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This paper will examine the Marine Corps' lone remaining legacy assault support helicopter, its history, its replacement, its current difficulties, potential solutions to off-set the impacts of decreased readiness, and the importance of heavy lift to Marine Corps and joint operations. The importance of studying the history and evolution of the CH-53 and Marine Corps heavy lift provides beneficial insight into future aspirations and capabilities. Until the CH-53K achieves full operational capability, the legacy CH-53E must be sustained to ensure its availability to safely meet the Marine Corps' and the joint force's current and future heavy lift requirements.

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MASTER OF MILITARY STUDIES

EVOLUTION OF CH-53 HEAVY LIFT

SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF MILITARY STUDIES

MAJOR MATTHEW W. QUIGLEY

AY 16-17

Mentor and Oral Defense Committee Member: Dr. Bradford A. Wineman
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Executive Summary

Title: Evolution of CH-53 Heavy Lift

Author: Major Matthew Quigley, United States Marine Corps

Thesis: This paper will examine the Marine Corps' lone remaining legacy assault support helicopter, its history, its replacement, its current difficulties, potential solutions to off-set the impacts of decreased readiness, and the importance of heavy lift to Marine Corps and joint operations. The current state of reduced CH-53E readiness reinforces the criticality of fixing and sustaining the CH-53E fleet, while ensuring the timely and successful implementation of the CH-53K to satisfy current and future heavy lift requirements.

Discussion: Surprisingly, the Marine Corps has delved in vertical lift since its experimentation with the autogiro during its involvement in Nicaragua in the early 1930s. The autogiro led to the development of the helicopter, which rapidly peeked curiosity for military applications. Following World War II, a series of studies occurred to analyze helicopter utilization to ensure dispersion from the effects of an atomic attack during amphibious operations. The benefits of helicopters on the battlefield began in Korea and continue to this day. Only one revolution in vertical lift technology involving the MV-22 and its tilt-rotor capability occurred since vertical lift's inception. However, vertical lift evolutions are numerous. Perhaps the most important series of evolutions involve the increased capabilities of vertical heavy lift. Military equipment will not get lighter and commanders will always want to lift more gear. The CH-53 series helicopter is the one and only premier heavy lift asset for the United States military. As such, the current sustainment of the CH-53E during severe readiness deficiencies and the increasing importance of its replacement (CH-53K) become more critical to ensuring current and future heavy lift capability to the US and joint force.

Conclusion: The importance of studying the history and evolution of the CH-53 and Marine Corps heavy lift provides beneficial insight into future aspirations and capabilities. Until the CH-53K achieves full operational capability, the legacy CH-53E must be sustained to ensure its availability to safely meet the Marine Corps' and the joint force's current and future heavy lift requirements.

DISCLAIMER

THE OPINIONS AND CONCLUSIONS EXPRESSED HEREIN ARE THOSE OF THE INDIVIDUAL STUDENT AUTHOR AND DO NOT NECESSARILY REPRESENT THE VIEWS OF EITHER THE MARINE CORPS COMMAND AND STAFF COLLEGE OR ANY OTHER GOVERNMENTAL AGENCY. REFERENCES TO THIS STUDY SHOULD INCLUDE THE FOREGOING STATEMENT.

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Preface

Originally, I began this project to prove that the CH-53E is still relevant in a world of increased MV-22 demand. However, I realized that the CH-53E and heavy lift has never lost relevance. My research evolved into recalling my experiences and researching the evolution of vertical heavy lift as it pertained to the CH-53. My primary reason for this project was to determine how the CH-53E fell into its current state of decreased readiness and identify the source(s) that will help prevent the crippling effect of reduced readiness in the future.

I would like to thank my mentor during this process, Dr. Bradford Wineman, whose experience and guidance contributed significantly to shaping my research, critical thought, and writing capabilities. Additionally, I would like to thank the APW-51 Heavy Helicopter Requirements Officer, Major Tom "Banshee" Trimble for his professionalism, quick response, and insight into all of my requests for information relating to this paper. I would also like to thank my officer and enlisted mentors (too many to list) whom have helped guide me in the right direction throughout my career. Finally, and most important, I would like to thank my wife and daughters for their support, encouragement, and patience during my long hours dedicated toward this masters and my time at Command and Staff.

Introduction

The current state of Marine Aviation, specifically in the areas of readiness and delays in fielding replacement aircraft for fixed-wing platforms and the CH-53E, present potentially devastating consequences in current and future support for Combatant Commanders and the nation. In the 2016 Aviation Plan, Lieutenant General Jon M. Davis, Deputy Commandant of Aviation, identifies the demand from Combatant Commanders for "[m]ore dispersed, distributed, and disaggregated forces, postured forward, ready to concentrate rapidly to achieve decisive results against any enemy—and the ability to do so within hours."[1] Marine Aviation seeks to ensure full support to the Combatant Commander and provide a wide array of options and flexibility ready for tasking when called upon to execute. An asset vital to ensuring that the Marine Corps wins the nation's wars is the CH-53E. This paper will examine the Marine Corps' lone remaining legacy assault support helicopter, its history, its replacement, its current difficulties, potential solutions to off-set the impacts of decreased readiness, and the importance of heavy lift to Marine Corps and joint operations.

The ability to rapidly mass and concentrate force in response to a threat is key to decisively defeating an enemy. In order to properly mass and respond rapidly, the force must be agile while possessing the proper equipment to remain mobile and engage the enemy. For years, the Marine Corps aimed to become a middleweight force by becoming lighter. The Marine Corps did not get lighter in terms of weight, rather it lightened the force by reorganization (e.g., removing a company from a battalion). The combat loads carried by infantry Marines have only increased over the years from the addition of heavy ballistic protection equipment, batteries required for new technological tools, and the ability to carry more gear in a larger rucksack. Similarly, the operational footprint has increased due to additional communications equipment,

armored vehicles, weapons, air conditioners, number of personnel assigned to a staff, etc. The equipment developed to replace aging gear in almost all cases is heavier. For example, the High Mobility Multipurpose Wheeled Vehicle (HMMWV) replacement, the Joint Light Tactical Vehicle weighs 14,000-lbs,[2] nearly double the HMMWV's weight.

The CH-53E and the CH-53K will be the helicopters most capable of lifting one or two JLTVs, if required for expeditionary displacement. Additionally, they will be the most capable vertical lift aircraft for moving the M777 155-mm howitzer and the 120-mm Expeditionary Fire Support System (EFSS) in their entirety with rounds. In comparison to the MV-22, the CH-53E cannot match the speed provided by the Osprey; however, it is able to utilize its aerial refuel capability to achieve the range capability and provide substantially greater lift capability and capacity. The CH-53E's heavy lift capability, coupled with the ability to range distant objectives continues to provide Combatant Commanders the ability to concentrate dispersed forces quickly when needed. Furthermore, the CH-53E's ability to range and retrieve a downed aircraft from an austere high, hot, and heavy environment is an unmatched and vital capability.

The current state of CH-53E readiness creates a significant challenge to the execution of its mission and support to Combatant Commanders. The easy solution for rectifying the current CH-53E readiness situation is acquiring and applying the requisite financing to solve Marine Aviation's readiness issues in its entirety. Knowing this course of action is highly improbable, the Marine Corps may fall back on one of its oft-used slogans—"do more with less." However, doing so absent analysis or efforts toward potential doctrinal or institutional solutions could finally lead to the Marine Corps doing what it can, with what it possesses. In the current case of the CH-53E, that would mean at best, the ability to fly less than half of the available aircraft in the inventory. This realization reinforces the criticality of fixing and sustaining the CH-53E

fleet, while ensuring the timely and successful implementation of the CH-53K to satisfy current and future heavy lift requirements.

CH-53 History

Before the helicopter formally existed, the Marine Corps gained an interest in vertical lift. *The Marine Autogiro in Nicaragua* identified the OP-1 as the first Marine rotary-wing aircraft. Lieutenants Frank June, Paul Putnam, Samuel Jack, and Edward Pugh flew this aircraft for a five-month period in 1932, during a conflict in Nicaragua. The autogiro and its pilots would support ground troops by conducting reconnaissance, delivering supplies and messages, and developing close air support techniques. This group of innovators ventured into a new and dangerous technology during a policing action; however, they would still expose themselves to potential capture by guerillas in the Nicaraguan jungles. Lynn Montross identified an important Marine Corps ideology that is still relevant today: "[T]hen, as now, the Marine Corps was a tactical laboratory in time of peace, a force in readiness in time of war. Air was an integral part of a Marine expeditionary force, not a separate arm."[3] This quote codifies the relevance of training hard and verifying tactics, techniques, procedures, and equipment, to ensure peak warfighting capability during conflict.

The Marine Corps' initial vertical lift experiments in Nicaragua displayed that even during the early stages of primitive technology, Marine aviators sought to push the envelope to identify new ways to support the Ground Combat Element (GCE). The Marine aviators attempted to increase the limited performance and agility of the autogiro by reducing the fuel load and removing excess parts. Conversely, they increased payload weight to determine the flight characteristics, which ultimately led to unsafe flight situations. A memorandum from

Lieutenant Colonel Roy Geiger to the Commanding Officer of 1st Marine Brigade on 12 July 1936, conveyed the Marine Corps' stance on vertical lift at the time:

> To date no type of autogiro has been demonstrated which will carry a reasonable fuel supply and military load and at the same time retain its peculiar characteristics of taking off and landing in a restricted area and hovering over a given spot. Until such time as this type of aircraft can carry a satisfactory military load and retain its flying characteristics, its use by the Marine Corps is not recommended.[4]

This was the beginning of Marine Corps vertical and heavy lift aspirations.

On 23 September 1946, the Chief of Naval Operations (CNO) put forth a request to evaluate future amphibious operations.[5] This request led to the formation of a senior board to which generated discussion, debate, and critical thinking about solutions to future issues. This board officially began the process of the Marine Corps' developmental analysis on the future use of helicopters as a Marine Corps warfighting tool. In a subsequent memorandum dated 24 Jul 1947, the CNO issued a requirement seeking an assault helicopter for utilization during Marine Corps amphibious operations. The requirement specified that the aircraft be capable of carrying twenty combat loaded infantrymen at 240 pounds per man; achieve a range of 300 nautical miles with a 5,000-pound payload; cruise at a speed of 100 knots; achieve a service/hover ceiling of 15,000/4,000 feet, respectively; and be as small as possible with blade fold ability.[6]

The helicopter continued to evolve and displayed its military relevance during the Korean War. The early helicopters used in Korea did not possess significant lift capability, but they did expedite tactical movement ability. As Colonel Jack Grace stated, "[I]n the first campaign of this struggle, the movement of tactical units by helicopter over the rough terrain of Korea demonstrated another revolutionary development, this time in four hours to move a company (224 troops, 17,800 pounds of cargo) to a hilltop position. The move would have taken 15 hours on foot."[7] Following Korea and leading into the Vietnam War, helicopter relevance to

warfighting gained significant traction. Focus of efforts centered upon achieving better capabilities in close air support of ground troops and the transport of troops and equipment.

In June 1956, the Marine Corps acquired the CH-37 and its ability to transport 8,000-pound payloads.[8] The desire for a heavy lift platform led to the first contract for such an aircraft awarded to Sikorsky for the 14,000-pound payload capable CH-53A on 24 September 1962.[9] On October 14, 1964, the Marine Corps heavy lift helicopter flew for the first time. The CH-53A would be battle tested during Vietnam and proved itself during numerous tactical recoveries of aircraft and personnel, troop inserts/extracts, and re-supply missions. In a May 1973 *Marine Corps Gazette* article, Colonel F. Kleppsattel noted that during the first four years in Vietnam, the CH-53A executed over 1,000 aircraft recoveries that saved taxpayers 432 million dollars.[10] Further proving the value of heavy lift helicopters and aircraft recovery, he estimated that this savings approximated the total cost of all CH-53A and CH-53D aircraft purchased.

Ultimately, the early successes in Vietnam led to a desire for a helicopter possessing more lift capability. This improved helicopter became the CH-53D, with more powerful engines, six main rotor blades to increase lift, an improved transmission, and a larger interior to handle more troops and cargo. Sikorsky delivered the first aircraft on 5 March 1969, with a total inventory of 126 delivered to the Marine Corps.[11] Again, the CH-53D proved its utility and value during the Vietnam War; and again, the desire for more lift manifested. In November 1971, the Deputy Secretary of Defense approved the initial CH-53E program.[12] The CH-53E would increase the external load capability to 32,000 pounds and possess the ability to recover itself and all aircraft in the Marine Corps inventory, minus the C-130.

Scope of Utilization in Afghanistan and Iraq

Since the terrorist attacks on 11 September 2001, the United States has remained engaged

in continuous combat operations. Heavy lift assets, both fixed-wing and rotary-wing, continue to provide significant lift capability. This capability ensures the expeditious movement of personnel and materiel into and out of theater. The Air Force and their strategic airlift assets (C-5 Galaxy and C-17 Globemaster) have experienced an astounding sortie generation requirement for heavy equipment movement since America's response to 9/11. The same holds true for the CH-53E, "the only heavy lift helicopter in the DoD rotorcraft inventory."[13] Perhaps no other mission during the "War on Terror" reinforced the capability and worthiness of rotary wing heavy lift than the initial assault into Afghanistan in November 2001.

Elements from the 15th Marine Expeditionary Unit (Special Operations Capable) (MEU (SOC)) and 26th MEU(SOC) combined to conduct the "longest amphibious airfield seizure in the history of the United States Marine Corps."[14] The platform of choice for the distant airfield seizure was the CH-53E due to its heavy lift, aerial refueling, and at the time, speed capabilities. Airfield seizures primarily require rapid and significant combat build-up, often with a requirement for mobility on the objective. In order to achieve its objective, three of the 15th MEU(SOC) CH-53Es loaded a combined payload of two Interim Fast Attack Vehicles and sixty-six Marines. Additionally, the 26th MEU(SOC) lifted a total of ninety-five Marines (each carrying a combat load) spread-loaded amongst three CH-53Es.[15] The CH-53E's heavy lift capability and ability to range 400 nautical miles permitted the rapid and mobile build-up of combat power on the objective during the initial assault wave. Furthermore, the CH-53E's aerial refuel capability allowed the aircraft to complete the 800 nautical mile round-trip utilizing one aerial refuel and permit the successful recovery of the aircraft and aircrews back to amphibious shipping to reset and posture for follow-on operations. The insert into what would become Forward Operating Base Rhino began the CH-53E's role in prosecuting the "War on Terror."

The CH-53 community (CH-53D and CH-53E) experienced changing mission assignments between Operation ENDURING FREEDOM (OEF) and Operation IRAQI FREEDOM (OIF). Originally, the CH-53E performed the heavy lift mission in Afghanistan. Once operations in Iraq commenced, a shift slowly occurred where the CH-53E, and later the CH-53D, would expand their assault support missions. The drawdown beginning in 2009 shifted the CH-53E and CH-53D back to Afghanistan and continued the Marine heavy lift mission until it ended in 2015.

The late entry of the CH-53D into Iraq and Afghanistan is an important development to note. The CH-46's fatigue and reduced capability to provide medium lift, as well as the subsequent delay in the availability of the MV-22, contributed to the necessity for the CH-53D in those theaters. The CH-53D essentially provided a medium lift capability with increased range to fill the gap of the CH-46 to MV-22 transition. Meanwhile, the CH-53E experienced more wear and tear while it carried the increased burden due to the delayed implementation of the MV-22.

The utilization of the CH-53E during general support missions shifted dramatically during OIF from 2005 through 2009. During OIF 05-07, CH-53E general support tasking comprised primarily of long-range ring routes in Al Anbar and the provinces south of Baghdad for cargo and passenger movements. These movements consistently comprised of fully loaded sections of aircraft. During this period, the CH-53E assisted in the rapid build-up of combat power during Operation STEEL CURTAIN and the external heavy lift of construction supplies for the creation of forward operating bases throughout Al Anbar.

During OIF 06-08, CH-53E utilization continued its focus on long-range ring routes throughout Al Anbar and missions to the provinces south of Baghdad were rare. General support

missions experienced a reduction in passengers and cargo where only one full aircraft became the norm. More direct action missions started to expand into the CH-53E mission. During this timeframe, CH-53E ventured at night into previously restricted areas of historically increased propensity for surface-to-air enemy engagements. Additionally, Aeroscout missions utilizing the CH-53E's capacity to transport the right number of troops for hasty interdiction operations, its fuel endurance for a four-hour mission, and use of its internal tactical bulk fuel delivery system to extend the endurance of H-1 aircraft for escort, became commonplace.

The significantly improved security situation and installation of the CH-53E Directional Infrared Countermeasure (DIRCM) system modification provided added survivability protection against surface-to-air threats and permitted daytime missions into previously restricted zones during OIF 09.1. Asset usage comprised of the long-range ring routes, but did not experience the consistent full passenger and cargo loadouts. Oftentimes, two CH-53D/Es launched on a ring route and barely one aircraft would achieve capacity. A response by a CH-53E Captain to a 2d Marine Aircraft Wing (MAW) aviation safety survey conducted in January 2008 identified the early stages of the trend of inefficient general support tasking:

> Efficiency of asset utilization. We routinely were tasked to fly missions of routine precedence that did not effectively utilize the aircraft. This is a concern when that 5 hour flight to fly 5 people for [rest and recuperation] R/R in an aircraft that requires 43.7 maintenance man hours per flight hour is inefficient when 5 more are leaving for the same reason from the same place the next day.[16]

The inefficient tasking was a major point of contention in squadron Operations Departments.

Despite efforts to assist in creating efficiencies, the tasking remained unchanged and numerous maintenance man-hours were spent preparing aircraft for inefficient tasking and wasted flight hours. The only benefit to reduced utilization was the ability to conduct combat sortie sustainment training on the front or backside of missions. However, the additional wear

and tear on the aircraft is another factor contributing to the current state of readiness within the CH-53E community.

Environmental Challenges and Constant Aircraft Upgrades

The environments of Iraq and Afghanistan posed significant challenges to the personnel, equipment, and aircraft that operated there for well over a decade. The CH-53D/E experienced significant wear and tear during prolonged operations in the high, hot, heavy, and sand infested environments. The challenges from operating in desert environments affected lift capability due to the effect of sand and debris on engines and the resultant performance reduction. The implementation of numerous mitigation strategies to counter the effects of decreased engine performance occurred over the years. These efforts included applying a protective coating to engine compressor blades to prevent erosion, increased engine washes, and ultimately upgrading the engines on the CH-53E and CH-53D.

During the transition of the CH-53D from Iraq to Afghanistan, the standard CH-53E General Electric T64-416 replaced the CH-53D's less powerful General Electric T64-413 engines to increase lift capability. Conversely, the CH-53E began modifying the T64-416/416A engines by upgrading the fuel control units to create General Electric T64-419 engines that equipped the Navy's MH-53E and generated significantly more power. Curiously, a 1994 *Marine Corps Gazette* article titled "The CH-53E Super Sea Stallion: Alone, Unarmed, and Unafraid" identified the fact the CH-53E could not accomplish all parameters set forth in the program's lift requirements. The authors added, "In any case, Marine CH-53Es are expected to receive the new General Electric T64-419 engines after the Navy upgrades its MH/CH-53E fleet."[17] It took just under twenty years for this upgrade to begin. The engine swaps generated more power and increased lift capability, which provided an increased safety buffer/power

margin to conduct heavy lifts. This extra power was critical during recovery of multiple downed aircraft in theater, particularly those involving 22,000-lb Boeing CH/MH-47 Chinooks.[18]

Enhancements to Aircraft Survivability Equipment (ASE), such as the DIRCM and dual-pod, forward firing, chaff and flare dispensers provided increased protection against surface-to-air missiles and small arms threats. The enhancements allowed commanders to accept more risk and send the CH-53E into areas of increased potential for enemy engagement, knowing that the ASE provided additional protection to the aircraft and personnel. The DIRCM and chaff/flare dispensing pod modifications involved a series of kit installs, which took an aircraft out of flight status for a period. The CH-53 possesses a ballistic protection system that contains numerous (and heavy) armor plates that may be added to the floor to protect the pilots and personnel in the cabin from small arms fire.

Over the years, upgrades in ASE and communications equipment have brought the CH-53 in-line with current technology, but added significant weight to the aircraft. The identification of the need for enhanced ASE should lead to the most advanced of those technologies being included on the CH-53K during original production. In fact, the large and bulky DIRCM Guardian Laser Turret Assembly (GLTA) currently attached to the CH-53E will be replaced by smaller, lighter, and better positioned GLTAs on the CH-53K.[19] The inclusion of lighter, more capable technologies will minimize the need for constant modifications that remove aircraft from flight status for an extended period and will maximize lift capability.

Marine Expeditionary Units and Assault Support Aircraft Mix

The debate and discussion on the proper mix of aircraft dedicated to a MEU has continued for years. Traditionally, the helicopter/tilt-rotor aircraft mix is twelve MV-22B, four CH-53E, four AH-1W/Z, and three UH-1Y. The rapid build-up of combat power in terms of

both personnel and supplies/equipment is an unmatched CH-53E capability. Often, the CH-53E is the only vehicle capable of the rapid movement of heavy gear, vehicles, supplies, and equipment. The ability of the CH-53E to provide mass on an objective reduces the number of aircraft in a zone or in the air at any given time, reduces deck cycles, and ultimately reduces risk. The CH-53E and its lift capability is a crucial asset to the MEU and as such, an increase in the number of CH-53Es dedicated to the MEU should become commonplace.

In the past, when MEUs were comprised of CH-46s instead of MV-22s, the reallocation of CH-53E heavy lift capability away from the MEU greatly diminished the capabilities of the MEU and the Amphibious Ready Group (ARG). In a Marine Corps Center for Lessons Learned report, *Marine Expeditionary Unit Operations Afloat: Lessons and Observations from 13th MEU Deployment, January through August 2009,* the 13th MEU stated that "[T]he reassignment of the MEU's CH-53E detachment to OIF for in excess of four months took away the long range lift, refueling and mission capabilities of the ARG."[20] Even with current day MEUs constituted by the MV-22, the impact from a loss of heavy lift capability is still significant. The MV-22 will be required to increase its sortie load and tasking to account for the increase in throughput of passengers and equipment.

If a Geographic Combatant Commander requires the MEU to divert its CH-53Es, surface connectors such as the Landing Craft Air Cushion (LCAC) and Landing Craft Utility (LCU) must play an increased role in passenger and cargo movements to supplement the MV-22B. The loss of heavy lift and the increased dependence on LCACs and LCUs for movement could pose significant challenges. *Wasp*-class Landing Helicopter Dock amphibious ships more easily accommodate the operation of LCAC and LCU surface connectors. However, if embarked aboard an *America*-class Landing Helicopter Assault ship there is not a well deck available for

LCAC/LCU utilization by the MEU. The lack of a well deck will necessitate most, if not all, movements of passengers and cargo via vertical lift. Even with a well deck capable ship, the ability to launch, traverse the sea, and recover LCACs and LCUs depends heavily on sea-state. Non-permissible sea-states will require flexible contingency plans that utilize the vertical heavy lift capability as means to execute time-critical movements.

A CH-53K In-Progress Review conducted in 2014, analyzed the MV-22 to CH-53K aircraft mix for MEUs and Marine Expeditionary Brigades (MEB) and the total procurement number for CH-53K. The report identified that a minimum of twenty CH-53Ks would be required to support MEB operations, but twenty-four CH-53Ks were optimal in high-hot-heavy conditions, especially if the JLTV required lift. A mix of thirty-six MV-22 to twenty-four CH-53K permitted efficient use of fuel, sorties, and deck space during MEB operations. For MEU operations, a mix of twelve MV-22 to four CH-53K or ten MV-22 to six CH-53K produced similar results. However, the Marine Corps staff study on CH-53K requirements concluded that an aircraft mixture utilizing six CH-53Ks would provide increased operational reach and permit the efficient lift of the JLTV.[21]

A Series of Setbacks

Beginning in 2014 and continuing to current day, the CH-53E experienced significant program setbacks that affected the community writ large. The dissemination of a series of Airframes Bulletin (AFB) issuances requiring the visual inspection of the inventory aircraft occurred. AFB-345 pertained to stress fractures near the ramp that could potentially lead to a catastrophic loss of aircraft and personnel. Additionally, AFB-346 concerned the potential for fire hazards caused by plastic zip ties used on substandard and poorly insulated Kapton wire bundles that could rub against metal cabin fuel lines. The result of the prolonged friction could

cause a hole in the fuel line and lead to atomized fuel spray, which could ignite from electrical arcing. The electrical arcing due to Kapton wiring is a suspected and proven culprit of past mishaps.

The results of these back-to-back problems identified in the AFBs severely affected the H-53 (Navy and Marine) community with respect to aircraft readiness, pilot and aircrew training, morale, and mission execution. Countless maintenance man-hours inspecting and rectifying discrepancies, as well as time awaiting parts and engineering support led to fewer available aircraft to support mission and training flight schedules. Further complicating the situation, shortly after the AFBs, an issue with the tail rotor system manifested itself amongst certain aircraft. The issue was potential catastrophic wear and destruction to the tail disconnect coupling caused by misalignment of tail rotor drive shafts and/or recently replaced disconnect couplings. Again, squadrons experienced varying wait times for engineering support to determine the cause and provide a fix. Additionally, affected aircraft were required to conduct visual inspections and re-lubrication of the tail disconnect coupling after every three hours of flight. This requirement significantly hampered training evolutions, as well as operations and maintenance tempos. Only after the aircraft completed twenty-five flight hours with no discrepancies noted, was it able to continue regular operations and inspection intervals.

The impacts from these rapid in succession safety of flight issues greatly affected and will continue to reverberate throughout the community for years to come. During this period, reduction in aircraft available to train caused squadrons to prioritize flight hours to meet current and future demands. Priorities for training are too numerous to codify. However, consistent priorities for a squadron usually include maintaining proficiency for current instructors; generating new Night System Instructors and Weapons and Tactics Instructors; qualifying new

co-pilots in high light and low light levels; training a pilot for completion of the Helicopter Aircraft Commander syllabus; and completing assigned fragmentary orders (FRAG) in support of higher headquarters requirements.

During this period of low ready basic aircraft (RBA), squadrons required more effort than ever to match priorities, ensure valuable flight training evolutions, and provide a quality spread in terms of flight time for pilots and aircrew in an attempt to maintain proficiency. From a west coast flight line perspective, many times squadrons could barely form a section of aircraft. The downside was tremendous, but the benefit was that squadrons identified the criticality of combining efforts to prioritize and attempt to ensure FRAG and training priority completion. Squadron Operations Departments would work with each other to determine priorities and find ways to combine or provide back-ups for training and FRAG evolutions. Squadron Commanding Officers would discuss priorities amongst each other and approve the use of aircraft, instructors, aircrew, ranges, enablers, etc. to ensure the achievement of training objectives and missions.

Force Shaping Impacts to Readiness

The budgetary constraints and their impacts brought about through sequestration reverberated throughout the Department of Defense. The Marine Corps implemented numerous cost-shaping tools and programs as an effort to minimize budgetary shortfalls. During Fiscal Year 2013, the Marine Corps implemented Officer and Enlisted Temporary Early Retirement (TERA) Programs as force-shaping and budgetary tools. These programs, in conjunction with the Voluntary Separation Pay Program, and Enlisted Voluntary Early Release Program provided the Marine Corps a means to trim the force and assist with living inside its means. However, as

it applied to the CH-53E community and Marine Corps Aviation writ large, the future impacts were crippling and in part responsible for the current state of aircraft readiness.

In the FY13 Enlisted TERA, Staff Sergeants possessing the MOS of 6323 (CH-53E Avionics Technician) were permitted to apply for early retirement.[22] This cut permitted some of the community's most highly trained Avionics Technicians to depart the force. The initial cut for FY14 Enlisted TERA provided no early retirement opportunities for Staff Sergeants or Gunnery Sergeants in critical CH-53E MOSs. However, a change to the MARADMIN published four months later added several of the critical CH-53E MOSs to the population approved for early retirement. The MOSs for Staff Sergeants included 6153 (CH-53E Airframes Mechanic) and 6173 (CH-53E Crew Chief). Additionally, the update permitted 6113 (CH-53E Flight Line Mechanic) and 6153 Gunnery Sergeants to seek early retirement.[23]

The departure of senior Staff Non-Commissioned Officers created a leadership vacuum within the community. There was a loss of leadership in the shops, on the flight line, in qualifications, and in training expertise. The departure of personnel who possessed the upper-level maintenance qualifications placed a burden on Maintenance Departments and junior Marines. It requires significant time, effort, and investment to progress Marines through the Collateral Duty Inspector (CDI), Collateral Duty Quality Assurance Representative (CDQAR), and Quality Assurance Representative (QAR) training pipelines. The departure of this senior leadership forced Maintenance and Division Chiefs to seek junior candidates to fulfill the newly created CDI, CDQAR, and QAR gaps.

The remaining maintenance workforce was younger and had less CH-53E knowledge and troubleshooting expertise than the seasoned Marines who departed the force early. From a numbers counting perspective, there were still senior SNCOs available from the critical MOSs;

however, these Marines were returning from special duty assignments and "B" billets. These Marines were out of their MOS for several years and the amount of time to retrain and requalify them on an airframe that experienced significant modifications and changes over the years posed substantial challenges. Maintenance Departments found themselves behind, but were able to continue to accomplish the mission on the backs of their Marines.

In addition to enlisted force shaping measures, similar initiatives occurred in the officer ranks. The CH-53E community went largely untouched until the introduction of the FY15 officer TERA. As in the enlisted initiatives, these measures were numbers based and may not have accounted for the types of qualifications lost. Several Weapons and Tactics Instructor (WTI) Field Grade Officers left the force early. Similar to the enlisted force shaping cases, the greatest impact was the loss of expertise, qualifications, and leadership within the officer ranks. While the burdens placed on the enlisted maintainers and crew chiefs were more distressing, the departure of senior pilots still affected the community.

The loss of senior enlisted maintainers and the resultant effects are contributors to the current readiness state. For comparison sake, the departure of senior maintainers with innovative troubleshooting skills and training would be similar to losing WTI or Air Mission Commander qualified pilots. The relationship between maintainers and pilots and their dependence on one another is critical and complementary to mission success. In order to prevent the detrimental impacts of future force shaping tools, these tools must take into account the loss of qualifications associated with the Marine's departure. The downsizing should account for more than the departure of a specific MOS; instead, it must include the impacts of qualification and experience lost.

Potential Solution to the Manpower Issue

A majority of the Marines who departed early due to TERA, VSP, VERP, etc., subsequently joined contract maintenance companies and continue to work on the CH-53E at depot or Fleet Readiness Centers. A majority of these individuals are retired Marine Staff Non-Commissioned Officers, but a significant amount are senior Sergeants that earned and possessed advanced maintenance qualifications. The main attributing factor for their departure from the Marine Corps is the prospect of earning significantly more money doing the same job in the civilian sector. Efforts and strategies to retain the highly skilled Marines who have excelled in their MOS require attention and further research.

One initial strategy is offering monetary bonuses to maintenance Marines who achieve and maintain higher qualifications. The bonus pay would be similar in structure to the flight pay received by their CH-53E Crew Chief counterparts. The amount provided may not meet the thresholds of Crew Chiefs, but any monthly or quarterly amount may help entice a Marine to remain knowing that his skill-set is worth just a little more to the Marine Corps. The challenge to this approach is identifying the actual cost or incentive from a manpower perspective required to keep a Marine.

If this method proved viable, the Flight Audit Control Board, which tracks Crew Chief flight pay entitlements, is a program that provides a model to issue and track these bonuses. The Quality Assurance (QA) Chief and Maintenance Chief could hold this board monthly or quarterly to track Marines that hold the qualifications and rate the payment. Assignment of a secondary MOS to track the advanced qualification (assists in future force shaping) and confirm the availability to receive additional pay would occur. The implementation of a sliding scale for the qualification, for example, CDIs equal $25, CDQARs equal $40, and QARs equal $50,

would then occur. If the suspension of a qualification were necessary, the payments would cease until the Maintenance/QA Chief determined it appropriate to reinstitute the Marine's qualification.

The King Stallion

In October 2015, the CH-53E's replacement, the CH-53K, conducted its first flight and is scheduled to achieve Initial Operational Capability (IOC) in 2019. The CH-53K King Stallion will be "[t]he only helicopter with the range and payload capable of offloading the Marine Expeditionary Brigade of 2024 in one cycle of darkness."[24] The King Stallion is advertising the ability to lift three times the current lift provided by the CH-53E and will seek to reduce the costs associated with flying and maintaining the aircraft by implementing current technologies into its design. The helicopter will be more reliable, survivable, and capable than its predecessor. Throughout the design phase, Sikorsky and the Marine Corps solicited the expertise from numerous seasoned CH-53E maintainers in the fleet to improve upon and validate design efficiency as it related to the maintainer and overall aircraft maintenance procedures.

Another method utilized to increase aircraft design and testing efficiency occurred through the implementation of the CH-53K Ground Test Vehicle (GTV). Too often during initial aircraft testing, manufacturers and engineers relied upon the aircraft achieving flight to workout design flaws. That approach led to several aviation mishaps resulting in death and aircraft delivery delays. The CH-53K GTV is an implemented best practice that provides a safe ground test environment where variables may be adjusted and dynamic components tested before the aircraft's first flight. This practice will reduce the risk to injury or death of test crew and minimize aircraft delays.

While the CH-53K will significantly increase the heavy lift capability of the Marine Corps and joint force it lacks the ability to recover or lift another CH-53K, which is no longer flyable due to mechanical issues or downing from enemy fire. The empty weight of a CH-53K is 43,750 pounds and its maximum gross weight with an external load is 88,000 pounds.[25] Therefore, one CH-53K recovering another CH-53K would require significant weight reduction (removal of engines, blades, tail section, and more) to get under the maximum lift capacity (36,000 pounds) of the external cargo hooks.

Aircraft recovery is one of the most beneficial capabilities that the CH-53E currently provides. This attribute offers the ability for rapid retrieval of aircraft from confined and usually non-permissive terrain, returns the airframe for repair or parts salvage (provides significant cost savings to the Department of Defense and the American taxpayer), and prevents exploitation by the enemy. Even when terrain is permissible, the recovery by air utilizing the CH-53E is a more viable option. While zone security and route escort are required for both the air and ground transport, the movement by air reduces exposure time to possible enemy reaction. It prevents movement via roads potentially laden with improvised explosive devices or complex ambush attacks. Additionally, the inability of the CH-53K to self-recover could prevent, or at least increase, the risk assumed by commanders desiring to use the CH-53K in contested enemy zones during initial combat waves.

Stallion Stalls

The CH-53K and its advertised vertical heavy lift technology enhancements provide an example of what Grant T. Hammond describes as the "[D]ebate between Technologists and Reformers."[26] Hammond utilizes Serge Herzog's characterizations of technologists and their views that technology is "a force multiplier, provides force flexibility, has the potential to

improve cost and equipment reliability and maintainability, and is indispensable given the alternatives."[27] The CH-53K and its technologies are designed to enhance operational and maintenance reliabilities, as well as cost effectiveness throughout the airframe's lifetime. However, one cannot discount the argument offered by the reformers in response to the importance levied on enhanced technologies. The reformers from Herzog's analysis argue the impacts of high technology are:

> (1) overemphasis on high technology has driven the cost of modern weapons out of control; (2) high technology has introduced a level of complexity that seriously hampers force readiness; (3) high technology is pushed in areas often irrelevant to success in combat and may even endanger its user; (4) the added increment in performance resulting from high technology rarely justifies the cost involved; and (5) high technology stretches acquisition and maturation, causing critical delays in technology integration and frequently unexpected technical problems.[28]

If cost overruns and delays occur due to the new-build technologies of the CH-53K, then questions on whether the cost of technology and impacts to readiness outweighed the benefits to enhanced seabasing capabilities, logistical efficiencies, and operational maneuver will follow. Technology cost-benefit concerns highlight potential worst-case scenarios for the CH-53K's implementation and future ability to execute the heavy lift mission.

A worst-case scenario for the CH-53E and CH-53K involves the CH-53K not meeting the established 2019 IOC and 2029 Full Operational Capability (FOC) timelines, and the CH-53E's inability to maintain the mission due to poor readiness. The Marine Corps is properly leveraging a response to this potential by proceeding with the current reset of all CH-53Es. The reset's main purpose is to fix the current readiness issue, but should pay dividends if properly maintained as a backup to offset any CH-53K delays. As the CH-53K nears IOC/FOC, the CH-53E cannot become an after-thought and must be maintained, funded, and supported until the CH-53K is FOC. The absence of such could lead to a situation similar to the MV-22's initial

delay in fulfilling its mission during OIF/OEF that caused an increased burden on other airframes.

A second scenario involves the inability to properly train and qualify pilots during the CH-53E to CH-53K transition. Under this scenario either aircraft delivery or the aircraft itself experiences issues (i.e., engineering/maintenance) preventing consistent flight training for the pilots and aircrew, which slows the pipeline of qualified personnel able to employ the CH-53K. One benefit to the current readiness situation is the creativity generated by squadrons to find more efficient and optimal paths to effective pilot training. Training plans for initial CH-53K pilot training should incorporate lessons identified on effective training strategies that increase training efficiencies, which arose in reaction to recent reduced aircraft availability (reference Appendix A). Increased reliance on high-fidelity simulators for training sorties will assist in developing skills and maintaining proficiencies if aircraft availability is restricted.

A final scenario involves inability to maintain funding support to achieve the two-hundred CH-53Ks desired by the Marine Corps. As a new-build helicopter, the CH-53K is an expensive program. In a recent interview, the CH-53K Program Manager stated that the CH-53K's average recurring flyaway cost per unit is $87.1 million and its program acquisition unit cost (PAUC) is currently $138.5 million.[29] Comparatively, the MV-22B's flyaway cost is $84.5 million per unit and its PAUC is $111.5 million.[30] If funding reductions for the CH-53K program occurs, manufacturers will most likely analyze their stake in the CH-53K. If it is no longer profitable for a manufacturer to develop or contribute to the CH-53K design, then the manufacturer will cease in supporting the effort. This will lead to sourcing another vendor to manufacture a requisite aircraft component, which may produce a product of lesser quality. The stipulations imposed on government contracting once an acceptable vendor is located would

significantly affect the CH-53K's arrival timeline. A means to counter possible federal funding cuts lies in the US government's potential offering of the aircraft to allied partners. Offering the aircraft to allies will assist with the significant cost and help fund future sustainability and supply efforts.

Conclusion

Involvement in sustained combat operations during the past fifteen years caused significant wear and increased utilization rates on the CH-53E. The decision not to conduct a full overhaul of CH-53Es during and after grueling combat flight operations in Iraq and Afghanistan contributed to the current readiness of the CH-53E fleet. At the time, this decision made sense. The fact that the aircraft were flying well and experiencing minimal long-term discrepancies masked the material readiness issues to come. Therefore, the lack of impending readiness issue triggering mechanisms made the decision to divert some funding to other priority programs, such as the program for the CH-53E replacement, the CH-53K, logical.

As the sole provider of the only heavy lift helicopter in the United States inventory, the Navy and Marine Corps are responsible to the nation to ensure the sustained readiness and availability of the CH-53E to execute its heavy lift mission. The Marine Corps must ensure the success of the CH-53E reset program to improve the dire readiness situation and increase airframe longevity while it waits for the CH-53K to be tested and operationally implemented. Absent the ability to successfully reset all CH-53E aircraft, the nation will lose its heavy lift warfighting capability and rely upon the CH-53K's delivery to the fleet.

The importance of studying the history and evolution of the CH-53 and Marine Corps heavy lift provides beneficial insight into future aspirations and capabilities. The Marine Corps continues its attempt to become the middleweight force, implying that it must get lighter.

Throughout the evolution of the CH-53 and Marine Corps heavy lift, one thing remains constant—a desire to lift more. Just because the Marine Corps states that it is getting lighter, does not mean that it does not want to lift more. The move towards a middleweight force is a shift toward lighter, smaller, and more agile units with increased lethality; however, in terms of lift requirements the Marine Corps is getting heavier. The Marine Corps will maintain its heavy lift capabilities with the CH-53E and increase the lift capability with the CH-53K. The CH-53K is not a revolutionary piece of gear like the MV-22; however, it is an evolutionary aircraft that will enhance the lift capabilities and warfighting prowess of the Marine Corps and the joint force in the future.

Although it may seem like the CH-53E was healthy one day and broken the next following the series of AFBs and tail rotor disconnect issues, this was not the case. The CH-53E's current state of readiness is due to series of compounding events that led the community and the Marine Corps to their current position. Significant risk is assumed if the Marine Corps relies upon the operational testing, evaluation, and implementation of the CH-53K occurring flawlessly and on time. The absence of vertical heavy lift assets will severely hamper the ability to mass an objective and establish a lodgment during amphibious and distributed operations. Once the Marine Corps is able to improve upon the material readiness of its legacy gear, the Marine Corps must take the lessons identified and convert them to lessons learned to prevent future readiness degradation.

Until the CH-53K achieves full operational capability, the legacy CH-53E must be sustained to ensure its availability to safely meet the Marine Corps' and the joint force's current and future heavy lift requirements. As stated by General Davis, "Our legacy gear will be ready until we are done with it. Improving the material readiness of our legacy gear—the key

component to current readiness—is no easy task, but we must do it." [31] The reset program currently implemented by the Marine Corps to fix the CH-53E inventory is providing the means to increase the material condition of the legacy CH-53E. Finally, the most critical variable to improving our readiness is the importance of the Marine. In future force shaping, the Marine Corps must not divest from the Marine; rather, it must invest in them.

APPENDIX A:

Case Study on Training and Deployment Execution with Reduced Readiness

This case study aims to capture the impacts to pre-deployment training requirements, as well as various strategies implemented to overcome the operations and maintenance impacts imposed upon HMH-466 by AFB 345, AFB 346, and tail rotor disconnect issues. After Marine Heavy Helicopter Squadron (HMH) 466's return from Afghanistan in late summer 2014, preparations began for future deployments. In February 2015, HMH-466 would reintegrate its 11th MEU detachment from deployment and continue preparations to conduct a change of operational control (CHOP) for its 15th MEU detachment scheduled in early summer 2015. After CHOP, the remainder of the squadron would execute an Okinawa Unit Deployment Program (UDP) and 31st MEU scheduled for November 2015. During this period, remedies for the AFB issues continued and the tail rotor disconnect issue affected several squadron aircraft.

The maintenance realities required a new mindset. Gone were the days when Operations could push its training plan and schedules to the Maintenance Department for simple concurrence due to the large pool of aircraft from which to choose. The minimal RBA and preparations for two MEU detachments and the UDP caused increased effort amongst the Operations and Maintenance Department for significantly more detailed coordination and communication. Operations had to have a place in the maintenance realm, i.e., knowing how many hours were available to fly on an aircraft, when inspections were due, time to phase, etc. Conversely, maintenance needed to know what priorities were on the horizon, scheduled flight windows, and the time available between recovery and the next launch.

The first training priority focused on ensuring that the 13th MEU detachment met the shipboard operations Training and Readiness (T&R) requirements for CHOP. Once complete

with the 13th MEU training requirements focus would shift to the 31st MEU detachment's T&R shipboard training requirements. The lack of RBA coupled with the lack of amphibious shipping available to execute required boat operations presented significant challenges to meeting objectives. Every chance to utilize each available deck window was the priority. Even when three aircraft were available to make one for the shipboard qualification window, it became necessary to coordinate with other squadrons for potential back-up aircraft. Ultimately, the 13th MEU detachment completed all aircrew in shipboard qualification, but the 31st MEU detachment came up short by one night crew prior to deployment. However, the crew achieved the required training shortly after arrival to Okinawa.

Maximizing each training evolution with numerous competing requirements led to a revision in operational and maintenance thinking with respect to the standard west coast training model. The vast majority of operations involved going "over the hill."[32] The minimal time to train, aircraft available to train, and the multitude of pilots to train pushed HMH-466 to schedule the majority of training evolutions to the Camp Pendleton range complex. This reasoning replaced the two-hour round trip transit and approximate hour of refueling evolutions characterized by "over the hill" operations with a thirty to forty-minute round trip and twenty-minute refuel evolution. This equated to roughly a sortie (one and one-half hours) gained and more pilot/aircrew throughput.

From a maintenance perspective, this model prevented the possibility of aircraft breakdown and subsequent aircraft recovery requirements in the El Centro and Yuma areas. The requirements for parts and/or troubleshooters occurred more rapid and with better ease to Camp Pendleton if required. Additionally, a driving motive from an operational to maintenance perspective was an attempt to preserve engines. During this time, GE-419 engines were in short

supply and every squadron on the line had trouble with underpowered engines. Conducting operations in Camp Pendleton limited the potential and amount of sand, rock, dust, and debris ingested into each engine. During the two-month period of this model's implementation prior to UDP and 31st MEU deployment, HMH-466 experienced minimal engine power issues and did not conduct an engine change. The focus increased the number of sorties and permitted increased pilot and aircrew proficiencies; however, it slightly reduced pilot and aircrew exposure to brownout landings.

During the UDP, the squadron experienced continued reduction in wasted transit time due to the close proximity of landing zones and ranges aboard Okinawa. Again, this afforded the ability to train more pilots and aircrew. A 1st MAW requirement required squadrons to achieve 50% aircraft readiness heading into a weekend or else the squadron would need to work the weekend to improve readiness. During the two months of the deployment, the squadron found itself working nearly every weekend to maintain 50% RBA. While sustainable to ensure mission accomplishment, the leadership implemented a change to the usual flight schedule battle rhythm used by a majority of the fleet squadrons.

Instead of Monday and Friday maintenance days with Tuesday through Thursday fly days, the squadron would shift to Monday through Wednesday fly days with Thursday and Friday maintenance days. This would resolve several issues. First and perhaps most important, it allowed two full maintenance days prior to the weekend and after three days of flying. This helped reduce Sunday night crew's workload and allow better focus to prepare the aircraft for the fly days. Additionally, it provided maintenance task continuity while limiting interruptions presented during training and FRAG missions. Next, the battle rhythm left flexibility to assist with training requirements. If training during the Monday through Wednesday fly days failed in

its completion due to maintenance or weather, Thursday allowed an added layer of flexibility to complete the dropped training. In the remaining four months of the deployment, only one weekend (minus a cross-country evolution and Balikatan) required a small contingent of squadron personnel and their efforts to test one aircraft in preparation for Balikatan 2016.

The herculean efforts on the backs of the maintenance Marines since arrival in theater and the turnaround in aircraft material condition and readiness permitted the squadron to deploy four out of five in-reporting aircraft in support of Balikatan 2016.[33] The four aircraft detachment self-deployed from Okinawa to the Philippines and back, while executing all training support and higher headquarters tasking. The operational and maintenance tempo provided by consecutive maintenance days during the week significantly improved material condition of the aircraft and contributed in the minimal aircraft issues experienced during the exercise.

The battle rhythm change was so successful that the squadron implemented it upon return from deployment. The advantages back home increased significantly. The primary advantage was due to the fact most 3d MAW squadrons were not flying operationally on Mondays. This increased range space availability and the ability to schedule external support enablers such as Helicopter Support Teams for external load operations and C-130s for Helicopter Air-Air-Refueling missions. Other west coast CH-53E squadrons have adopted this schedule from time to time as well.[34]

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