sense that KC-130 pilots often operate in support of other aircraft, so what might constitute a ferry flight for a helicopter would be tasking for a KC-130 (since they are performing a support service). Meanwhile, CH-53 helicopters are more prone to maintenance than their fixed wing counterparts. This results in more administrative maintenance flights.

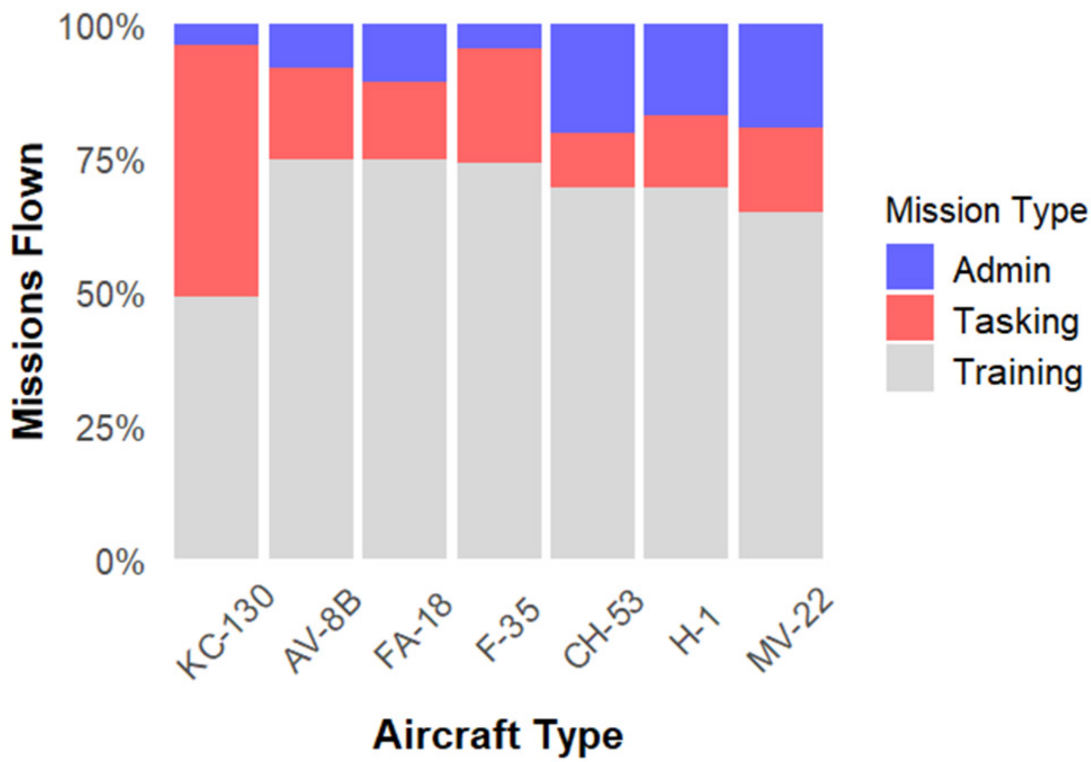


Figure 16. Mission Quality Breakdown by Aircraft. Adapted from USMC (2023).

Pilot qualification level plays a role in the quality of flights experienced. Figure 17 illustrates that while all three pilot qualification tiers experience roughly 15% Tasking, Tier 2 pilots sustain approximately 5% higher proportion of Admin Flights than Tier 1 or Tier 3 pilots. There are three possible explanations that could characterize this difference. Firstly, T&R limitations around certain types of training drive the most qualified pilots to teach the most junior pilots, leaving the Tier 2 pilots to perform Admin Flights in the interim. Alternatively, Tier 2 pilots may exhibit less quality than Tier 3 pilots and be more suited for Admin Flights. A third possible explanation could be personal taste and career trajectory—more senior qualifications come with increased responsibility and potentially more contractual obligation time. Tier 2 pilots may tend to prefer less tactical applications of flight and have more desire to pursue a career with the airlines, thus preferring Admin Flights to help build their flight hours toward the airline minimums.

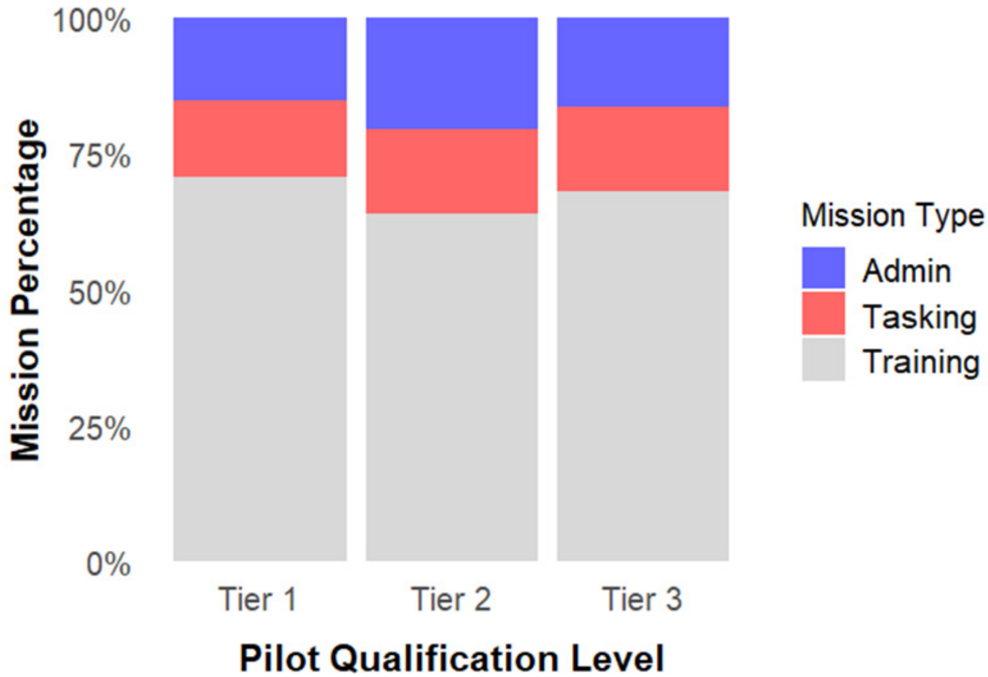


Figure 17. Pilot Qualifications in Relation to Flight Quality. Adapted from USMC (2023).

E. CONCLUSION

The data captured from M-SHARP and TFDW grants insight into the individual-level differences of the Marine pilot experience. While it is simple to look at the descriptive statistics and draw preliminary conclusions, the true correlations between flight hours and retention outcomes are nested within the relationships and interactions of these described variables. In the next chapter, I will perform a secondary analysis of this data to extract correlations and impacts across the population.

THIS PAGE INTENTIONALLY LEFT BLANK

V. METHODOLOGY AND RESULTS

A. APPROACH

In this study, I use four methods to find out what helps keep pilots in their jobs. Initially, I used an Ordinary Least Squares (OLS) regression to examine the relationship between several key factors, such as the average monthly flight hours and their impact. This step helped identify the elements that significantly affect flight time, which, in turn, could also play a role in a pilot's decision to stay or leave. It also highlighted which variables contribute most to variations in flight hours.

Next, I applied the significant factors identified through the OLS to a Linear Probability Model (LPM), akin to Williams's (2021) approach in examining the influence of duty station locations on retention rates. Through this LPM, I aimed to quantify the effects of flight hours (along with other critical factors) on pilots' retention, shedding light on the complex interplay of variables that inform a pilot's decision to continue or end their service.

For the third approach, I combined variable groups that the OLS identified as contributing to flight hours and plot their outcomes for pilots who separated and those who remained up to the eight-year mark. This method was used to reveal any oscillatory patterns, seasonality, or irregularities in the data that the OLS or LPM estimates might not catch.

Finally, I constructed a pre-event study to examine monthly flight time near the separation event window and the 14 months leading up to it. This approach would mirror patterns observed in variable graphs but would specifically focus on the month of separation rather than a fixed eight-year flying career mark. I used this template to compare the flight hour averages of separating pilots in the months leading up to their separation with a counterfactual group of retained pilots with comparable flying experience. The results produced by these four approaches would be drawn together to inform the discussion on the variation of flight hours across the Fleet and their impact on retention.

1. Ordinary Least Squares Design

The model employed predicts the average monthly total pilot time $\text{AvTPT}_{i,a,t}$ for pilot *i*, who flies aircraft *a* at duty station *t.* In the model, AvTPT depends on:

- $\boldsymbol{X}_i$—includes pilot-specific characteristics such as gender, dependent status, and race category, capturing the demographic diversity within the pilot population.

- $\mathbf{Y}_{i}$—represents variables related to the pilot's professional life and operational duties, including their winging year (marking the career stage), years of flying experience (reflecting proficiency), pilot qualifications (indicating skill level), and the nature of their flight duties (measured by the percentage of administrative and tasking flights), all of which are expected to influence the pilot's engagement and performance as measured by flight time.

- μ_a and δ_t are fixed effects for aircraft type and duty station, respectively, acknowledging that different aircraft and locations offer varied flying opportunities and challenges that can impact a pilot's flight time.

- $\varepsilon_{i,a,t}$—the error term, encapsulating unobserved factors that may affect the average monthly flight time for the unique combination of pilot, aircraft type, and duty station.

Such that:

$$\text{AvTPT}_{i,a,t} = \alpha \boldsymbol{X}_i + \beta \mathbf{Y}_i + \mu_a + \delta_t + \varepsilon_{i,a,t}$$

This assesses how individual characteristics, career progression (experience), and structural factors (aircraft type, pilot designation year, and duty station) influence a pilot's monthly flight time and can inform the discussion on target recipients for retention strategies.

2. Linear Probability Model (LPM) Design

This model examines the probability of separation, $\text{Separation}_{i,a,t,w}$ for pilot i, flying aircraft a, at duty station t, with experience w. In the model, Separation depends on:

- $\boldsymbol{X}_i$—encompasses demographic characteristics such as gender and race category, considering how these aspects might influence a pilot's likelihood of separation.

- $\mathbf{Y}_i$—represents the operational factors, including the normalized average monthly flight time, pilot qualifications, and the nature of flight duties as measured by the percentages of administrative and tasking flights, normalized for interpretability.

- μ_a and δ_t are fixed effects for aircraft type and duty station, respectively, acknowledging that different aircraft and locations offer varied flying opportunities and challenges that can impact a pilot's flight time.

- γ_w represents fixed effects for the year the pilot was designated, allowing the model to control for cohort-specific effects that could influence separation.

- $\varepsilon_{i,a,t,w}$—the error term, encapsulating unobserved factors that may affect the average monthly flight time for the unique combination of pilot, aircraft type, duty station, and cohort year.

Such that:

$$P(\text{Separation}_{i,a,t,w}) = \alpha\boldsymbol{X}_i + \beta\mathbf{Y}_i + \mu_a + \delta_t + \gamma_w + \varepsilon_{i,a,t,w}$$

This assesses how individual characteristics, career progression (experience), and structural factors (aircraft type, pilot designation year, and duty station) influence a pilot's decision to retain or separate from the Marine Corps. This regression does not account for influences external to the Marine Corps but rather focuses on the internal processes and looks to uncover their various impacts on pilots' retention decisions.

B. METHOD 1: VARIATION IN FLIGHT HOURS

To examine the variation of flight hours across the Fleet, I pared down the primary dataset to reflect specific cohorts I could observe homogeneously over time. The first step involved focusing exclusively on pilots who earned their 'wings' between 2017 and 2018, with their first flight occurring in 2018. This range allowed for a cross-section of pilots large enough to demonstrate meaningful variation while controlling for time-based influences, such as aircraft readiness levels, that might vary across larger cohort spans. Additionally, I monitored pilots across the same period of their careers to remove the impacts of increased rank on flight hour averages. The balance panel consisted of their first 42 consecutive months. Since the first set of flight orders is traditionally written for four years, I limited the number of months to 42 (3.5 years) to capture the first tour experience before a pilot moved on to a second set of orders. I did not consider pilots who departed the squadrons prior to the 42nd month.

The cohort was organized into three models for OLS regression comparison, detailed in Table 8, to estimate the average flight hours per month for pilots. To interpret the regression results, one begins with the constant value at the bottom of each model column, which denotes the baseline average flight hours per month for the reference group. Adjustments based on different pilot characteristics are made by applying the coefficients listed alongside each covariate on the left side of the table. These coefficients signify how much more or less, compared to the baseline, a pilot in each respective category is expected to fly. For example, an MV-22 pilot (the excluded aircraft type forming the reference constant) would be expected to have 10.85 flight hours per month in Model 1, whereas a KC-130 pilot would be expected to have an additional 9.43 hours per month, equating to a total of 20.28 hours per month.

Model 1 is the simplest model, accounting only for the aircraft type flown in the prediction of the outcome variable, but it describes 39% of the variation seen in monthly flight hour averages. Models 2 and 3 were given subsequent controls to sharpen the estimate, with Model 3 giving the best prediction based on the assumed covariates and their relationships with flight hours. From the coefficients calculated in Model 3, RW pilots (H-1s and CH-53s) tend to fly 2–3 flight hours a month more than MV-22 pilots, whereas FW jet pilots (AV-8s, F-35, FA-18s) tend to fly 0–2 hours per month less. KC-130 pilots have the strongest flight hour average, with an estimated six additional flight hours per month over that of MV-22s.

Regional duty stations appeared to have no effect on the monthly flight hour estimates. When duty station alone is regressed on monthly flight hours, pilots in Arizona show to have 2 hours per month less than pilots on the East Coast; however, the controls for aircraft type quickly absorb the level of impact (there are primarily FW jet squadrons in Arizona, and FW jets fly less than RW and TR). Once aircraft type and demographics are accounted for, as in Table 8, Arizona has a positive effect on monthly flight hours per pilot as compared to the East Coast, all other variables held constant.

Of the demographic controls used, having a dependent (either a child or spouse) appeared as the only covariate that had a significant impact on flight hour averages, though it was responsible for a difference of less than 1 hour per month. Conversely, individual qualification and quality of flight tended to be highly correlated with flight hour averages. Tier 3 pilots (the most qualified) tended to have three additional flight hours per month, as compared to Tier 1 pilots. Simultaneously, pilots who flew more flights with a Tasking mission were positively correlated with an additional flight hour per month.

The regression results from above, coupled with the findings shown in an unbalanced panel (Table 13) in the Appendix, describe the variation in flight hours across the Fleet. They ultimately indicate that aircraft type, qualification level, and years of experience drive the vast majority of the flight hour variation. Duty Station has little influence on average flight hours achieved. Therefore, from these results, it could be surmised that a pilot located in Japan would be no better or worse off than a pilot on the East Coast, *ceteris paribus*—holding all things equal—in flight hour averages across their first tour.

Table 8. 2017-2018 Cohort Balance Panel OLS Estimates. Adapted from USMC (2023).

	Average Flight Hours per Month		
	(1)	(2)	(3)
Aircraft Type (Reference: MV-22)			
AV-8	-0.73	-1.13	0.04
	(0.76)	(0.83)	(1.05)
CH-53	3.11***	3.07***	3.34***
	(0.43)	(0.44)	(0.41)
F-35	-1.18	-1.85*	-1.35
	(0.76)	(1.07)	(1.11)
FA-18	-0.87	-0.90	-0.69
	(0.89)	(0.90)	(0.99)
H-1	1.62***	1.68***	1.90***
	(0.38)	(0.40)	(0.38)
KC-130	9.43***	9.49***	5.82***
	(0.89)	(0.95)	(1.39)
Regional Duty Station (Reference: East Coast)			
Arizona		1.12	0.79
		(1.17)	(1.00)
Hawaii		0.30	-0.24
		(0.76)	(0.66)
Japan		-0.06	-0.50
		(0.73)	(0.64)
West Coast		-0.28	-0.42
		(0.37)	(0.32)
Demographics (Reference: White)			
Female		-0.44	-0.48
		(0.72)	(0.61)
Has Dependents		-0.76**	-0.88***
		(0.33)	(0.28)
Race: Declined to Respond		-0.08	-0.22
		(0.81)	(0.68)
Race: Minority		0.56	0.18
		(0.64)	(0.54)
Pilot Qualification Level (Reference: Tier 1)			
Tier 2 Pilot			0.39
			(0.32)
Tier 3 Pilot			3.23***
			(0.35)
For Each 10% of Flights that are Admin			-0.17
			(0.29)
For Each 10% of Flights that are Tasking			0.86***
			(0.27)
Constant	10.85***	11.01***	9.69***
	(0.26)	(0.76)	(1.08)
Population Mean	12.141	12.141	12.141
Observations	280	280	280
R^2	0.39	0.41	0.58
Note:	*p<0.1; **p<0.05; ***p<0.01		
	OLS. Data from 2018 to 2022. Standard errors in parentheses. All pilots began flying in 2018.		

C. METHOD 2: THE IMPACT OF FLIGHT HOURS ON SEPARATION

Addressing flight hour variation directly is manageable, but the core research question—how flight hours influence pilot retention—is more complex. To unravel this, I applied Methods 2 through 4 to better understand the complicated relationship between flight hours, flight quality, and retention. No single method would tell the complete story, but together, they more aptly describe the variable interactions at play.

The process began by developing a Linear Probability Model (LPM). In preparing the LPM, I refined our focus to pilots nearing their separation eligibility after their initial contract period (normally contracted at either six or eight years from winging). To ensure a clean analysis, I omitted Marines who left the service after 20 or more years, as their retirement-driven departures could distort our understanding of the factors at play. Consequently, I concentrated on pilots who began their careers between 2012 and 2015, aligning with our observation period from 2018 to 2022. This timeframe allowed us to capture those either completing their service agreements or becoming eligible for application for separation while excluding those nearing retirement. This methodical selection resulted in a dataset of 859 pilots, among whom approximately 162 chose to separate. Among those in this sample, the average separating pilot left six years after winging.

Table 9 illustrates the estimated relationships between covariates and the probability of separation with three models. Model 1 has the fewest number of covariates and shows flight hours to have no impact on the retention decision, but the estimate is noisy. Based on the projected standard error of 2.5, the confidence interval surrounding flight hours' impact stretches from -4 to +6 percentage points, indicating that the impact of flight hours could be negative, positive, or null on the decision to separate. As controls are added, however, flight hours begin to display a statistically significant impact in Model 3, indicating that a pilot is 7.2 percentage points more likely to separate for each additional ten monthly flight hours flown. If this relationship holds, the top 25% of all flyers (as measured by monthly flight hour averages) would be 5.5 percentage points more likely to separate than the bottom 25%, based on the interquartile range.

Table 9. Cohorts 2012–2015 Probability of Separation. Adapted from USMC (2023).

	Probability of Separation		
	(1)	(2)	(3)
Flight Time			
Each Additional 10 Flight Hours per Month	0.81	0.87	7.20***
	(2.52)	(2.53)	(2.70)
Aircraft Type (Reference: MV-22)			
AV-8	-8.24	-8.57	-12.15*
	(6.18)	(6.28)	(6.57)
CH-53	-3.84	-4.29	-5.35
	(4.13)	(4.17)	(4.14)
F-35	-14.65**	-17.11**	-15.73**
	(6.71)	(7.43)	(7.68)
FA-18	-4.67	-4.17	-7.13
	(6.16)	(6.22)	(6.26)
H-1	-8.72**	-9.36**	-10.97***
	(3.63)	(3.81)	(3.75)
KC-130	-4.40	-2.65	-8.82
	(4.99)	(5.11)	(6.35)
Pilot Designation Year (Reference: Winging 2012)			
Winging 2013	-4.61	-4.71	-7.16*
	(4.00)	(4.00)	(3.93)
Winging 2014	-2.63	-3.08	-5.46
	(3.92)	(3.91)	(3.84)
Winging 2015	-8.75**	-8.52**	-12.92***
	(3.95)	(3.96)	(3.94)
Regional Duty Station (Reference: East Coast)			
Arizona		9.48	9.44
		(8.05)	(7.90)
Hawaii		-2.19	-3.10
		(6.87)	(6.70)
Japan		-5.18	-5.46
		(5.44)	(5.32)
West Coast		1.54	0.71
		(3.02)	(2.96)
Demographics (Reference: Male/White)			
Female		14.89**	15.77**
		(6.80)	(6.64)
Race:Declined to Respond		-0.40	-0.55
		(5.13)	(5.02)
Race: Minority		12.82**	12.47**
		(5.83)	(5.69)
Pilot Qualification Level (Reference: Tier 1 Pilot)			
Tier 2 Pilot			-12.74***
			(3.63)
Tier 3 Pilot			-23.77***
			(3.69)
Quality of Flight (Reference:Training Flights)			
Each Additional 10% Admin Flights			0.29
			(1.28)
Each Additional 10% Tasking Flights			-0.45
			(1.19)
Constant	27.12***	25.49***	36.57***
	(4.62)	(4.94)	(6.32)
Population Mean	18.859	18.859	18.859
Observations	859	859	859
R^2	0.02	0.03	0.08

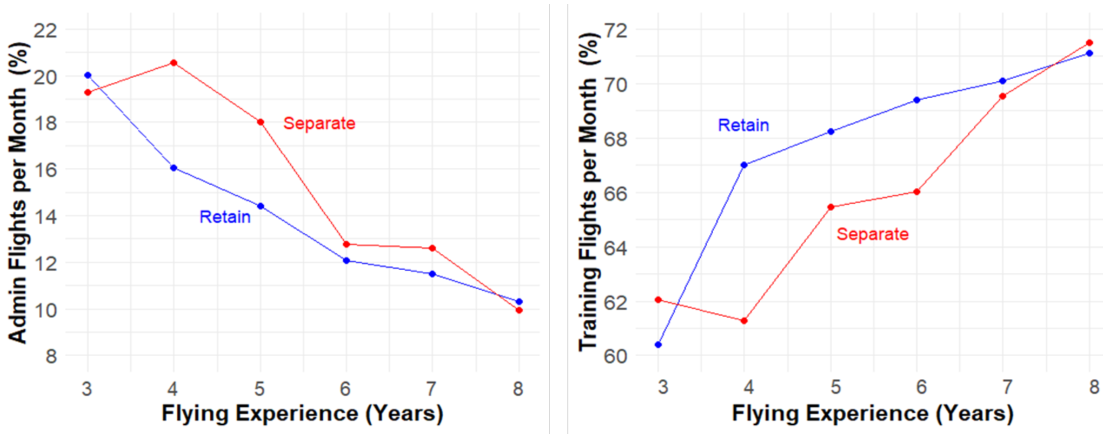
Note: *p<0.1; **p<0.05; ***p<0.01
Linear Probability Model. Data from 2018 to 2022. Standard errors in parentheses. Coefficients represent percentage point differences.

Other notable relationships are found within this regression. The MV-22 community appears to be more likely to attrite than any other aircraft type. This can be viewed by the negative coefficients on all other aircraft in comparison to the MV-22 reference group. While they are not all individually statistically significant, they bear joint significance via examination in an F-test, indicating that aircraft type is likely a contributing factor in retention outcomes. This could also indicate that the retention decision may not be the same across all aircraft types. Marine pilots have vastly different experiences across each of the aircraft platforms, they have different post-service opportunities based on the quantity and quality of their flight hours, and they possibly have different propensities toward military service, driving them to select their respective communities in the first place. The data also reveals that pilots that winged in 2015 were 13 percentage points more likely to remain in the Marine Corps than pilots from the cohort of 2012. This, however, could be indicative that either they had less time in observation to attrite than the classes of 2012, or COVID had a larger impact on their cohort when they neared the end of their first contract.

Demographically, females were 16 percentage points more likely to separate than their male counterparts. However, one difficulty in interpreting this is that dependent status could not be controlled for in the regression. Because the raw data did not indicate when a dependent was gained, and person-level fixed effects could not be employed, a binary indicator for dependent status might skew outcomes as Marines in 2012 might have more time to accumulate dependents than Marines in 2015, considering the observation window cuts off at the end of 2022. As dependents can be representative of a spouse or a child, the heavy weight on females’ likelihood to separate might be partially explained by the relationship unseen between females and children.

Commensurate with Griffin (2018), highly qualified Marines tended to be much more likely to opt toward retention than separation. Tier 3 pilots, which includes the WTIs that Griffin (2018) controls for, were 24 percentage points more likely to be retained than Tier 1 pilots. This does not necessarily indicate a causal relationship, however. Squadrons are required to maintain fixed minimums of qualified personnel, so the pursuit of qualifications is not consistent with a measure of quality, though it can be indicative of it. Squadrons rationally push the highest-quality pilots toward higher qualifications; however, if a pilot decides early that they want the flexibility to leave the Marine Corps following their first contract and want to avoid further contractual obligations, they will opt out of qualification progression and a runner-up will be selected in their place. Additionally, selection to attend higher levels of qualification is based on performance relative to peers, not a quantifiable baseline metric. Thus, there are two possible causal explanations. It is possible that high-quality Marines get qualified and choose to stay in the Marines—the experience of getting qualified bolsters and shapes retention, as suggested by Giffin (2018). Conversely, it is also plausible to say that Marines with the intention to stay get chosen to get qualified—the decision to remain in service shapes qualification.

The LPM indicates that quality of flight has no real impact on retention outcomes, but this is primarily explained through the relationship between quality of flight and qualification level. When the qualification level is removed from the regression, Admin flights have a significant negative correlation with retention. For each additional 10% of missions flown under the Admin bin, a pilot was as much as four percentage points more likely to separate than retain. Training proportions had the opposite effect, showing that for each additional 10% of missions flown under the Training bin, a pilot was as much as two percentage points more likely to retain. Figure 18 shows the inverse relationship of the Admin and Training flights between pilots that retained and separated within the cohort span.



Admin proportion of flights flown (left); training proportion of flights flown (right)

Figure 18. Missions Flown by Cohorts 2012–2015. Adapted from USMC (2023).

Figure 18 suggests that pilots that separate fly as many as five percentage points more Admin flights and six percentage points fewer Training flights than retained pilots. However, pilots of varying qualifications are more likely to fly certain missions. Referencing Figure 17, pilots of lower qualification are more likely to fly Admin flights, and lower qualification levels are more highly correlated with separation. Figure 19 shows that separating pilots proportionately had a lower qualification average than retained pilots, which acts as a possible explanation for why the quality of flight varies between the two groups shown in Figure 18. Figure 19 shows that more than 50% of all pilots retained were qualified at the Tier 3 level, whereas fewer than 30% of separated pilots held the same qualification status.

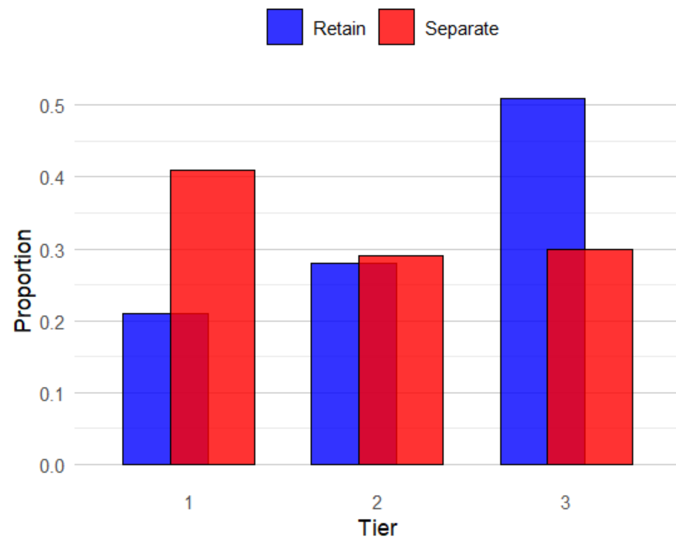


Figure 19. 2012-2015 Cohort Qualification Proportions. Adapted from USMC (2023).

D. METHOD 3: FLIGHT HOURS OVER TIME

The LPM used to address the relationship between flight hour averages and retention outcomes relies on a linear relationship between the two, but they may not have a linear relationship based on the U-shaped curve of flight hours over time. More fidelity is required on the timing of flight hours, qualifications, and retention decisions to better understand their relationships.

Referencing back to Figure 4 in Chapter II, flight hours are closely tied to a pilot's career progression. The illustration provided was normative in nature, describing how the Air Wing traditionally operates. Using pilot winging dates to create the curve shown in Figure 20, the monthly averages over a career emerge and positively mimic the career flight hour shape seen in Figure 4. While the curve shown in Figure 20 has been smoothed for display using a Locally Estimated Scatterplot Smoothing (LOESS) method, the overall plot matches the expected shape and curvature described in Figure 4. The data shows that pilots begin with few monthly flight hours while unqualified before proceeding towards a career maximum between 3–6 years of flying experience. After this point, their monthly averages decrease as a function of their advanced rank and increased job responsibilities outside of the aircraft.

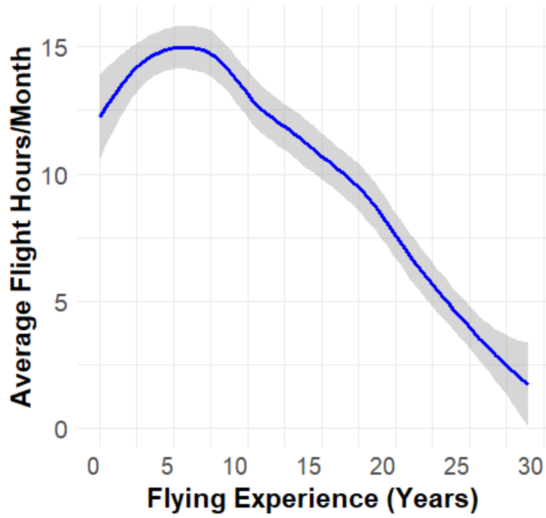
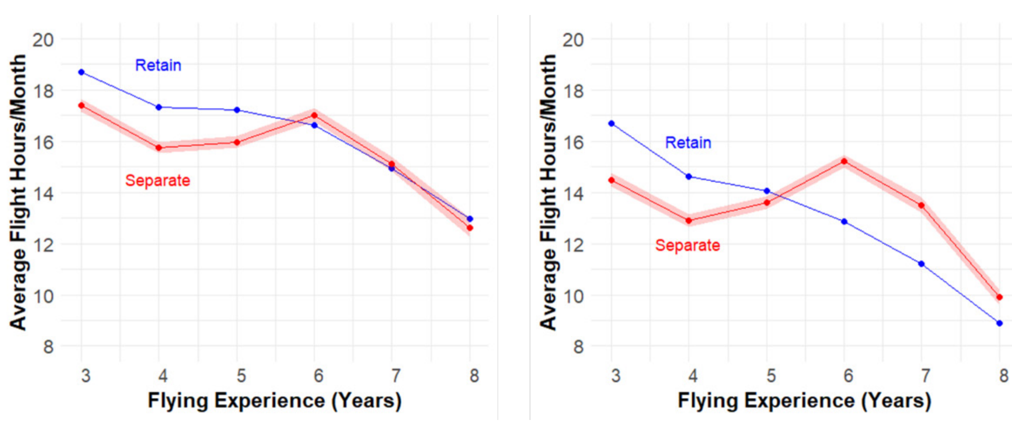


Figure 20. Pilot Experience Over a Career. Adapted from USMC (2023).

Replicating the methodology used in the LPM, the cohorts of 2012–2015 were pulled out for further analysis and plotted first by monthly averages in Figure 21 (left) (accounting only for months a pilot actually flew) and then second by monthly averages with interpolated zeroes in Figure 21 (right) (assigning a value of '0' to all interim months with no associated flight time).



Monthly flight hours (left); interpolated monthly flight hours (right)

Figure 21. Flying Averages from Cohorts 2012–2015.
Adapted from USMC (2023).

In Figure 21, The blue lines indicate pilots who chose to stay beyond their initial contract while the red lines illustrate the flight hour averages of those that elected to separate. The lightly shaded region around the red line represents the confidence interval based on the calculated standard error. Both calculation methods showed that pilots who separated had fewer average flight hours during the first portion of their career (corresponding to their first set of orders) than pilots who chose to retain. However, during the second tour of flying (years 4–7), separating pilots reached a commensurate flight hour average to retained pilots. Note in Figure 21 (right) that pilots who opted to separate climb well above retained pilots in average flight hours during the second tour. These graphs together show that the second tour rift is not caused by separators flying more, but by retained pilots flying less. Zooming in on the pilots with interpolated zero-months, 48% of retained pilots had two or more consecutive months of zero flight hours (indicating that they have temporarily left flying, most likely for a non-flying job), whereas only 38% of separating pilots displayed this characteristic. Figure 22 further draws out this relationship, showing that separating pilots spent as much as 90% of their time in a flying capacity by year 7, in contrast to retained pilots who spent 75% of their time flying at the same point in their career.

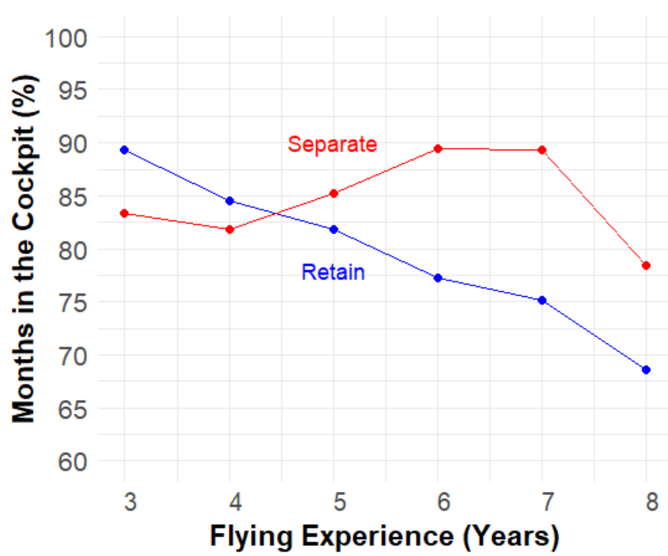
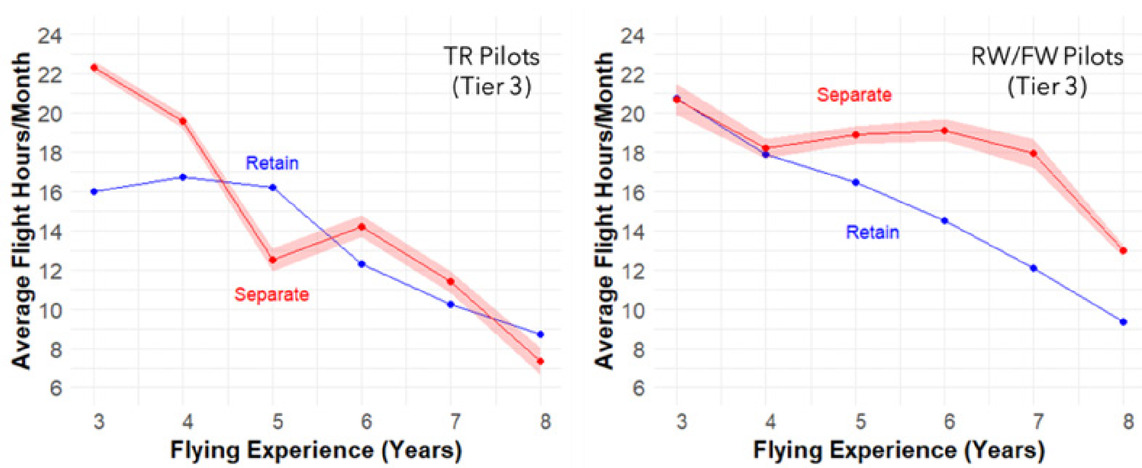


Figure 22. Months Spent in a Flying Capacity.
Adapted from USMC (2023).

This disproportionality in pilots temporarily leaving a flying role explains the gap in flight hours seen in Figure 21 (right)—separating pilots are continuing to fly longer into their career than non-separating pilots. The results from the LPM suggest that aircraft type might play a vital role in separating outcomes—but would I see the same here? When the individual aircraft are extracted in this analysis, there is one anomaly: TR pilots (MV-22s) exhibit different behavior than RW and FW pilots. TR pilots that separate tend to have an average of 2 more flight hours per month than retained pilots during their first tour. This starkly contrasts with the aggregate experience described above. When an additional qualification constraint is applied to look at only the Tier 3 pilots, the distinction is even greater. Figure 23 (left) shows Tier 3 TR pilots, while Figure 23 (right) looks at Tier 3 pilots who fly all other aircraft.



TR Pilots of Tier 3 Qualification (left); FW/RW Pilots of Tier 3 Qualification (right)

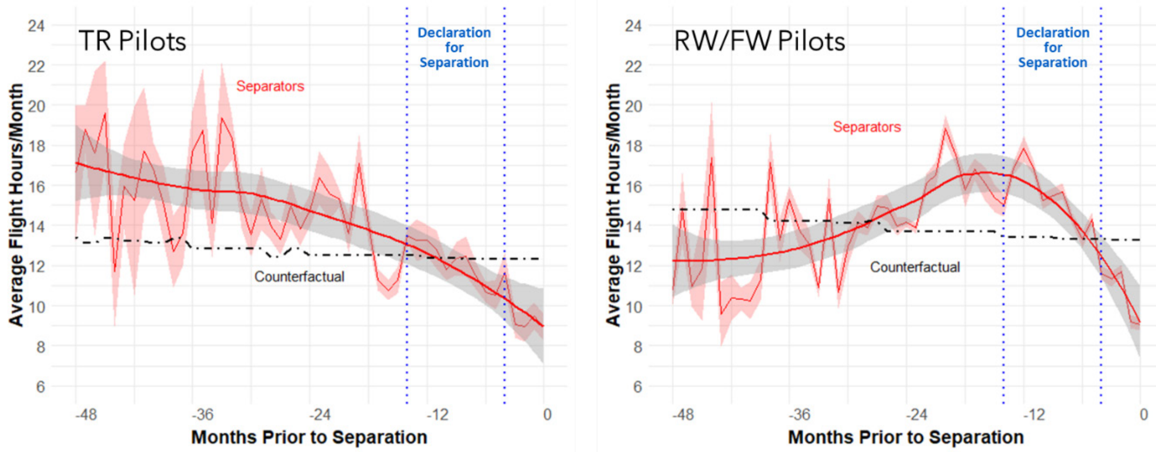
Figure 23. Highly Qualified Pilot Monthly Flight Averages.
Adapted from USMC (2023).

TR Pilots of Tier 3 qualification who chose to separate have a significantly larger monthly flight hour average than retained pilots. Meanwhile, Figure 23 (right) shows that there is no perceptible difference between highly qualified first-tour pilots that separate and retain across the rest of the Fleet.

E. METHOD 4: SEPARATION PRE-EVENT STUDY

The previous analysis aimed to understand flight hours by looking at different stages in a pilot's career without directly linking these hours to the decision to leave. However, it failed to account for how the varying lengths of pilot contracts (six or eight years) and the distribution of these contracts within the sample could affect the data's pattern. Additionally, the potential influence of the separation application process on these patterns was not considered. To address these issues, I developed a new method in the form of a pre-event study. This approach overlooks the specific durations of pilot contracts, focusing instead on changes in flight hour averages in the 48 months leading up to a pilot's decision to leave. It compares these averages against those of pilots who decide to stay, ensuring each comparison is between pilots with similar flight experiences at each time point. The same cross-section of data from Method 3 was applied, looking at the monthly flight data of the winging cohorts of 2012–2015 while interpolating all interim months not in observation as a value of zero.

Just as in the previous approaches taken, TR pilots stood out from their RW and FW brethren. Figure 24 illustrates the comparison, breaking out TR aircraft in Figure 24 (left) and the remaining FW and RW aircraft in Figure 24 (right). Separating pilots, the associated standard errors, and a LOESS smoothing line are indicated in red, whereas the counterfactual—retained pilots with equivalent experience—are plotted in black. Marine Corps policy requires that Marines apply for separation no earlier than 14 months and no later than four months prior to the desired separation date (HQMC, 2019a). This application for separation window is depicted in blue, with an expectation that pilots with earlier intention for separation will congregate at the 14-month mark, and a flight hour differential might be visible. Once a Marine is slated to leave service, squadron investment in the form of qualifications and flight hours naturally might decrease if there are other pilots vying for the flight time and have the intention to remain.



TR Pilots (left); FW/RW Pilots (right)

Figure 24. Pre-Event Study on Separating Pilots. Adapted from USMC (2023).

In Figure 24 (left), TR pilots planning to leave showed higher average flight hours compared to their peers until they started the separation process. In contrast, Figure 24 (right) shows a different pattern for the rest of Marine Corps Aviation pilots, who flew fewer hours on average until just before receiving their final orders, at which point their hours exceeded those of their peers. These results reinforce the previous findings and discussion that the motivations behind pilot retention across the Fleet may vary significantly by T/M/S. Moreover, these findings imply that the process of deciding to separate from service is linked with specific patterns in flight hours. Specifically, TR pilots who decide to separate have a decreasing average until the point of intersection with the counterfactual average in the vicinity of the 14-month mark. For RW and FW pilots, the 14-month mark represents a local maximum, after which their monthly hours begin to decrease rapidly.

F. DISCUSSION

Thus far, numerous relationships have been described regarding the possible interactions of flight hours and separation. From the data, it is apparent that competing trends are present across different flying communities. Qualitatively, MV-22s and CH-53s are the most similar communities. They are both dual-piloted platforms, they perform similar missions, and they have comparable squadron sizes with a similar complement of assigned aircraft. Table 10 confirms their likeness by comparing the pilot compositions of the cohorts of 2012–2015. The sample data illustrates that there is nothing in their constituency that would indicate their retention patterns would radically differ. However, the outcomes examined thus far indicate there are unseen factors that are dramatically influencing the decision to retain or separate from the Marine Corps, and those factors may influence MV-22 pilots differently.

Table 10. 2012-2015 Cohort Breakdown. Adapted from USMC (2023).

	MV-22	CH-53	H-1	AV-8	FA-18	F-35	KC-130
	TR	RW		FW			
Demographics							
White	83%	87%	88%	92%	88%	93%	87%
Ethnic Minority	8%	4%	5%	4%	4%	2%	6%
Declined to Respond	9%	9%	6%	4%	8%	5%	8%
Dependent Status							
Has Dependents	79%	74%	72%	84%	88%	88%	82%
No Dependents	21%	26%	28%	16%	12%	12%	18%
Pilot Qualification Level							
Tier 1	21%	23%	22%	27%	36%	17%	45%
Tier 2	28%	28%	26%	51%	32%	42%	19%
Tier 3	52%	49%	53%	22%	32%	42%	36%
Duty Station							
East Coast	41%	45%	30%	63%	48%	27%	43%
West Coast	35%	45%	67%	29%	38%	17%	29%
Japan	11%	2%	1%	0%	8%	15%	29%
Hawaii	12%	7%	0%	0%	0%	0%	0%
Arizona	2%	1%	1%	8%	6%	42%	0%
Missions Flown							
Percent Admin	20%	25%	20%	6%	10%	4%	4%
Percent Tasking	16%	11%	13%	19%	16%	22%	46%
Percent Training	64%	65%	68%	76%	74%	74%	50%

Should the characteristics of separating and retaining pilots' career flight hours truly be different, it should follow that the treatment may need to be different as well to address the key motivations for separation. Assessing the data evaluated in this study, two viable explanations emerge: burnout and marketability.

1. Burnout

The first way to interpret the data would be qualitatively through burnout. Pilots who log more flight hours are likely to experience fatigue and burnout more intensely. All Marine pilots maintain jobs outside of the aircraft, even while in the performance of flying duties. Pilots with greater flight hour averages can be viewed as physically working more hours each month. With this interpretation in mind, TR pilots who fly frequently early in their careers may reach burnout quicker and elect to separate. An expansion on this interpretation might suggest that there are fewer opportunities for second-tour flying, yet pilots who continue to fly are experiencing higher levels of burnout and choose to exit service—the pattern seen with RW and FW communities.

Through this interpretation, however, the effects of burnout prove difficult to measure and compare across aircraft types. Flight hours act as a proxy for other variables unseen. With each individual aircraft community experiencing different quantities of flight hours, deployment cycles, and community-specific demands, the sensitivity to flight hour variations may vary in its contribution to burnout. Aircraft community culture, individual command climates, ground jobs held, and resources available to each community would need further study to fully understand the impacts and contributors of burnout. For Marines that fall into this category, organizational change would be required to address their primary qualms and alleviate their desires to seek alternate employment opportunities.

2. Increased Marketability

Pilots of high quality and greater quantities of flight hours may have more opportunities outside of the Marine Corps and, therefore, find it easier to separate. In this scenario, the more money the Marine Corps invests in a pilot, the more valuable they are to civilian markets. Plainly spoken, the Marine Corps is financing the qualification of its personnel out of a job. For TR pilots, the more highly flown pilots are separating at greater rates than the counterfactual. Flight hours are correlated with qualifications, and qualifications are assumed to be positively correlated with quality (though not measured in this data). Through this lens, it could be argued that, on average, the TR community is losing its higher-quality pilots. Conversely, the remaining pilots that chose to retain, and later become highly qualified, had lower monthly averages earlier in their careers and were not their squadrons' primary bids for success. In an opposite fashion, the RW and FW communities appear to be separating pilots that fly below the counterfactual. Under the same logic, this would indicate that these communities, on average, are retaining the most qualified and highest quality pilots.

Pilot proficiency is not only a measure of skill but also a key to marketability in robust external hiring markets. Given the stringent requirements for an Unrestricted Airline Transport Pilot (ATP) license, which mandates a minimum of 1,500 flight hours, pilots are inherently motivated to accumulate as much flight time as possible during their service. This drive is further amplified by the significant monetary value of flight hours in the civilian sector, where multi-engine time can cost approximately $400 per hour (FlyLegacy, 2022). For example, a pilot completing their first tour with 800 flight hours faces the challenge of covering an estimated $280,000 to gain the additional hours required for an unrestricted ATP license if they move to a non-flying position. An alternative path exists through a restricted ATP, available at 750 hours for military pilots. However, it requires flying with a regional airline at a significantly reduced salary compared to major airlines to build the requisite flight time toward an unrestricted ATP (AOPA, n.d.). This scenario underscores the rational inclination for Marine pilots, especially those eyeing a future in commercial aviation, to maximize their in-service flight hours when such opportunities are at no direct cost to them.

Marines whose decision to separate is primarily influenced by their marketability receive the most attention through aviation incentive bonuses. These bonuses aim to entice Marines who are on the fence, finding their life in the Corps sufficiently satisfactory and the prospect of seeking alternative employment sufficiently daunting, to commit to additional service time in exchange for financial compensation. However, Marines who are determined to leave and are primarily motivated by economic gain may not be as inclined to accept these bonuses.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY OF FINDINGS

- Variation in flight hours belongs chiefly to aircraft type, qualification level, and years of experience. Duty stations and demographics have little impact on the number of flight hours received.
- Flight hours have an inverted U-shape over the course of a career, with an inflection point between 3–6 years of flying (corresponding with the end of the first set of orders).
- The LPM suggests that for each additional 10 flight hours per month, a pilot is 7.2 percentage points more likely to separate. However, based on the unbalanced panel of pilots and limited observation window in this this study, the coefficient estimate could be refined if a larger sample of pilots were to be studied. Running the LPM again on a balanced panel of pilots with known separation outcomes may yield different results than the cross-tour approach employed here.
- The plots of various groups' flight hours over time coupled with their retention outcomes indicate that the career timing of the hours flown may have more impact on retention outcomes than the career-average monthly flight hours. For RW and FW aircraft, separating pilots tend to fly fewer hours earlier in their career than retained pilots, yet more towards the end. TR pilots act as the exception with more flight time early on in their career, and a steady decline until separation.
- Separating pilots tend to fly more administrative flights and fewer training flights as a proportion of their monthly flight experiences. This is likely explained through the distribution of qualifications, and therefore has no significant impact on retention outcomes.

- There are multiple competing explanations that can be tied to the data. While no single one can fully encapsulate pilots' motivations to retain or separate, a combination of the suggested narratives is likely at play.

B. RECOMMENDATIONS FOR POLICY AND FUTURE STUDY

The Linear Probability Model (LPM) suggests that merely increasing flight hours may not significantly influence retention decisions among pilots; in fact, additional flight hours could potentially enhance their marketability, making them more inclined to pursue opportunities outside the Marine Corps. The small magnitude of monthly flight hours averages on the retention decision implies that pilots' decisions to stay or leave are influenced by a broader spectrum of their Marine Corps experience, with flight hours playing only a minor role at the current level of sensitivity.

While Williams (2021) noted that duty stations impacted retention outcomes, I could not replicate that conclusion with the data on-hand in this study. Both models used duty stations, but without person-level fixed effects to garnish the impacts of changing duty stations over a career, the true impact cannot be fully uncovered. In this study, I could only measure the impact of a pilot's final observable duty station, and I found that the final duty station had no significant impact on pilots' retention decisions.

The chief finding of this study is that the relationship between flight hours and pilot separation differs significantly for TR pilots compared to RW and FW pilots. Regardless of the incentive or program pursued to address the adversary of pilot retention, a tailored approach to specific communities might have favorable impacts to address the underlying motivations displayed here rather than a singular overarching incentive policy. Aviation bonuses are routinely offered in different amounts and for different contract durations for each T/M/S, but future non-monetary incentives may need to be slightly more diverse in their approach to capture the hidden differences illustrated.

Given the fixed nature of annual flight hours and training opportunities, a more strategic approach might involve timing aviation bonus offerings to coincide with milestones in pilot progression rather than at the juncture of separation eligibility. It is possible that pilots often make their decision to separate well before their eligibility window opens. Proactively identifying and incentivizing pilots who demonstrate a commitment to continued service in the Marine Corps, customized to their specific aircraft T&R progression, could foster a more targeted investment in those most likely to contribute to the Corps' aviation mission over the long term.

While monetary incentives will retain some pilots, they do not necessarily ensure the retention of the most qualified or highest-quality pilots. By recognizing burnout as a possible contributor to pilot retention outcomes, an expanded group of pilots can be targeted for retention. Implementing measures such as reallocating high-stress, non-flying duties to non-pilots or contractors could alleviate some of the operational burdens on pilots and allow them to focus their responsibilities more squarely on flying. This could open the door for high-quality pilots whose chief motivation isn't monetary gain to remain in the Corps. Although this approach would entail additional costs due to an increase in personnel within Squadrons, the investment in retaining highly skilled pilots—who primarily desire to fly—could offset these expenses by reducing the need for continuous pilot training and recruitment.

This study's scope was necessarily limited to specific cohorts and a finite observation period of pilot careers. To confirm the observations made here and to refine the understanding of factors affecting pilot retention, further research encompassing a wider dataset and extending over a more prolonged period is highly recommended. Such investigations could provide more definitive insights into effective retention strategies, benefiting both the Marine Corps and its aviators.

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX. ADDITIONAL REGRESSION RESULTS

Table 11. Standardized OLS—Balance Panel 2018 Cohort. Adapted from USMC (2023).

	Average Flight Hours per Month		
	(1)	(2)	(3)
TMSAV-8	-0.73	-1.13	0.04
	(0.76)	(0.83)	(1.05)
TMSCH-53	3.11***	3.07***	3.34***
	(0.43)	(0.44)	(0.41)
TMSF-35	-1.18	-1.85*	-1.35
	(0.76)	(1.07)	(1.11)
TMSFA-18	-0.87	-0.90	-0.69
	(0.89)	(0.90)	(0.99)
TMSH-1	1.62***	1.68***	1.90***
	(0.38)	(0.40)	(0.38)
TMSKC-130	9.43***	9.49***	5.82***
	(0.89)	(0.95)	(1.39)
Duty_StationArizona		1.12	0.79
		(1.17)	(1.00)
Duty_StationHawaii		0.30	-0.24
		(0.76)	(0.66)
Duty_StationJapan		-0.06	-0.50
		(0.73)	(0.64)
Duty_StationWest Coast		-0.28	-0.42
		(0.37)	(0.32)
GenderF		-0.44	-0.48
		(0.72)	(0.61)
Dependents		-0.76**	-0.88***
		(0.33)	(0.28)
factor(Race_Category)Declined to Respond		-0.56	-0.18
		(0.64)	(0.54)
factor(Race_Category)Ethnic Minority		-0.63	-0.39
		(0.55)	(0.46)
factor(PilotQual)2			0.39
			(0.32)
factor(PilotQual)3			3.23***
			(0.35)
PercentAdmin_std			-0.14
			(0.24)
PercentTasking_std			0.90***
			(0.29)
Constant	10.85***	11.56***	10.83***
	(0.26)	(0.44)	(0.42)
Population Mean	12.141	12.141	12.141
Observations	280	280	280
R^2	0.39	0.41	0.58
Note:	*p<0.1; **p<0.05; ***p<0.01		
	OLS. Data from 2018 to 2022. Standard errors in parentheses. All pilots began flying in 2018. Continuous variables are standardized.		

Table 12. 2012-22 Cohort Unbalanced Panel OLS Estimates. Adapted from USMC (2023).

2012+ Unbalanced Panel OLS Estimates

	Average Flight Hours per Month		
	(1)	(2)	(3)
WingingYear2013	-0.29	-0.08	-0.15
	(0.35)	(0.33)	(0.30)
WingingYear2014	0.83**	0.20	-0.36
	(0.36)	(0.33)	(0.31)
WingingYear2015	-0.51	-0.69**	-0.91***
	(0.37)	(0.34)	(0.31)
WingingYear2016	-0.94**	-0.67*	-1.01***
	(0.37)	(0.35)	(0.32)
WingingYear2017	-1.23***	-1.19***	-1.43***
	(0.39)	(0.36)	(0.33)
WingingYear2018	-1.79***	-1.92***	-1.41***
	(0.40)	(0.38)	(0.35)
WingingYear2019	-2.31***	-2.59***	-1.44***
	(0.42)	(0.39)	(0.37)
WingingYear2020	-2.36***	-2.59***	-1.21***
	(0.44)	(0.41)	(0.39)
WingingYear2021	-3.22***	-3.46***	-2.00***
	(0.50)	(0.47)	(0.44)
WingingYear2022	-3.48***	-2.95***	-1.54**
	(0.83)	(0.78)	(0.71)
YearsFlying1	3.23***	3.36***	2.46***
	(0.25)	(0.24)	(0.22)
YearsFlying2	4.85***	5.01***	3.75***
	(0.26)	(0.25)	(0.23)
YearsFlying3	4.91***	5.09***	4.01***
	(0.28)	(0.26)	(0.24)
YearsFlying4	3.73***	3.99***	2.96***
	(0.31)	(0.29)	(0.26)
YearsFlying5	3.57***	3.72***	2.49***
	(0.34)	(0.32)	(0.29)
YearsFlying6	2.24***	2.35***	1.05***
	(0.38)	(0.36)	(0.33)
YearsFlying7	0.81*	0.76*	-0.41
	(0.43)	(0.40)	(0.37)
YearsFlying8	-1.12**	-1.17**	-2.64***
	(0.51)	(0.48)	(0.44)
YearsFlying9	-1.67***	-1.64***	-3.95***
	(0.61)	(0.57)	(0.52)
YearsFlying10	-0.97	-0.86	-3.97***
	(0.82)	(0.77)	(0.69)
GenderF	-0.35	-0.82***	-0.53**
	(0.31)	(0.30)	(0.27)
Dependents		-0.31**	-0.39***
		(0.14)	(0.13)
factor(Race_Category)Declined to Respond		-0.72**	-0.31
		(0.29)	(0.26)
factor(Race_Category)Ethnic Minority		-0.44*	-0.30
		(0.23)	(0.21)
TMSAV-8		-0.61**	-0.36
		(0.30)	(0.29)
TMSCH-53		1.47***	1.82***
		(0.19)	(0.17)
TMSF-35		-2.02***	-2.42***
		(0.27)	(0.30)
TMSFA-18		-2.61***	-2.47***
		(0.30)	(0.28)
TMSH-1		2.32***	2.07***
		(0.16)	(0.15)
TMSKC-130		6.92***	4.04***
		(0.24)	(0.26)
Duty_StationArizona			0.42
			(0.36)
Duty_StationHawaii			-0.64**
			(0.28)
Duty_StationJapan			0.26
			(0.23)
Duty_StationWest Coast			0.50***
			(0.13)
factor(PilotQual)2			0.80***
			(0.17)
factor(PilotQual)3			4.01***
			(0.16)
I(PercentAdmin/10)			-0.40***
			(0.04)
I(PercentTasking/10)			0.99***
			(0.04)
Constant	10.68***	9.76***	8.53***
	(0.42)	(0.42)	(0.41)
Population Mean	12.482	12.482	12.482
Observations	9,776	9,776	9,618
R^2	0.10	0.21	0.35

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$
OLS. Data from 2018 to 2022. Standard errors in parentheses. Reference data is based on a White Male of Tier 1 qualification who flies MV-22s out of the East Coast and became a Winged Pilot in the year 2012.

Table 13. 2012-2015 Logit Model Separation Estimates. Adapted from USMC (2023).

	Model 1	Model 2	Model 3
AvTPT.mo	0.08	0.09	0.71
PILOT_DESIGNATION_EFFECT_DATE2013	-4.69	-4.75	-7.22
PILOT_DESIGNATION_EFFECT_DATE2014	-2.71	-3.13	-5.58
PILOT_DESIGNATION_EFFECT_DATE2015	-8.73	-8.56	-12.91
TMSAV-8	-8.22	-8.67	-12.83
TMSCH-53	-3.89	-4.34	-5.55
TMSF-35	-14.54	-16.54	-18.31
TMSFA-18	-4.74	-4.33	-8.40
TMSH-1	-8.82	-9.38	-11.23
TMSKC-130	-4.55	-2.69	-8.94
Duty_StationArizona		11.92	14.23
Duty_StationHawaii		-2.01	-2.41
Duty_StationJapan		-4.89	-4.45
Duty_StationWest Coast		1.61	1.25
GenderF		14.15	14.54
Race_CategoryDeclined to Respond		-0.41	-0.89
Race_CategoryEthnic Minority		12.74	12.72
PercentAdmin			0.01
PercentTasking			-0.07
PilotQual2			-13.34
PilotQual3			-24.31

Logit Model with average marginal effects. Data from 2018 to 2022.
Coefficients represent percentage point differences against reference variables.
REF:[Winging 2012, MV-22, East Coast, Male, White, PercentTraining, PilotQual 1]

Table 11 represents the same regression seen in Table 8, but with normalized coefficients for continuous variables. This approach was aimed at standardizing the variables to such the coefficients of the continuous and discreet variables could be more readily compared for their impact on the outcome variable—average flight time per month. For all discreet variables, the coefficients can be interpreted as they are read; compared to an MV-22 pilot, a CH-53 pilot would be expected to fly 3.34 more flight hours per month. The coefficients tied to a variable such as PercentTasking_std, however, are to be read differently. The coefficient value on PercentTasking_std indicates that a pilot would receive 0.9 additional flight hours per month for each standard deviation of percentage-flights-flown that are in the Tasking mission set. The results seen here mimic the results seen in Table 8, showing that qualification level and aircraft type are most influential in the flight hours variations seen across the 2018 cohort.

Table 12 represents an unbalanced panel of pilots with inputs from the cohorts of 2012 through 2022. This regression was used to monitor the greater effect of the covariables in use across a larger population for estimation of monthly flight time but has the key control addition of years of experience and winging year. While there are 2,536 unique pilots in observation, the annual records are used to capture changes over time in each pilot's career, prompting the nearly 10,000 observations noted in the regression. From this data, years of experience joins the aircraft type and qualification level in describing most of the variation in flight hours.

Table 13 represents a logistic regression model run in tandem with the linear probability model seen in Table 9. The Logit Model found similar outcomes to the LPM, estimating a slightly larger (more negative) effect for F-35 toward separation, and a slightly larger (more positive) effect belonging to Arizona. These findings indicate that F-35 pilots might be slightly more likely to retain, and Arizona may be slightly more contributory to separation than described by the LPM. However, all coefficient signs are equivalent across the two models and all remaining coefficient magnitudes are commensurate.

LIST OF REFERENCES

2D Marine Aircraft Wing. (2023). *Standard Operating Procedures for Flight Operations* (WgO 3710.38E). United States Marine Corps.

AOPA. (n.d.). *Airline Transport Pilot*. Retrieved February 13, 2024, from https://www.aopa.org/training-and-safety/learn-to-fly/flying-for-a-career/airline-transport-pilot.

Aviation Readiness: Hearing before the United States Senate, Committee on Armed Services, Subcommittee on Readiness, 114th Congress 2 (2016). https://docs.house.gov/meetings/AS/AS03/20160706/105159/HHRG-114-AS03-Wstate-DavisJ-20160706.pdf

Berger, D. (2021). *Talent Management 2030*. United States Marine Corps. https://www.hqmc.marines.mil/Portals/142/Users/183/35/4535/Talent%20Management%202030_November%202021.pdf

Bernthal, J. (2022). Fixed-wing-Pilot-Retention: Barriers, recommendations, and broader implications. *Marine Corps Gazette*, *June*. https://mca-marines.org/wp-content/uploads/Fixed-wing-Pilot-Retention.pdf

Best Places. (n.d.). *Climate by City*. Retrieved December 20, 2023, from https://www.bestplaces.net/climate/city

Cross, R., & Prusak, L. (2002). The People Who Make Organizations Go—Or Stop. *Harvard Business Review*, *June*. https://hbr.org/2002/06/the-people-who-make-organizations-go-or-stop

Data USA. (n.d.). *U.S. Marines Industry Group*. Retrieved October 16, 2023, from https://datausa.io/profile/naics/u-s-marines#:~:text=On%20average%2C%20full%2Dtime%20employees,average%20annual%20salary%20of%20%2425%2C754.

Davis, J. (2017, July 14). *Lt. Gen. Jon Davis Retirement Letter on Marine Corps Aviation*. https://news.usni.org/2017/07/14/document-lt-gen-jon-davis-retirement-letter-on-marine-corps-aviation

FAPA.aero. (n.d.). *Major Airline Pilot Hiring History*. Future & Active Pilot Advisors. Retrieved November 21, 2023, from https://www.fapa.aero/pilot-hiring-history

Flight Time Limitations and Rest Requirements: All Flight Crewmembers, 14 CFR 121.471 (2023). https://www.ecfr.gov/current/title-14/chapter-I/subchapter-G/part-121

FlyLegacy. (2022). *Aircraft Rental*. https://flylegacyaviation.com/aircraft-rental/

Gordon, C. (2023, June 5). *Air Force Bumps Annual Retention Bonus for Aviators Up To $50K*. Air & Space Forces Magazine. https://www.airandspaceforces.com/air-force-aviators-annual-bonus/

Government Accountability Office. (2022). *Weapon System Sustainment Aircraft Mission Capable Goals Were Generally Not Met and Sustainment Costs Varied by Aircraft* (GAO-23-106217). https://www.gao.gov/assets/gao-23-106217.pdf

Griffin, J., Fredlake, C., Hiatt, C., & Shuford, R. (2018). *Understanding the Marine Corps Aviator Inventory* (DRM-2018-U-018461-1Rev). CNA.

Headquarters United States Marine Corps. (2009). *Marine Corps Flying Hour Program (FHP) Management* (MCO3125.1B). Department of the Navy. https://www.marines.mil/portals/1/Publications/MCO%203125.1B.pdf

Headquarters United States Marine Corps. (2019a). *Separation and Retirement Manual* (MCO 1900.16 CH 2). Department of the Navy. https://www.marines.mil/portals/1/Publications/MCO%201900.16%20CH%202.pdf?ver=2019-02-26-080015-447

Headquarters United States Marine Corps. (2020). *Aviation Training and Readiness Program Manual* (NAVMC 3500.14E). Department of the Navy. https://www.marines.mil/News/Publications/MCPEL/Electronic-Library-Display/Article/2396543/navmc-350014e-ch-1/

Headquarters United States Marine Corps. (2022). *2022 United States Marine Corps Aviation Plan*. Department of the Navy. https://www.aviation.marines.mil/Portals/11/Documents/Aviation%20Plan/2022%20Marine%20Aviation%20Plan%20FINAL%20April%202022.pdf

Headquarters United States Marine Corps. (2023). *MV-22B Training and Readiness Manual* (NAVMC 3500.11G). Department of the Navy. https://msharp.usmc.mil/msharp/#tnrManualEditor/50f94ef9-e746-4d63-ae11-9d7ff8853941

Headquarters United States Marine Corps, D. (2019b). *Marine Corps Aviation Weapons and Tactics Training Program* (MCO 3500.109A). Department of the Navy. https://www.marines.mil/Portals/1/Publications/MCO%203500.109A.pdf?ver=2020-01-23-121407-927

Josephs, L. (2020, March 10). *Delta and American cut flights, freeze hiring as Coronavirus hurts travel demand*. CNBC. https://www.cnbc.com/2020/03/10/delta-makes-deep-flight-cuts-as-coronavirus-hurts-demand-ceo-expects-it-to-get-worse.html

Josephs, L. (2023, August 22). *American Airlines pilots approve sweetened labor deal with big raises*. CNBC. https://www.cnbc.com/2023/08/21/american-airlines-pilots-approve-labor-deal-with-big-raises.html

LeCompte, T. (2009, November). The Book of Hours: A peek into the logbooks of history's notable pilots. *Smithsonian Magazine*. https://www.smithsonianmag.com/air-space-magazine/the-book-of-hours-136493265/

Manpower Plans and Policy. (2023, February). *Week 2 Leveling Brief*. Aviation Officer Retention Operational Planning Team Summit, Quantico, VA.

Military and Civilian Personnel Overview: Hearing before the United States Senate, Committee on Armed Services, Subcommittee on Personnel (2022). https://www.armed-services.senate.gov/imo/media/doc/Statement%20of%20Lt%20Gen%20Ottignon.pdf

Office of the Chief of Naval Operations. (2022). *NATOPS General Flight and Operating Instructions Manual* (CNAF M-3710.7). Department of the Navy. https://www.cnatra.navy.mil/assets-global/docs/cnaf-m-3710.7.pdf

Schlappig, B. (2023, August 21). *American Pilots Approve New Contract With Huge Pay Raises*. One Mile at a Time. https://onemileatatime.com/news/american-airlines-pilots-contract/

U.S. Bureau of Labor Statistics. (2023, September). *Airline and Commercial Pilots*. https://www.bls.gov/ooh/transportation-and-material-moving/airline-and-commercial-pilots.htm#tab-3

U.S. Marine Corps. (2023). *Marine Sierra Hotel Aviation Readiness Program (M-SHARP)* (2.34.2.12665) [Computer software]. Electronic Consulting Services INC. https://msharp.usmc.mil/

Acquisition Research Program
Naval Postgraduate School
555 Dyer Road, Ingersoll Hall
Monterey, CA 93943

www.acquisitionresearch.net