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Balancing The Triple Constraints and Mitigating Risk: An Analysis of Alternatives for the CH-53K

December 2025

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ABSTRACT

The U.S. Marine Corps (USMC) faces a critical heavy-lift capability gap as the CH-53E fleet approaches the end of its operational and maintenance viability. That gap jeopardizes the heavy-lift rotary-wing capability that is essential for supporting USMC expeditionary operations. This research analyzes the decision to field the CH-53K despite persistent cost growth, schedule delays, and technical deficiencies, and it evaluates whether alternative solutions could better fulfill USMC heavy-lift requirements. Using a capabilities-based assessment, DOTmLPF-P analysis, and an analysis of alternatives consistent with DoD acquisition guidance, this study compares four courses of action: continue CH-53K procurement, shift to the CH-47F Block II, extend the CH-53E while investing in autonomous heavy-lift systems, or cancel the CH-53K and sustain the CH-53E. Results show that although the CH-53K provides unmatched lift, survivability, and shipboard compatibility, it also exhibits the highest cost, greatest schedule risk, and ongoing performance challenges. The analysis finds that no single alternative fully closes the heavy-lift gap without trade-offs, but the CH-53K remains the only materiel solution capable of meeting all validated requirements. If performance is weighted more heavily than cost, schedule and technical risk, then full rate production of the CH-53K emerges as the most viable option for closing the USMC's heavy-lift capability gap.

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ABOUT THE AUTHORS

MAJ Adam Anderson commissioned through the Army OCS program in 2014 after earning a Bachelor of Arts degree in Criminal Justice from the University of St. Thomas in St. Paul, MN. He previously served as a Civil Affairs officer and completed deployments to Bosnia-Herzegovina and Poland before transferring to the Army Acquisitions Corps and attending NPS. His next assignment will be as the systems acquisitions officer for U.S. Army Special Operations Aviation Command.

LCDR Rebekah Haba graduated Coast Guard Basic Training in 2007 and completed Avionics Electrical Technician "A" School in 2008. As an enlisted member, she served as an HH-60J and MH-60T Flight Mechanic at Air Station Elizabeth City and Air Station Sitka, and as an Airman at Air Station Los Angeles. Selected for the Coast Guard's Pre-Commissioning Program for Enlisted Personnel, she earned her Bachelor of Science in Aeronautics, with a Minor in Aviation Safety, from Embry-Riddle Aeronautical University in Daytona Beach, FL, graduating Summa Cum Laude in 2013. That same year, she received her commission from Coast Guard Officer Candidate School in New London, CT. In 2015, LCDR Haba earned her Wings of Gold at Naval Flight School in Pensacola, FL, and subsequently reported to Air Station Elizabeth City where she flew as an MH-60T Aircraft Commander. During her tour she also served as the Facilities Engineering Officer, Flight Services Officer, and Aviation Materiel Officer, and earned her designation as a Coast Guard Aeronautical Engineer. In 2021, she reported to Aviation Training Center Mobile as the MH-60T Aeronautical Engineering Officer, Deputy Engineering Officer, and MH-60T Chief Test Flight Pilot. She completed a Master of Business Administration and Leadership Certificate from Spring Hill College in 2024. Upon graduation from the Naval Postgraduate School, LCDR Haba will report to NAS Patuxent River, MD, where she will serve as the MH-60R/CG Acquisition Lead at PMA-299.

Maj Collin Wheeler was Commissioned in the Marine Corps in 2015 following his graduation from Colorado State University with a Bachelor of Arts degree in History. After finishing TBS and flight school, he served primarily at MCAS New River in North

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LIST OF ACRONYMS AND ABBREVIATIONS

AAC	Advance Acquisition Contract
AAF	Adaptive Acquisition Framework
AOA	Analysis of Alternatives
APB	Acquisition Program Baseline
ARG/MEU	Amphibious Readiness Group/Marine Expeditionary Unit
ASE	Aircraft Survivability Equipment
CAPE	Cost Assessment and Program Evaluation
CAS	Close Air Support
CBA	Capabilities-Based Assessment
CDR	Critical Design Review
DAS	Defense Acquisition System
DoD	Department of Defense
DoDI	Department of Defense Instruction
DODIG	Department of Defense Office of the Inspector General
DOTmLPF-P	Doctrine, Organization, Training, materiel, Leadership and Education, Personnel, Facilities, and Policy
DOT&E	Department of Test and Evaluation
EABO	Expeditionary Advanced Base Operations
EGR	Exhaust Gas Reingestion
EMD	Engineering & Manufacturing Development
FOC	Full Operational Capability
FRP	Full-Rate Production
FY	Fiscal Year
GAO	Government Accountability Office
GE	General Electric
HLR	Heavy-lift Replacement
ICD	Initial Capabilities Document
IOC	Initial Operational Capability
IOT&E	Initial Operational Testing and Evaluation
JCIDS	Joint Capabilities Integration and Development System
JLTV	Joint Light Tactical Vehicle

JROC	Joint Requirements Oversight Council
KPP	Key Performance Parameter
LRIP	Low-Rate Initial Production
MCA	Major Capability Acquisition
MDAP	Major Defense Acquisition Program
NAVAIR	Naval Air Systems Command
NDAA	National Defense Authorization Act
NM	Nautical Mile(s)
O&S	Operations and Sustainment
OUSD(A&S)	Office of the Under Secretary of Defense for Acquisition and Sustainment
PM	Program Manager
POM	Program Objective Memorandum
PPBE	Planning, Programming, Budgeting, and Execution
RDT&E	Research, Development, Test & Evaluation
SDD	System Development and Demonstration
SDTA	System Developmental Test Article
SLEP	Service Life Extension Program
USCG	United States Coast Guard
USD(AT&L)	Under Secretary of Defense for Acquisition, Technology, and Logistics
USMC	United States Marine Corps
VTOL	Vertical Take-Off and Landing
WSARA	Weapon Systems Acquisition Reform Act

I. INTRODUCTION

Heavy-lift rotary-wing aviation has been a critical enabler for the U.S. Marine Corps (USMC), providing the logistical agility necessary to support expeditionary operations, since Sikorsky delivered the first CH-53A Sea Stallion in 1964 (National Naval Aviation Museum, n.d.). In response to emerging USMC requirements, including rotor blade folding capabilities and an upgraded fuselage, the CH-53D variant was introduced in 1967 to enhance shipboard compatibility and mission flexibility (Military.com, n.d.; National Naval Aviation Museum, n.d). The CH-53E Super Stallion has been the backbone of the USMC heavy-lift fleet, transporting troops, vehicles, artillery, and supplies to and from remote, austere environments since it replaced the CH-53D in 1981 (Military Update, 2025). Key improvements included the addition of a third engine, improved main rotor blades, composite tail rotor blades, a dual-point cargo system, a dual digital automatic flight control system, and an engine anti-ice system (Military Update, 2025). These upgrades enabled the aircraft to lift the majority of the USMC's equipment, operate in all weather conditions, and carry external loads at higher airspeeds, thereby greatly enhancing mission effectiveness (Military Update, 2025). However, after over four decades of service, the CH-53E has reached the limits of its operational and maintenance viability (Dowling, 2002; Trimble, 2019). Increasing sustainment costs, aging components, evolving threat environments that required more capable systems necessitated a modern replacement (Dowling, 2002; Trimble, 2019). In response, the Department of Defense (DoD), under the direction of the USMC and Naval Air Systems Command (NAVAIR), initiated the CH-53K King Stallion program to produce a next-generation heavy-lift helicopter capable of meeting the complex demands of 21st-century warfare (NAVAIR, n.d.; Office of the Director, Operational Test & Evaluation, 2017). As part of the DoD's broader modernization strategy, the CH-53K is intended not only to ensure the continuity of heavy-lift capabilities but also to enhance them dramatically. The primary mission of the CH-53K is to support the Marine Air-Ground Task Force by transporting heavy equipment and personnel from ship to shore, particularly during amphibious and expeditionary operations (Laird, 2025; NAVAIR, n.d.). It also supports secondary missions, including humanitarian assistance, disaster relief, and special operations (Laird, 2025; NAVAIR, n.d.).

The CH-53K King Stallion program represents a significant leap forward in heavy-lift helicopter technology for the USMC and the broader DoD. Developed by Sikorsky Aircraft Corporation, a Lockheed Martin company, the CH-53K is a technologically advanced helicopter equipped with a suite of advanced capabilities, making it the most modern heavy-lift helicopter in the U.S. military inventory (Lockheed Martin, n.d.). Its standout feature is the ability to lift 27,000 pounds externally over a 110-nautical-mile mission radius in high/hot conditions (3,000-feet altitude at 91°F), more than triple the lift capability of its predecessor, the CH-53E (NAVAIR, n.d.). It is powered by three General Electric (GE) T408 engines, each producing 7,500-shaft horsepower, enabling it to carry vehicles such as the Joint Light Tactical Vehicle (JLTV) via external hook (Lockheed Martin, n.d.). The aircraft features fly-by-wire flight controls, which enhance stability, agility, and reduce pilot workload, even in degraded visual environments (Lockheed Martin, n.d.). Its wider composite airframe and digital glass cockpit provide improved crew situational awareness, while advanced onboard diagnostics and health monitoring systems significantly reduce maintenance time and costs (NAVAIR, n.d.). The CH-53K also features a fully coupled autopilot system like systems currently in use in the MV-22B, and vast improvements have been made to the communications equipment incorporated in the aircraft, affording commanders additional command and control (C2) options (Naval Technology, n.d.).

Additionally, the aircraft features the most advanced Aircraft Survivability Equipment (ASE) produced, capable of identifying a wide array of threats, including small arms fire, Man-Portable Air Defense Systems, and advanced anti-aircraft missile systems (Naval Technology, n.d.). To achieve this capability, the CH-53K features redundant ASE systems, which establish a layered defense against the wide range of weaponry used in modern conflict (ODOT&E, 2024). An advanced countermeasure system is also incorporated, adding an additional layer of protection against both radar and infrared threats (ODOT&E, 2024). The CH-53K is designed for full shipboard compatibility, high survivability in contested environments, and seamless integration into joint and coalition operations, making it a critical enabler for expeditionary and distributed warfare (NAVAIR, n.d).

Since its inception, though, the CH-53K program has faced a series of challenges and delays stemming from technical, integration, and programmatic issues. Early in development, critical problems, including main gearbox failures, flight control instabilities during sling load operations, and engine integration complications, led to significant redesign efforts and extended testing periods (Athey, 2019). Software development also lagged, with integration of the helicopter's advanced digital systems proving more complex than anticipated (Department of the Navy, 2021). Technical issues that were identified later included problems with the blade fold system, issues incorporating the ASE, and engine gas reingestion (ODOT&E, 2018). These technical hurdles contributed to schedule slippages, pushing Initial Operational Capability (IOC) from 2019 to 2022 and delaying full-rate production until 2023 (ODOT&E, 2018). Additionally, rising costs, growth in airframe weight, and supply chain disruptions, particularly during the COVID-19 pandemic, exacerbated production challenges (Office of the Secretary of Defense, 2023). Further delays mean the CH-53K is not slated to deploy until 2025. However, that date continues to be pushed back, and the expected timeline for Full Operational Capability (FOC) has also slipped, from an initial estimate of 2021 to the most recent prediction of 2032 (Everstine, 2025).

A. PURPOSE OF RESEARCH/RESEARCH QUESTIONS

The purpose of this research is to analyze and understand the USMC's decision to move forward with the CH-53K program despite numerous delays and increasing costs while trying to reach set key performance parameters. It also seeks to find an alternative to the beleaguered CH-53K. To do so, this case study analyzes four heavy-lift options to determine the best approach for meeting USMC heavy-lift requirements while adhering to cost, schedule, and performance constraints. This research aims to address the following three key questions: Which platform best aligns with the USMC's long-term operational and strategic needs for heavy-lift capabilities? What are the significant trade-offs in cost, schedule, and performance when considering the four alternatives? Is there a better alternative to the CH-53K that meets USMC heavy-lift requirements and can reach the force faster and at less cost?

B. RESEARCH METHODOLOGY

The primary objective of this research is to provide a comprehensive evaluation of the Heavy-lift Replacement (HLR) program and the acquisition decisions leading to the CH-53K King Stallion. By applying Department of Defense (DoD) acquisition frameworks, this study employs a structured methodology that begins with a Capabilities-Based Assessment (CBA) to identify mission shortfalls and validate the heavy-lift capability gap. A Doctrine, Organization, Training, materiel, Leadership and Education, Personnel, Facilities, and Policy (DOTmLPF-P) analysis is then used to evaluate whether non-materiel solutions, such as changes in doctrine, training, or sustainment, could close the gap or whether a materiel solution is required. Finally, an Analysis of Alternatives (AoA) is used to compare the feasibility, cost, schedule, performance, and risk of extending the CH-53E, procuring CH-47F Block II aircraft, developing the CH-53K King Stallion, or upgrading the CH-53E fleet while simultaneously investing in autonomous heavy-lift systems. This analysis ensures consistency with Joint Capabilities Integration and Development System (JCIDS) and DoD Instruction 5000.84 (Office of the Director, Cost Assessment and Program Evaluation, 2020) and evaluates whether the CH-53K represents the most effective solution to fulfill the USMC heavy-lift capability gap.

C. RESEARCH LIMITATIONS

This report presents an unclassified analysis of the CH-53K acquisition program, comparable aircraft, and upgrade options tailored to best meet the needs of the USMC. As the aircraft is currently still being delivered, one of the most significant limitations faced is maintaining accurate information throughout the study, including shifting timelines, total program cost, individual airframe price, and the most up-to-date delivery numbers.

Additionally, only unclassified information is included, which results in many aspects of the airframe being omitted when considering aircraft capabilities. Commonly classified information is associated with the ASE, communications systems, and navigation capabilities, many of which are significant improvements over the CH-53E's capabilities.

Lastly, the limited ability to acquire program documentation directly from the source has restricted the acquisitions analysis to reports or articles produced after the program slip had already begun. The ability to acquire the initial documents associated with the CH-53K would provide significantly higher insight into many of the decisions made early in the program, which resulted in many of the unfavorable outcomes experienced.

D. ORGANIZATION

The following chapters chronologically outline the requirements, timeline, and challenges of the CH-53K program using all official reports published on the program, including governmental reports, publications from third-party entities, and articles from news and media sources. Chapter II provides a detailed history of the CH-53K program, and Chapter III summarizes previous research and reports about the CH-53K program, including the challenges the program has faced since inception. Chapter IV provides the USMC's current heavy-lift requirements to establish a baseline for potential alternative options. The chapter then goes on to identify alternative heavy-lift options for the USMC and analyzes each alternative's ability to meet USMC operational needs and requirements. This research focuses on alternatives to include continuing the CH-53K program, adopting the CH-47F Block II from the Army, upgrading the existing CH-53E while investing in autonomous heavy-lift technology, and canceling the CH-53K program. Chapter V analyzes each alternative using a capabilities-based assessment and AoA to determine the best path forward for the USMC. Lastly, Chapter VI provides a summary, conclusions, lessons learned, and recommendations for future research. The focus of this research is a case study, designed to analyze the critical decisions made throughout the CH-53K's program of record and understand the reasoning behind those decisions.

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II. BACKGROUND

This chapter provides the foundation for analyzing the CH-53K through the DoD's Adaptive Acquisition Framework (AAF). It is divided into three main parts. First it explains how "Big A" acquisition, JCIDS, PPBE, and the Defense acquisition System (DAS), convert validated operational needs into funded programs. Second, it provides historical context for the USMC heavy-lift program and identifies CH-53E capability and sustainment gaps. Finally, it explains how those gaps led to the establishment of the CH-53K program and how the program has evolved throughout the "Big A" process.

A. ACQUISITION PROCESS

The DoD's AAF governs acquisition pathways and provides authorities with flexibility to tailor processes to program characteristics (Office of the Under Secretary of Defense for Acquisition and Sustainment [OUSD(A&S)], 2020a). As a Major Capability Acquisition (MCA) program, the CH-53K follows the milestone-driven structure of the AAF. The AAF is designed to balance acquisition requirements with cost, schedule, and performance, also known as the triple constraints (OUSD[A&S], 2020a). Central to this framework are three interconnected and interlinked decision support systems that comprise "Big A" acquisition: JCIDS, the Planning, Programming, Budgeting, and Execution (PPBE) process, and the DAS, also known as "Little A" Acquisition (see Figure 1; Schultz, n.d.).

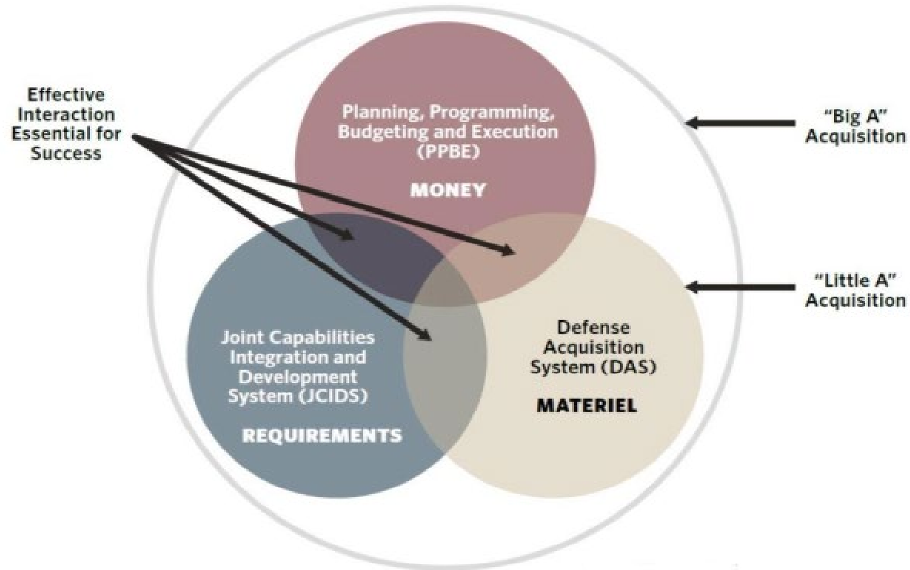


Figure 1. DoD Decision Support System Depicting JCIDS, PPBE, and DAS Interactions. Source: Schultz (n.d.).

1. Joint Capabilities Integration and Development System

JCIDS is the DoD's formal process for generating major acquisition requirements and ensuring capability development aligns with the National Defense Strategy (Joint Chiefs of Staff, 2021). It is regulated by Chairman of the Joint Chiefs of Staff Instruction 5123.01I, *Charter of the Joint Requirements Oversight Council (JROC) and Implementation of the Joint Capabilities Integration and Development System*. JCIDS is governed by JROC, which is responsible for validating the Joint Performance Requirements, ensuring interoperability, and providing oversight across the joint force (Chairman of the Joint Chiefs of Staff, 2015).

The JCIDS process begins by identifying a capability gap and developing a validated need (requirement) based on mission demands (Joint Chiefs of Staff, 2021). These requirements are documented in the Initial Capabilities Document (ICD) and Capabilities Development Document. Reviewed by Functional Capabilities Boards and validated by JROC, these documents establish the basis for the Key Performance Parameters (KPPs) and serve as the measurable standards of program success (Joint Chiefs of Staff, 2021). For example, the USMC's pursuit of a next-generation heavy-lift helicopter is articulated and validated through JCIDS documentation.

JCIDS uses deliberate, urgent, and emergent requirement lanes to align capability development with operational needs and timelines (Joint Chiefs of Staff, 2021):

Future requirements with a fielding timeline exceeding 2 years will utilize the deliberate process. This process uses the ICD to validate joint military capability requirements and the Capabilities Development Document to validate performance attributes of proposed solutions. Staffing timelines are 67 days for an ICD, 59 days for an Information Systems, 40 days for a Software ICD, and 103 days for a CDD or Information Systems. This process is best suited for long-term, high-cost programs such as major weapon systems, ships, or aircraft (Joint Chiefs of Staff, 2021).

In contrast, the Urgent and Emergent Process lanes provide a mechanism for addressing pressing capability gaps related to ongoing or anticipated contingency operations. These lanes aim to field solutions within a 2-year timeframe. Urgent requirements' staffing timelines are accelerated and processed in 15 days, and emergent requirements are executed in 31 days. Urgent needs typically involve situations in which lives are in danger and immediate solutions are required. In contrast, emergent needs reflect critical shortfalls that, although not immediately life-threatening, significantly affect mission effectiveness (Joint Chiefs of Staff, 2021).

Together, these three JCIDS lanes provide a flexible framework, with the deliberate process providing joint oversight for long-term capabilities and the urgent and emergent processes allowing the DoD to respond rapidly to near-term operational demands (Joint Chiefs of Staff, 2021).

2. Planning, Programming, Budgeting, and Execution

PPBE is the DoD's primary budgeting and resource allocation system. Governed by DoD Instruction 7045.14, PPBE provides the regulatory framework for translating strategic guidance into actionable fiscal plans. After requirements are established, programs compete for funding against other programs during the annual PPBE cycle (DoD, 2013). In the planning phase, priorities are developed by thoroughly reviewing various strategic documents, including the National Security Strategy and the National Defense Strategy, to identify long-range requirements that align with national objectives (DoD, 2013). The programming phase translates the planning guidance into a detailed, time-phased allocation of resources across a 1–5-year period (DoD, 2013). Each DoD component (Air Force, Army, Marine Corps, Navy, and Space Force) develops a Program Objective Memorandum (POM) to outline how it will meet the strategic goals and propose resource lanes for forces, funding, and manpower (Joint Chiefs of Staff, 2021). The Office of the Secretary of Defense then reviews POMs and integrates them into a defense program (Joint Chiefs of Staff, 2021). Next, in the budget phase, the resource plans in the POM are converted into a detailed 1-year Budget Estimate Submission to align with fiscal policy and Congressional expectations (Joint Chiefs of Staff, 2021). The Budget Estimate Submission is reviewed by the Under Secretary of Defense Comptroller and Office of Management and Budget representatives to ensure proper funding categories, pricing, and execution to develop Program Budget Decisions that will ultimately shape the final defense budget that is submitted to the president (DoD, 2013). Finally, the Execution phase assesses the rate at which the funds are being obligated and spent and ensures the funds are achieving the intended outcomes (DoD, 2013). This process helps identify shortfalls and any necessary adjustments to resources or structure. The results of the assessment are drafted into the Annual Performance Report to demonstrate how well the DoD is meeting goals outlined in the president's budget (DoD, 2013). This structured approach ensures funding decisions are strategically aligned and fiscally sound across all phases.

3. Defense Acquisition System

The DAS, often referred to as Little A acquisition, is established under DoD Directive 5000.01, *The Defense Acquisition System*, and implemented through DoD Instruction (DoDI) 5000.02, *Operation of the Adaptive Acquisition Framework* (OUSD[A&S], 2020a, 2020b). These publications provide the overarching principles and processes that govern all defense acquisition programs. The AAF consists of six tailored pathways: Urgent Capability Acquisition, Middle Tier of Acquisition, MCA, Software Acquisition, Defense Business Systems, and Acquisition of Services, allowing program managers to adapt strategies based on risk, timelines, and capability requirements (see Figure 2; OUSD[A&S], 2020c).

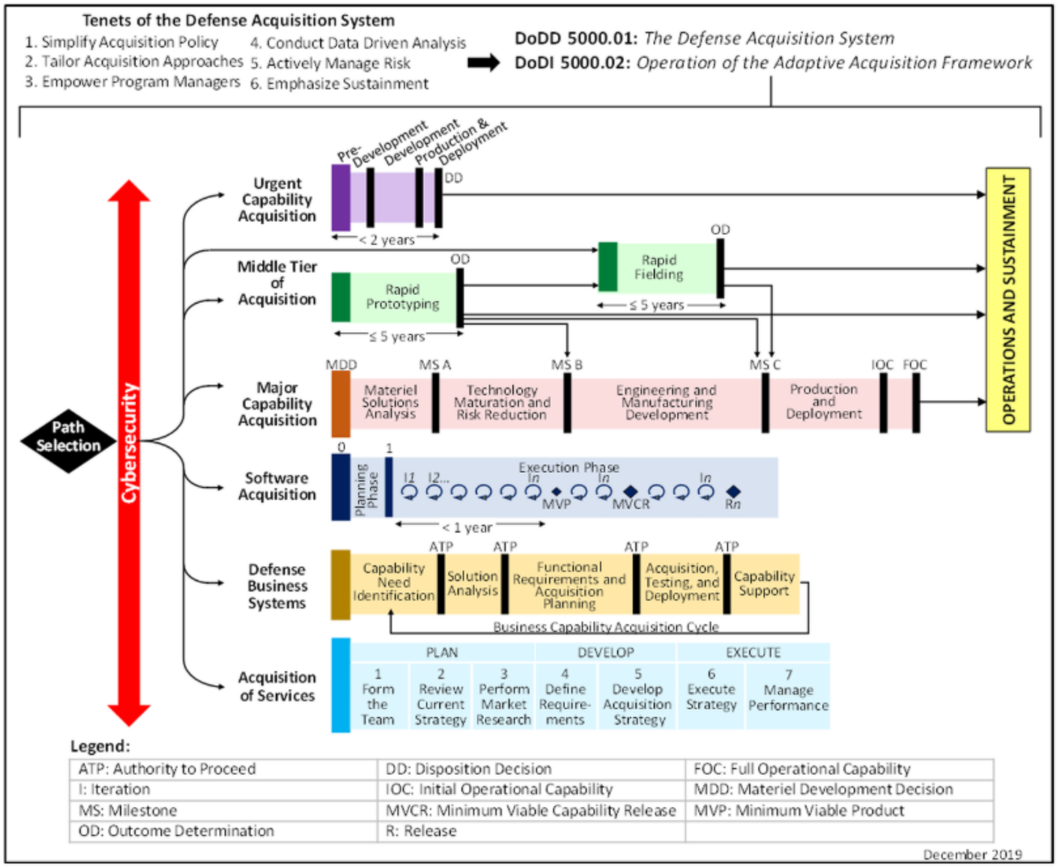


Figure 2. DoD Adaptive Acquisition Framework Pathways. Source: OUSD (A&S; 2020c).

Under the MCA pathway, the CH-53K follows the milestone structure of the DAS from development through defined Milestone Decisions A, B, and C and progresses through distinct phases: Materiel Solution Analysis, Technology Maturation & Risk Reduction, Engineering & Manufacturing Development (EMD), and Production & Deployment (OUSD[A&S], 2020c). At each phase, the Milestone Decision Authority makes a milestone decision to determine if the program has met the necessary criteria to proceed. (OUSD[A&S], 2020c). For example, Milestone B marks the transition into EMD, where system design is finalized and prototypes are tested (OUSD[A&S], 2020c). Each phase has a distinct purpose and ultimately ensures that technical risks are managed, costs remain within budget, and performance is demonstrated prior to full-rate production (OUSD[A&S], 2020c).

4. Triple Constraints

The triple constraints of cost, schedule, and performance provide a framework to evaluate risks and identify potential trade-offs in acquisition programs (Karnes & Mortlock, 2021). The three dimensions are highly interdependent; improving one negatively affects the others, while accepting trade-offs may provide positive benefits for another (Karnes & Mortlock, 2021). All three elements must be continuously evaluated and integrated throughout the acquisition life cycle to set realistic expectations, conduct trade-off analyses, and inform milestone decisions. They are also fundamental to the development of the three sections of the Acquisition Program Baseline (APB), with KPPs listed verbatim in the performance section of the APB, along with threshold and objectives values for cost, schedule, and performance requirements (OUSD[A&S], 2020c).

5. Capabilities-Based Assessments

A CBA is designed to identify and assess gaps in joint warfighting capability, identify materiel and non-materiel solutions and is completed before the development of any JCIDS documents (Joint Chiefs of Staff, 2021). Both materiel and non-materiel solutions include modifications to DOTmLPF-P. While non-materiel solutions may be achieved entirely through those adjustments, materiel solutions typically require additional follow-on acquisition programs to be successfully fielded (Joint Chiefs of Staff, 2021).

The USMC initiated a CBA in the early 2000s to assess the HLR requirement. A series of shortfalls were identified in the CH-53E fleet, including payload capacity, range in high/hot environments, survivability against modern threats, and long-term reliability and sustainment (Lorell et al., 2005). Consistent with JCIDS requirements, the CBA resulted in the generation of an ICD, validated by JROC, which framed the need for the HLR and later informed the 2003 AoA that Booz Allen Hamilton completed in September 2003 (Joint Chiefs of Staff, 2021; Government Accountability Office [GAO], 2009).

6. Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, Facilities, and Policy Analysis

According to the Joint Chiefs of Staff (2021), the DOTmLPF-P analysis is conducted to identify and propose non-materiel solutions or to complement materiel solutions. The lowercase "m" indicates materiel solutions that enable DoD forces to operate effectively but does not signify new materiel development, as DOTmLPF-P Change Recommendations do not advocate for new materiel development but focus on adjustments to doctrine, organization, training, leadership, and education, personnel, facilities, and policy (Joint Chiefs of Staff, 2021).

The USMC assessed DOTmLPF-P options in the early 2000s. Adjustments in doctrine and organization fixes, such as redistributing assets or mixed-fleet approaches, and training and operational modifications in degraded environments, like the CH-53E's degraded performance in high/hot conditions, offered incremental improvements but could not offset payload and survivability limitations (Dowling, 2002; Lorell et al., 2005). Although leadership, personnel, and facilities were not identified as critical limiting factors, high sustainment maintenance labor hours per flight hour strained aviation units. The CH-53E was approaching airframe limits, and rising ownership costs led to the need for a Service Life Extension Program (SLEP) through 2025 (Dowling, 2002). However, RAND found that only a materiel solution, the CH-53K, could close the USMC heavy-lift capability gap (Lorell et al., 2005).

7. Analysis of Alternatives

The AoA provides an analytical comparison of potential materiel solutions to an identified and validated capability gap (DoD, 2017). They are essential to ensuring programs enter development with well-defined baselines and an understanding of cost, schedule, performance, and risk trade-offs. Conducted after the Materiel Development Decision and before Milestone A, the AoA evaluates life-cycle cost, schedule, performance, operational effectiveness, suitability, and risk across a range of feasible alternatives (DoD, 2017; OUSD[A&S], 2020c). The purpose of the AoA is to identify the best option and then serve as a guide throughout the Materiel Solution Analysis Phase (DoD, 2017). The Director of Cost Assessment and Program Evaluation (CAPE) develops and approves AoA study guidance, approves DoD Component–prepared AoA study plans, and evaluates adequacy for Major Defense Acquisition Programs (MDAPs; DoD, 2017).

In 2003, the USMC commissioned Booz Allen Hamilton to conduct the HLR program AoA (GAO, 2009). While the details of that study remain limited in public sources, the Department of the Navy and RAND analysis indicate that the AoA considered three viable solutions: extending the service life of the CH-53E, procuring CH-47 aircraft in a joint-service configuration, or developing a new-build heavy-lift helicopter (Assistant Secretary of the Navy for Research, Development, and Acquisition, n.d.; Lorell et al., 2005). The AoA determined that, despite the higher costs and risks involved, only a new aircraft could fully meet the payload, range, and survivability requirements (Assistant Secretary of the Navy for Research, Development, and Acquisition, n.d.; Lorell et al., 2005). This conclusion supported the Milestone B decision in December 2005 and the initiation of the CH-53K King Stallion program (Department of the Navy, 2021).

The Heavy-lift Replacement AoA was conducted prior to major acquisition reforms that reshaped how the DoD manages AoAs. At the time, CAPE did not have statutory authority to review AoAs, and many programs advanced into development with too many technical unknowns and insufficient knowledge of cost, schedule, and performance risks (W GAO, 2009; Weapon Systems Acquisition Reform Act [WSARA], 2009). The GAO (2009) found that although the CH-53K AoA had a broad scope of alternatives and an adequate risk assessment, it chose an alternative too early, experienced problematic timing, and had late or absent guidance from the Office of Program Analysis and Evaluation. The premature timing, combined with late or absent guidance, resulted in alternatives being selected before sufficient systems engineering knowledge, technology readiness data, and risk assessments were available (GAO, 2009). These deficiencies were not unique to the CH-53K; the GAO's 2009 assessment of 96 MDAPs documented that 72% had experienced unit cost increases since their initial estimates, and the average delay in delivering initial operational capabilities was 22 months.

In response, Congress passed the WSARA of 2009, which strengthened systems engineering, required technology maturity at key milestones, and gave CAPE explicit oversight of AoAs. These mandates were codified in DoDI 5000.84 (Office of the Director, CAPE, 2020), which establishes AoA policy.

In 2019, the CH-53K program experienced the impact of these reforms following persistent cost growth and performance concerns. The Office of the Secretary of Defense directed CAPE to conduct a new AoA to reassess whether the CH-47F Block II Chinook might serve as a viable alternative to the CH-53K (Trevithick, 2019). This requirement reflected the heightened scrutiny and discipline enacted by the WSARA reform. The DoD continued to enhance its efforts in evaluating AoAs, which culminated in a 2021 report from the OUSD(A&S). The report, which was created in collaboration with RAND and the Institute for Defense Analyses concluded that despite progress, there were still challenges in ensuring adequate time, unbiased trade-space exploration, and alignment to best practices (Joseph, 2021).

B. HISTORIC USMC HEAVY-LIFT REQUIREMENTS

From fleet experience, it is abundantly clear that to meet the unique mission sets and demanding logistics considerations associated with Expeditionary Advanced Base Operations (EABO), the USMC relies heavily on assault support aircraft. These factors include condensed timelines, significant geographic distance, and astounding amounts of equipment. The current fleet of assault support aircraft consists of the C-130 "Hercules," MV-22B "Osprey," UH-1Y "Huey," and CH-53E "Super Stallion," each of which serves a unique purpose. As the only fixed-wing aircraft, the C-130 has the most cargo capacity of any of the USMC assault support aircraft and can travel the greatest distance. However, the EABO construct has limitations, notably the inability to land on remote islands without sufficiently flat landing areas or improved surfaces. The MV-22B is a tiltrotor aircraft that can travel significant distances at very high speeds compared to other rotary aircraft, and it can remain on station for extended periods of time. It also has a modern communications suite, making it a great choice as a C2 asset. Where the MV-22B falls short is its ability to carry significant cargo weight, particularly in high, hot, and heavy conditions. The UH-1Y typically flies in conjunction with the AH-1Z as Close Air

Support (CAS) assets, and while the Huey does serve as another capable armed C2 asset, it is limited by the cargo weight that it can embark and the time it can stay on station, making it a better fit for CAS and Special Operations–type missions. The CH-53E has the largest cargo capacity of any helicopter currently employed by the USMC. However, it falls short in terms of the age of the platform, the need for retrofitting with modern technology, and the exponential maintenance costs. An aging platform translates into parts wear and ultimately shortages of crucial engine, drivetrain, and electronic parts, which results in reduced readiness rates and higher costs to maintain the existing fleet. Additionally, the growth in technology since the development of the CH-53E has resulted in midlife upgrades and "bolt-on" components, some of which are incompatible with legacy systems, which have impacted the aerodynamic characteristics of the aircraft and increased base weight, thus decreasing lift capacity.

As observed, given the different roles of each assault support aircraft, the Marine Corps has established training and readiness manuals that not only lay out the requirements that each squadron must meet, but also the mission sets and capabilities that are required of each aircraft, which can be traced back to initial phases of procurement. Within the core portion of mission-essential tasks for USMC heavy-lift aircraft are combat assault transport, heavy rotary wing air delivery, aviation support of tactical recovery of aircraft and personnel, and air evacuation. The CAT requirement involves an aircraft capable of conducting a long-range air assault, carrying enough combat-loaded Marines to accomplish the objective effectively, and integrating with escort aircraft in various communication mediums. To conduct AD, USMC aircraft must be able to quickly and efficiently deliver a broad spectrum of equipment, weapons, or supplies in support of ground operations that may range from resupply to EABO to humanitarian assistance and disaster relief operations. TRAP missions require an aircraft large enough and crews sufficiently trained to recover not only isolated aircrew, but also airframes that have been downed due to enemy fire, mechanical issues, or environmental considerations. Lastly, the mission set of AE requires an aircraft capable of transporting a large number of people in the event of a non-combatant evacuation while also being equipped to transport dozens of litter-bound patients in the event of a mass casualty event.

For decades, the CH-53E has fulfilled the Marine Corps' core assault support requirements. However, the aging fleet, inability to acquire new airframes, and limited capacity to meet replacement parts requirements have raised concerns about the heavy-lift aspect of the Marine Corps' fleet. Obsolescence is also a concern, as the CH-53E still uses steam gauges and linkage-based flight controls. At the same time, many modern aircraft have evolved to glass cockpits and fly-by-wire technology. Many technological evolutions have been incorporated within the Super Stallion fleet, but each new iteration has increased the base weight of the aircraft, reducing the margin of lift capacity. For an aircraft whose sole purpose is maximizing lift capacity, an alternate solution must be considered.

C. CH-53K PROGRAM HISTORY

The Navy initiated the CH-53K program in 2003 to replace the aging CH-53E that had been in service since 1981 (Laatsch, 2003). While a very capable heavy-lift aircraft on paper, the CH-53E is plagued by constrained performance at high altitude and high temperatures (Laatsch, 2003). The CH-53E can only fly 200 nautical miles (N) while carrying 7,600 pounds if the pressure altitude is 3,000 feet and the temperature is 91 degrees Fahrenheit or more (Laatsch, 2003). Additionally, the CH-53E lacks survivability upgrades required on the modern battlefield (Laatsch, 2003). These limitations led to the 2003 AoA that validated the requirement to develop a new heavy-lift aircraft to support USMC operations (Delgado, 2020).

The CH-53K was designed to be the most powerful helicopter in the DoD, significantly expanding USMC capabilities (NAVAIR, 2025). Key features of the CH-53K include:

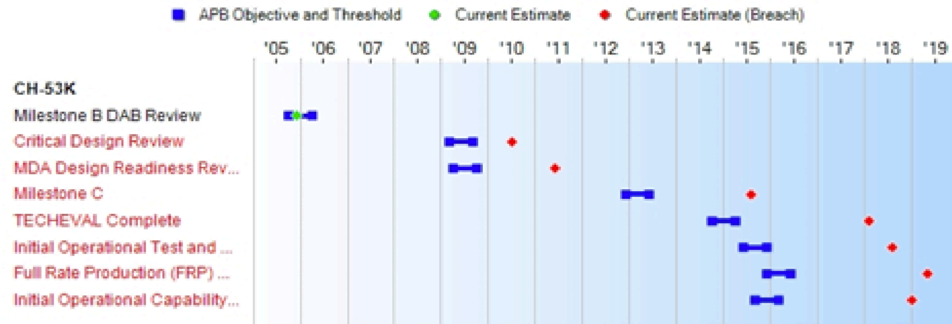
- Increased max lift capacity to 36,000 pounds under standard conditions and 27,000 pounds to a radius of 110 NM away under high/hot conditions (NAVAIR, 2025)
- Fly-by-wire flight controls and a glass cockpit to increase survivability, safety, and the ability to operate in degraded visual environments (NAVAIR, 2025)
- Approximately 63% fewer parts than the CH-53E, low-maintenance elastomeric rotor head, and high-efficiency composite rotor blades to improve maintenance (Hill, 2025; NAVAIR, 2025)

- The USMC originally planned to purchase 156 aircraft at a program acquisition unit cost of approximately $96 million per aircraft and to achieve initial operational capability by September 2015 (Pridgen, 2011).

The program quickly moved through Milestone B and into EMD in December 2005, followed by a system development and demonstration (SDD) contract award to Sikorsky in January 2006 (DoD, 2011). As the CH-53K program moved into testing and development, multiple design deficiencies requiring design revisions were exposed, leading to schedule delays and increased costs (Delgado, 2020). As of 2019, the CH-53K had a total of 126 technical deficiencies, which include, “Airspeed indication anomalies, low reliability of main rotor gearbox, hot gas impingement on aircraft structures, tail boom and tail rotor structural problems, overheating of main rotor dampers, fuel system anomalies, high temperatures in the #2 engine bay, and hot gas ingestion by the #2 engine, which could reduce available power” (Trevithick, 2019, p. 6).

As a result of these challenges, the APB was updated in 2013 to reflect the increased costs and then once again re-baselined in 2019 after breaching the APB schedule milestone for technical evaluation complete, Initial Operational Testing and Evaluation (IOT&E) complete, IOC, and Full-Rate Production (FRP) decision review (DoD, 2023). Figure 3 shows the delays in major milestones along the acquisition pathway.

Schedule



Milestones	SAR Baseline Dev Est	Current APB Development Objective/Threshold		Current Estimate	
Milestone B DAB Review	OCT 2005	OCT 2005	APR 2006	DEC 2005	
Critical Design Review	MAR 2009	MAR 2009	SEP 2009	**JUL 2010** [1]	
MDA Design Readiness Review	APR 2009	APR 2009	OCT 2009	**JUN 2011** [1]	(Ch-1)
Milestone C	DEC 2012	DEC 2012	JUN 2013	**AUG 2015** [1]	
TECHEVAL Complete	OCT 2014	OCT 2014	APR 2015	**FEB 2018** [1]	(Ch-2)
Initial Operational Test and Evaluation (OPEVAL) Complete	JUN 2015	JUN 2015	DEC 2015	**AUG 2018** [1]	
Full Rate Production (FRP) Decision Review	DEC 2015	DEC 2015	JUN 2016	**MAY 2019** [1]	
Initial Operational Capability (IOC)	SEP 2015	SEP 2015	MAR 2016	**JAN 2019** [1]	

[1] *APB Breach*

Figure 3. Original CH-53K APB Schedule. Source: DoD (2011).

After prolonged testing and design revisions, the CH-53K was finally declared IOC in April 2022 and entered FRP in December 2022, but at a significant increase in cost and delay in schedule (DoD, 2023). The PAUC of the CH-53K is now an estimated $123 million per aircraft, and the USMC increased the total purchase to 200 aircraft (DoD, 2023). Table 1 shows the original cost estimate from the 2005 APB and the current estimated cost.

Table 1. Current Estimate Compared with Current Baseline. Source: DoD (2023).

Category (CY$M) Base Year: 2006	Original Baseline 12/22/2005	Current Estimate PB 2025	% Change
Program Acquisition Unit Cost			
Acquisition Cost	14,980.9	24,683.5	
Program Quantity	156	200	
PAUC	96.031	123.417	28.52%
Average Procurement Unit Cost			
Procurement Cost	11,018.9	17,784.7	
Procurement Quantity	152	196	
APUC	72.493	90.738	25.17%

The Current Estimate's constant-year dollars have been converted from Base Year 2017 to Base Year 2006 using the National Defense Budget Estimates for FY 2024 (Green Book).

Although the CH-53K finally entered FRP, production and deliveries of the aircraft are protracted through 2031, with FOC not expected until 2032, almost 30 years since the decision to initiate the program (DoD, 2023; Everstine, 2025). These delays have left government decision-makers questioning the future of the CH-53K program. A timeline of significant events for the CH-53K program is shown in Table 2.

Table 2. CH-53K Program Timeline of Significant Events. Source: DoD (2023).

Date	Description
September 2003	AoA completed, resulting in decision to initiate a HLR program
December 2004	JROC approved CH-53K Capabilities Development Document
October 2005	The HLR program completed a Milestone B Defense Acquisition Board (DAB) review
December 2005	Under Secretary of Defense for Acquisition, Technology, and Logistics (USD[AT&L] signed the Milestone B ADM for entry into SDD
January 2006	SDD contract awarded to Sikorsky for the CH-53K
July 2010	The CH-53K program conducted the Critical Design Review (CDR)
June 2011	Assistant Secretary of Defense for Research and Engineering completed a Post CDR Assessment, determining the program demonstrated to enter System Capability and Manufacturing Process Demonstration

April 2013	Updated APB approved based on an updated Program Life-Cycle Cost Estimate (PLCCE) and January 2013 service cost position (SCP)
May 2013	Contract award for four System Developmental Test Article (SDTA) aircraft; beginning with this contract, the CH-53K program began procuring GE T-408 engines directly from General Electric Aviation
October 2015	First Flight completed on EMD aircraft
April 2016	Low-Rate Initial Production (LRIP) Lot 1 advance acquisition contract (AAC) awarded
August 2016	Four EMD aircrafts in flight test
October 2016	Program successfully completed an IOT&E in West Palm Beach, FL
January 2017	Letter of Request for Pricing and Availability
June 2017	LRIP Lot 2 AAC awarded
July 2017	Letter of Offer and Acceptance issued to Germany for potential Direct Commercial Sales
November 2017	The CH-53K program was re-designated from an ACAT 1D to ACAT 1C Program
February 2018	LRIP Lot 2 AAC awarded
January 2019	The CH-53K program was reported as a breach of the APB schedule milestone for Milestone C decision to resolve concurrency issues, engine supply chain, parts availability, and cost growth. An MDAP breach was reported and certified by the USD(AT&L). Program initiated correction of deficiencies and continued to conduct operational test and evaluation activities
March 2019	The CH-53K program was rebaselined as part of the APB schedule milestone for Milestone C decision to resolve concurrency issues, engine supply chain, parts availability, and cost growth. LRIP Lot 2 contract awarded for two aircraft and first FRP decision review
August 2019	LRIP Lot 4 AAC and Lot 3 contract awarded for three aircraft in Fiscal Year (FY) 2018 and seven aircraft in FY2019
October 2019	Deputy Assistant Secretary of Defense for Acquisition Enablers approved 10 (1) address consideration of Operations and Support affordability constraints in acquisition strategies and program decision reviews and (2) address Operations and Support affordability in LRIP aircraft

January 2020	Assistant Secretary of the Navy for Research, Development, and Acquisition and Defense Acquisition Executive, in concurrence with the Department of the Marine Corps, signed a DoDI 5000.85–compliant FRP decision memo to support FRP decision and approve an updated APB that incorporates LRIP aircraft quantities; a full funding certification issued to Congress
November 2020	LRIP Lot 5 contract for six aircraft awarded
March 2021	Israel Ministry of Defense (MoD) submitted Letter of Request for Letter of Acceptance for 12 aircraft (with options up to 18)
November 2021	LRIP Lot 6 contract for one aircraft awarded
December 2021	LRIP Lot 7 AAC awarded
December 2021	Letter of Request publicly issued to Germany (Foreign Military Sales)
December 2021	Israel MoD Letter of Acceptance signed
January 2022	LRIP Lot 6 contract for nine aircraft awarded
February 2022	First International MoD test contract for 4 aircraft awarded on LRIP Lot 6
April 2022	IOC declared
April 2022	IOT&E complete
May 2022	The airframe Lot 6 contract was modified May 31, 2022, to add two additional aircraft added by Congress in the FY2022 Consolidated Appropriations Act
October 2022	Lot 6 AAC awarded
December 2022	FRP approved
February 2023	FRP APB approved
April 2023	Lot 6 Engine contract, Lot 7–8 engine Block Buy Contract awarded
August 2023	Lot 7–8 Airframe Block Buy Contract awarded (including Israel)
December 2023	CH-53K Materiel Support Date
December 2023	FRP Lot 9 AAC awarded

D. SUMMARY

This chapter provided an understanding of how the CH-53K program evolved within the DoD's AAF. It first illustrated how "Big A" systems provided the structured processes for validating requirements, allocating resources and managing program execution. It then linked these systems to the USMC heavy-lift missions and identified the CH-53E's limitations. These insights demonstrated the need for an alternate USMC heavy-lift solution and enables a further analysis of the CH-53K program through a CBA, DOTmLPF-P, and AoA.

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III. LITERATURE REVIEW

This literature review examines prior research, government reports, and oversight publications related to the CH-53K King Stallion program and the broader defense acquisition environment in which it was developed. The purpose of this chapter is to highlight existing analyses to identify the recurring factors that contributed to the program's cost growth, schedule delays, and technical challenges. First, it explores a previous case study about the CH-53K's developmental history. Second, it examines assessments of the pre- and post-reform Analysis of Alternatives (AoA) processes. Last, it looks at the body of research documenting the program's key milestones and performance outcomes. Through this review, the chapter establishes the empirical and historical foundation necessary to evaluate how acquisition practices, technological maturity, and policy changes have shaped the CH-53K's negative trajectory and continue to inform lessons for future major defense acquisition programs.

A. PREVIOUS CASE STUDIES

In 2020, Ensign Alexis Delgado conducted a case study for the Naval Postgraduate School on the CH-53K program history to identify what led to the schedule delays and cost growth. Delgado (2020) examined the defense acquisition process, how it was applied to the CH-53K program, and all relevant government reports, publications, and articles from various media sources that were published prior to 2020. In the report, she highlighted multiple compounding factors that led to the program's significant schedule delays and cost overruns. These factors include program management by the program manager (PM), changes in procurement quantities, and contractor staffing issues (Delgado, 2020).

First, the PM's inability to manage the triple constraint of cost, schedule, and performance throughout the program caused significant delays and incurred additional costs (Delgado, 2020). The CH-53K was designed to provide triple the lift capacity of the CH-53E but was constrained to the same size as the CH-53E (Delgado, 2020). This required pushing the limits of immature technology, which led to missed performance goals during testing and, consequently, cost and schedule growth (Delgado, 2020); these delays should have been expected due to the immature technology and the importance of meeting performance requirements and factored into the program schedule (Delgado, 2020). While cost and schedule baselines changed multiple times throughout development and production, performance baselines remained the same (Delgado, 2020). Additionally, the design was not stable prior to the CDR (Delgado, 2020). The program released 89% of design drawings, when the best practice is 90% at the CDR (Delgado, 2020). While this is only a 1% difference, the purpose of the CDR is to have a stable design prior to production, and design reworking can lead to significant schedule delays and increased cost, both of which were seen with the CH-53K (Delgado, 2020).

Second, the procurement quantity of the CH-53K increased from 156 to 200 aircraft, which was incorrectly attributed to the increased cost of the program (Delgado, 2020). The increased quantity caused the USMC to re-baseline the program, but the Inspector General questioned the estimates, resulting in a negative Inspector General report (Delgado, 2020). According to the IG, the increased research, development, test, and evaluation (RDT&E) costs were due to the technical setbacks and schedule delays, while procurement costs only increased slightly due to the additional 44 aircraft (IG, 2013a). The GAO also reported that the program's cost and schedule setbacks were mainly credited to technical issues rather than increased procurement quantities (GAO, 2011).

Third, contractor staffing issues during the early stages of the program led to delays in the aircraft's development (Delgado, 2020). Sikorsky failed to adequately staff the program with qualified personnel during some of the most critical stages of the aircraft's development (Delgado, 2020). This can be attributed to parent company Lockheed Martin's ownership change in 2015 and the subsequent shifting of the production line from Palm Beach, FL, to Stratford, CT (Delgado, 2020). Sikorsky decided to build the first four SDTA aircraft at the Palm Beach facility and then build the remaining aircraft at the Stratford facility, which required those production line changes (Delgado, 2020). The production line move resulted in equipment and configuration changes that interrupted production, and the move occurred during production of the system demonstration test articles (SDTAs; Delgado, 2020). This transition during assembly led to issues achieving statistical control of the critical manufacturing process that is required prior to FRP (Delgado, 2020).

B. ANALYSIS OF ALTERNATIVES ASSESSMENTS

The HLR program AoA was completed in 2003. It was during a pre-reform acquisition environment that the GAO (2009) characterized MDAPs as having systemic cost growth, schedule delays, and immature technologies at program initiation. Since the publication of that report, the acquisition community has undergone significant reform, including the WSARA (2009), the codification of AoA requirements in DoDI 5000.84 (Office of the Director, CAPE, 2020), and subsequent congressional oversight through the FY2020 National Defense Authorization Act (NDAA; 2019). The DoD's 2021 *Assessment of Analysis of Alternative Studies in the Department of Defense as Compared to Best Practices* provides a post-reform benchmark for how AoAs are conducted and evaluated against best practices (Joseph, 2021). Together, these reports allow for a two-sided analysis. GAO-09-665 offers context for the CH-53K's original AoA, while the 2021 assessment establishes the standards by which today's and future AoAs should be judged (GAO, 2009; Joseph, 2021). An understanding of the pre-reform environment provides a valuable historical lens for interpreting the CH-53K's developmental trajectory.

1. Heavy-Lift Requirement Program's Pre-Reform Analysis of Alternatives: GAO-09-665

The 2009 GAO report *Defense Acquisitions: Many Analyses of Alternatives Have Not Provided a Robust Assessment of Weapon System Options* provides a broad assessment of 96 MDAPs, including rotary-wing and fixed-wing aircraft, ground vehicles, and missile systems (Government Accountability Office, 2009). Its primary purpose was to assess the effectiveness of the DoD's AoA process in guiding program initiation, the factors influencing AoA scope and quality, and whether previous DoD policy changes had enhanced the effectiveness of the AoAs (GAO, 2009). Its findings provide insight into the acquisition environment in which the HLR program AoA was conducted in 2003 (GAO, 2009). The GAO (2009) found that 72% of MDAPs experienced unit cost growth, with an average delay of 22 months in delivering initial capabilities. Many programs entered system development without fully mature technologies, which elevated downstream integration risks (GAO, 2009). Weaknesses in systems engineering, testing, and manufacturing readiness were cited as recurring drivers of instability (GAO, 2009). Decision-makers frequently advanced programs into development without having the essential knowledge and technological maturity necessary to provide reliable cost and schedule estimates, which ultimately undermined the credibility of the pre-reform AoAs (GAO, 2009). Applied to the CH-53K, GAO-09-665 provides important external validation that the program's subsequent struggles, including gearbox immaturity, fly-by-wire integration challenges, delayed IOC, and substantial cost growth, were not uncommon in DoD major acquisition programs (GAO, 2009). Therefore, GAO-09-665 serves as a reference point for the HLR program, identifying that it occurred during a period when AoAs and milestone decisions were frequently undermined by premature commitments and inadequate risk assessment (GAO, 2009).

2. Post-Reform AoA Benchmarks: Office of the Under Secretary of Defense for Acquisition and Sustainment 2021 Assessment

The Office of the Under Secretary of Defense for Acquisition and Sustainment OUSD(A&S) partnered with RAND and the Institute for Defense Analyses to evaluate DoD AoAs that were conducted between FY2015 and FY2020. The evaluation was conducted to meet the requirements of Section 832 of the FY2020 NDAA (Joseph, 2021). In the 2021 OUSD(A&S) report *Assessment of Analysis of Alternatives Studies in the Department of Defense as Compared to Best Practices*, a post-reform evaluation was provided for AoAs conducted during that period. The study compared recent AoAs against nine best practices (shown in Table X) identified by the GAO, MITRE, the Air Force, and the Department of Energy (Joseph, 2021). Its methodology combined literature reviews, data collection from AoA reports, and surveys of subject matter experts (Joseph, 2021). The assessment identified three key problem areas that the DoD should focus on improving (Joseph, 2021).

First, the time constraints imposed by Congress were insufficient to conduct a thorough AoA (Joseph, 2021). The nine-month completion timeframe allotted by Congress was deemed inadequate, as the median duration to conduct an AoA was 13 months, and further variation was observed (see Table 3 Joseph, 2021). Additionally, nearly half of the surveyed respondents reported insufficient time to conduct rigorous analysis (Joseph, 2021).

Second, 43% of respondents indicated they did not fully understand the baseline capability before conducting their AoAs, which provided no benchmark for comparison, undermining the credibility of the studies and allowing for arbitrary comparisons between alternatives (Joseph, 2021).

Third, over 70% of respondents perceived some form of bias toward a particular AoA solution from either stakeholders, sponsors, or organizational predispositions, which constrained the objectivity of the alternatives considered (Joseph, 2021).

Despite these shortcomings, the 2021 report provided a structured benchmark for evaluating current and future AoAs (Joseph, 2021). The report also provided key recommendations, which included extending AoA timelines, requiring clear baseline definitions before evaluating alternatives, and reducing bias by documenting selection criteria based on mission needs/requirements prior to choosing an alternative solution (Joseph, 2021). The OUSD(A&S) also recommended the use of an AoA after-action report/suggestion box, since the organization conducting the AoA has the most significant insight as to what worked and what did not (Joseph, 2021). These recommendations represented an effort to institutionalize lessons learned and prevent the recurrence of pre-reform weaknesses.

Table 3. Recent AoA Nine Best Practices. Source: Joseph (2021).

Best Practice	**Source(s)**
Provide AoA teams with adequate resources (funding, time, personnel)	GAO (2016); MITRE (2014)
Ensure the team understands the baseline capability for comparison	GAO (2016)
Eliminate bias toward a particular solution	DOE (2018); MITRE (2014); GAO (2016); USAF Office of Aerospace Studies (2016)
Assign properly experienced staff to the AoA team	GAO (2016)
Ensure adequate staffing levels for each AoA	MITRE (2014)
Conduct a DOTMLPF analysis prior to the AoA	MITRE (2014)
Complete a risk analysis	GAO (2016)
Complete a sensitivity analysis	GAO (2016)
Conduct the AoA at the highest feasible level	DOE (2018); Ullman (2011)

Table 4. Time to Complete AOA (in Months, for Most Recent 5 Years). Source: Joseph (2021).

Component	N	Min	Q1	Median	Mean	Standard Deviation	Q3	Max
Air Force	7	6.0	9.5	10.0	14.6	7.9	19.5	28.0
Air Force, Navy	1	16.0	16.0	16.0	16.0	NA	16.0	16.0
Army	9	4.0	11.0	13.0	17.0	11.5	25.0	36.0
Army, USMC, SOCOM	1	21.0	21.0	21.0	21.0	NA	21.0	21.0
Navy	4	3.0	10.5	14.5	17.2	14.3	21.2	37.0
Space Force	1	12.0	12.0	12.0	12.0	NA	12.0	12.0
USAF, USN	1	9.0	9.0	9.0	9.0	NA	9.0	9.0
USMC	1	11.0	11.0	11.0	11.0	NA	11.0	11.0
All DoD	**25**	**3.0**	**10.0**	**13.0**	**15.7**	**9.6**	**20.0**	**37.0**

Although the 2019 CAPE re-examination of the HLR AoA was conducted in the post-reform WSARA era, the program's continued cost growth and performance concerns suggest that some of the weaknesses highlighted in the 2021 OUSD(A&S) study remain present.

This reinforces that although reforms have been codified into AoA policy, execution challenges remain. The CH-53K program serves as a case study of how legacy challenges can persist even in a reformed acquisition environment.

For this capstone, the 2021 assessment serves as the evaluative lens for how an AoA should be conducted today. It highlights the standards, adequate time, unbiased alternatives, clear baseline definitions, robust risk and sensitivity analysis, and DOTmLPF-P integration against which the CH-53K's 2003 AoA can be retroactively assessed. Moreover, even though CAPE conducted a re-look in 2019, many of the issues identified in the 2021 report, such as timeline pressure, unclear baselines, and potential bias in alternative selection, suggest that the CH-53K program may still have been affected by structural challenges that reforms have only partially addressed.

C. PREVIOUS RESEARCH

Throughout the life cycle of the CH-53K King Stallion, numerous reports and research articles have framed the successes and failures of the program. These publications consist of oversight reports, press articles, service directives, and reference materials. To accurately reflect the program, it is vital to incorporate a timeline and associate key milestones, setbacks, and cost associations, which are captured in the articles that span more than 2 decades. While this program has experienced numerous setbacks, it has still followed the traditional acquisitions pathway with important events such as requirement identification, initial baseline establishment, risk assessment, design maturity assessment, operational testing and IOC, FRP, and Live-Fire Test and Evaluation, which have all been well-documented. Unique to the CH-53K program are additional key events, which include a program reset, fleet transition considerations, and industrial base capacities. Furthermore, newer articles have also outlined deployment status, cost realization, and overall program status in recent years. To accurately map the CH-53K program, it is important to consider each of these aspects in detail and examine the supporting documentation for each major phase within the life cycle.

Initial requirements for the replacement of the Marine Corps' vertical heavy-lift capability were outlined in December 2005 and later published in a NAVAIR (2006) announcement in January 2006. From the report, the need to develop a modernized heavy-lift asset for the USMC stemmed from the aging CH-53E fleet, increased demand for tactical heavy-lift following post 9/11 combat operations, and the necessity to continue flight operations from existing amphibious shipping, aligned with the Amphibious Readiness Group/Marine Expeditionary Unit (ARG/MEU) construct (NAVAIR, 2006). Concerns with the current CH-53E fleet were based on a service life assessment program assessment that the airframe has a limitation of 6,120 flight hours due to component fatigue in the aircraft's transition bulkhead section, which was estimated to begin impacting the fleet in 2011 at a rate of 15 aircraft per year (NAVAIR, 2006). Additionally, noted was the logistics support provided by Marine Corps heavy-lift assets and their role in the War on Terror, as well as the gap they filled within the overall national security strategy (NAVAIR, 2006). The wars in Iraq and Afghanistan, as well as conflict across various parts of Africa, required a tactical long-distance logistics capability in austere conditions and high temperatures, a mission built for heavy-lift. These conflicts not only highlighted the Marine Corps' need for a replacement to the CH-53E but also sparked similar interests by the U.S. Army, leading to a proposal for a joint heavy-lift asset (NAVAIR, 2006). From the 2005 initial estimate, there were no airframe designs that had been considered yet, and the delivery timeline suggested that a joint heavy-lift asset would not be fielded until 2025, over a decade after the current fleet of CH-53Es would face retirement (NAVAIR, 2006). Furthermore, analysis of a possible joint requirement revealed that the resulting asset would result in an aircraft that is too large to operate from an ARG/MEU (NAVAIR, 2006). Typically, an ARG/MEU consists of three ships, including a Landing Helicopter Dock or a Landing Helicopter Assault, an Amphibious Transport Dock, and an Amphibious Dock Landing, which collectively host a variety of aircraft (U.S. Naval Academy, 2025). Aircraft embarked on these vessels include USMC fixed-wing attack aircraft, rotary-wing attack aircraft, medium-lift assets, Navy utility helicopters, and a detachment of CH-53s to fulfill the heavy-lift requirement. Flight operations on these vessels require specific aircraft folding capabilities that other services typically do not require. Their adaption into a joint heavy-lift asset would increase prices and delay timelines for traditional ground forces that do not require the folding capability. Not only would the 2025 timeline be unable to meet the requirements of replacing the aging CH-53E fleet to meet the mission requirements of post 9/11 combat operations, but the design considerations to effectively operate from ARG ships would have significant impacts on models that are adapted for use by other services.

Based on the considerations associated with the development of a joint-service heavy-lift helicopter and the possible impacts to the fleet, policymakers decided to develop a new generation of CH-53 aircraft rather than pursue other alternatives. On December 22, 2005, the Honorable Kenneth R. Kreig, serving as the Under Secretary of Defense for Acquisition, Technology, and Logistics, authorized the development of the CH-53K, and an initial delivery of 156 aircraft was expected by 2015 (NAVAIR, 2006). With the development of a new aircraft, initial baselines were established, which led to program risk and design maturity considerations being identified. In appearance, the CH-53E and CH-53K models share many of the same characteristics. However, the baseline capabilities and integrated technologies that were initially identified for incorporation into the CH-53K meant a redesign of the entire aircraft and incorporation of technologies that had not been thoroughly tested or incorporated into airframes yet (GAO, 2021). Capabilities to be incorporated included a complete glass cockpit, fly-by-wire capabilities, high-efficiency rotor blades, an elastomeric rotorhead, upgraded engines, modernized internal and external cargo systems, and enhanced ASE, as outlined in the initial announcement of the new aircraft (NAVAIR, 2006). Additionally, the new design featured numerous increases in overall performance, as the CH-53k is designed to carry a

27,000-pound external load 110 NM at 91.5 degrees and 3,000’ (GAO, 2021). The overall weight of the aircraft increased by approximately 7,000 pounds, the internal load increased from 15,000 pounds in the Echo to 18,000 pounds in the Kilo, and the external load increased from 8,265 pounds in the CH-53E to 36,000 pounds in the CH-53K (GAO, 2021). Furthermore, the initial procurement estimate of 156 aircraft was increased to 200 total aircraft, significantly impacting the overall budget of the program (GAO, 2011). Even early in the project life cycle, significant technical advancements, changes in procurement amounts, and immature design capabilities invited risk in all three critical categories of cost, schedule, and performance. As evident from the program’s recent documentation, slips have occurred in all three categories, resulting in substantial price increases, significantly delayed timelines, and the failure to produce deployable aircraft. According to NAVAIR (2006), the initial program development budget totaled $4.4 billion, which consisted of a $2.9 billion cost-plus award fee contract for the SDD phase. Recent updates, to include a selected acquisition report from 2019, placed the development phase at approximately $8.1 billion, nearly double the initial estimates (DoD, 2019). In terms of total program cost, the DoD Office of the Inspector General (DODIG) concluded in an unclassified 2024 summary that confirmed developmental costs were $8.1 billion for the CH-53K, on top of an additional $26.6 billion for procurement, which did not include the estimated $63 billion that will be required for Operations and Sustainment (O&S; DODIG, 2024). According to the same report, this placed the CH-53K at a procurement cost of $135.8 million per unit, making it one of the most expensive aircraft in the U.S. military arsenal (DoDIG, 2024). On top of cost overruns, schedule slips have also been observed, which is evident in a September 2025 report by Lockheed Martin, the direct owner of Sikorsky, stating that only 20 CH-53Ks have been delivered to date, despite the 156 initially estimated by FY2015 in the 2005 initial estimate. In addition to cost and schedule setbacks, performance delays have also been noted. According to a *Marine Corps Times* article from April 2024, CH-53Ks are not expected to reach FOC until 2029; initial deployment timelines have continued to shift right, with the latest estimate being 2024, which was still not accomplished. Cited reasons for the performance shortfalls include the inability of the automatic blade fold system to operate correctly, the unexpected erosion of the tail and main rotor blades, and the lack of a structural repair manual, leaving the CH-53K in a non-deployable status (Office of the Director, Operational Test & Evaluation, 2023). Additionally, the incorporation of modernized ASE in the aircraft has further delayed the aircraft's deployment timeline, as the technology is not available yet for this airframe (Office of the Director, Operational Test & Evaluation, 2024). Evidence provided confirms that the CH-53K program is behind all parameters of cost, schedule, and performance in both initial estimates and updated acquisition assessments.

Given the shortfalls experienced during the initial years of the CH-53K program in relation to all factors, including cost, schedule, and performance, a program reset was conducted, which included an investigation of a massive timeline slip and cost increase, as reported in 2015 (GAO, 2021). The GAO (2021) report found that key milestones have slipped by up to 7 years, while program costs have increased by approximately $15.3 billion, caused by the technical issues identified and an increase in procurement numbers. Additionally, the GAO (2021) determined that the master schedule used to map the CH-53K program was not established according to industry standards, was not well constructed, and was an unreliable product. In terms of performance, Sikorsky was initially expected to deliver 156 aircraft by 2015. A 2023 article from *Defense News* stated that, to date, only 9 CH-53Ks have been delivered to the fleet, and the first deployment cycle for the new aircraft was expected to be 2025 (Eckstein, 2023). Later reports published by NAVAIR in September 2025 state that, to date, only 20 aircraft have been delivered to the USMC, and the deployment timeline has slipped to 2027 for a first Marine Expeditionary Unit deployment (NAVAIR, 2025). The causes of the delays were attributed to 126 technical deficiencies noted in the aircraft design. Most notably, the reingestion of hot gas in the number two engine was documented, which resulted in engine fire concerns (Eckstein, 2023). Previous concerns with the CH-53E model were well-documented, including at least 16 incidents of exhaust gas reingestion that had occurred since 1996, resulting in multiple fatalities and a lawsuit based on program negligence (Mayko, 2005). Given the CH-53K setbacks, a program deviation report was submitted to the Milestone Decision Authority in January 2019, which also included a $158 million above threshold reprogramming request (DoD, 2019). The following year, a program reset was implemented with overall optimism, referencing similar setbacks in the F-35 program and noting significant improvements in the learning process (Eckstein, 2020). In addition to identifying the aircraft's 126 technical risk areas, the program reset also addressed other issues, including a slip in the test flight program and poorly organized testing requirements (Eckstein, 2020). The reset uncovered that while the aircraft had been flying consistently, few data points were being collected during individual flight events; the solution was to lay out a new program testing schedule that included clear project objectives (Eckstein, 2020). Applying lessons learned from similar programs, production was slowed at the Sikorsky plant to find solutions to technical issues and implement changes in the assembly line for follow-on lots of aircraft (Eckstein, 2020). Overall, the program reset was regarded as a success, with both the government and industry expressing approval (Eckstein, 2020). To date, the CH-53K has still not deployed, and significant cost and schedule slips have occurred; however, the program reset put the program back on track in terms of technical risk and testing schedule.

Following mitigation of the identified technical issues, most importantly, the exhaust gas reingestion issue that had been a factor for the two newest generations of the CH-53, the aircraft was able to complete IOT&E, and its baseline capabilities were confirmed. The project officially declared IOC on April 22, 2022, which was followed by a service announcement on April 25 (Eckstein, 2022). Throughout the process, developmental testing was primarily conducted by Air Test and Evaluation Squadron Two One in Patuxent River, MD (Eckstein, 2022). Further IOT&E was conducted by a Marine Operational Test and Evaluation Squadron One detachment located at Marine Corps Air Station New River, NC (Eckstein, 2022). Testing confirmed the aircraft's capability to transport 27,000 pounds of cargo 110 nautical miles under high, hot, and heavy conditions (Eckstein, 2022). Additional test considerations of the CH-53K include the September 5, 2021, recovery of a downed MH-60S in the White Mountains in California (NAVAIR, 2021). Flying at approximately 12,000 feet above ground level, the CH-53K was able to successfully transport the crashed MH-60S, weighing 15,200 pounds, over 23 nautical miles, marking its first successful operational mission (NAVAIR, 2021). Following the recovery, the pilots stated that they had every confidence in the CH-53K to conduct the mission safely despite it only having 6 months of flight operations (NAVAIR, 2021). Included in the announcement of program IOC accomplishments was the statement that the CH-53K had achieved a capability of 57% more horsepower through upgraded engine systems while also reducing parts numbers by approximately 63%, which will ultimately reduce maintenance hours and expense while also increasing operational readiness figures for the fleet (Eckstein, 2022). As reported in a 2023 selected acquisition report, IOT&E on the CH-53K was completed in April 2022 (DoD, 2023). At the time of the IOC announcement, the expected FRP date was FY2023, with a full deployment capability of a detachment-sized element of CH-53Ks on a Marine Expeditionary Unit by FY2024 (Eckstein, 2022).

The FRP decision in December of 2022 marked the first time the CH-53K program had been ahead of projected schedule, making the announcement months before projected timelines that had been determined following the program reset and the completion of IOC (Edwards, 2022). NAVAIR's H-53 Heavy Lift Program Office (PMA-261), responsible for all aspects of the CH-53K acquisition process, had initial estimates a 2029 FOC (Edwards, 2022). Updated procurement assessments estimated the purchase of 10 new aircraft in FY 2023, followed by 15 in FY 2024, and 21 aircraft each year from FY 2025 through FY 2027 (USNI News, 2022). A modernized acquisition selection report (MSAR) published in the same month already reported slip in the delivery of aircraft, stating that 13 aircraft had been removed from the Future Years Defense Program (FYDP), allocating 11 aircraft to the end of the proposed procurement timeline, which was then expected to be 2030 (Department of Defense, 2022). Recent reports indicate 44 total program aircraft have either been delivered or are already under contract, with an expectation to build a total of 200 (NAVAIR, 2025). While others suggest that the total number of aircraft currently in production or under contract is 74 (Zona Militar Editorial Team, 2025). Furthermore, Lockheed Martiin Sikorsky has recently announced a five-year contract award to build a total of 99 CH-53K's, claiming that 20 have already been delivered to the USMC (Lockheed Martin Corporation, 2025). The 2029 initial estimate to achieve FOC has experienced additional program slip as well, with the most recent projection being deployable by 2026 and FOC complete by the year 2032 (Everstine, 2025).

D. SUMMARY

This literature review highlights the technical, managerial, and policy factors that have shaped the CH-53K King Stallion program from its inception to the present. The review demonstrated how early design immaturity, unstable baselines, and staffing shortfalls contributed to persistent cost and schedule overruns. It also situated the CH-53K within the broader evolution of defense acquisition reform, comparing pre-reform shortcomings outlined in the 2009 GAO report with the post-reform benchmarks established in the 2021 OUSD(A&S) assessment. Despite significant policy advances intended to improve acquisition outcomes, many of the systemic challenges such as inadequate risk assessment, schedule pressure, and technological integration issues remain evident in the program's trajectory. Collectively, the reviewed literature establishes a baseline understanding to the problems that have plagued the CH-53K program and created doubt about the future of the program. This CH-53K program foundation informs the subsequent analysis of how the USMC should proceed to best fulfill USMC heavy-lift requirements.

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IV. CASE STUDY

Fifteen years since passing Milestone B, the PM for the CH-53K King Stallion program had a significant problem. Not only has the CH-53K still not replaced the aging CH-53E Super Stallion or even reached IOC, but Congress is beginning to question the future of the program due to the continued delays and rising costs. The performance, by most accounts, is impressive. The CH-53K can lift more than any other Western helicopter ever fielded, with modern survivability systems, digital maintenance tools, and fly-by-wire controls. It is a leap forward, but at a significant cost.

The King Stallion's price tag has doubled since its inception. Its unit cost now exceeds $135 million, more than a fully loaded F-35B (Mizokami, 2017). Congress is asking hard questions, and defense leaders are feeling pressure to do more with less. Additionally, the threat environment is evolving quickly, driving a necessity to develop autonomous and AI-driven capabilities. Challenged with this dilemma, the USMC faced a tough question. Is the CH-53K still worth the significant cost, or are there other options that will meet USMC requirements? Four options are to be considered:

1. Stay the course. Fully fund and field the CH-53K as planned.
2. Find an alternative. Replace the program with a more affordable alternative, like the Army's CH-47F Block II.
3. Buy time. Cancel the CH-53K program. Refurbish and upgrade the existing CH-53E fleet. Invest in next-generation autonomous heavy-lift solutions.
4. Cut losses. Cancel the CH-53K program and continue using the legacy CH-53E as is.

A. MODERN USMC HEAVY-LIFT REQUIREMENTS

The United States Marine Corps is redefining how it fights. For decades, the vision of amphibious warfare was rooted in a single idea of massing on a location (Navy, 2023). This meant massed ships, massed forces, and massed firepower coming ashore (Navy, 2023). Now, in an age of precision missiles, anti-access/area denial (A2/AD) environments, and satellite surveillance, that kind of mass is a liability (Navy, 2023).

The way ahead for the USMC is EABO, a new doctrine built around agility, dispersion, and speed (Navy, 2023). This doctrine calls for small Marine units to leapfrog from island to island, temporary forward arming and refueling points, and long-range fires from remote positions (Navy, 2023). This equates to a minimal footprint with maximum impact to reduce vulnerability of forces to the U.S. adversary's advanced precision fires. Critical to the success of this doctrine is logistics (Navy, 2023).

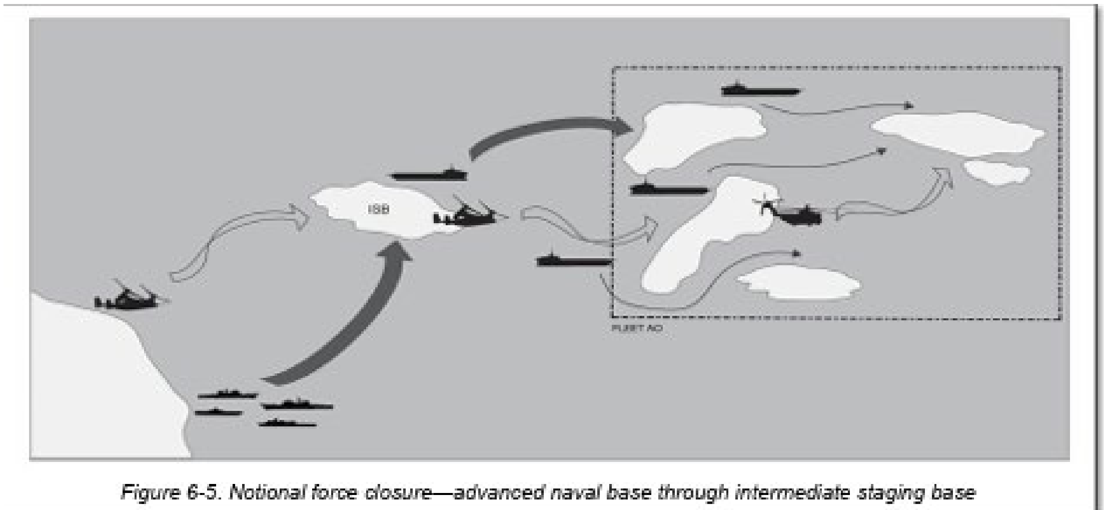

Figure 4. Advanced Naval Base through Intermediate Staging Base. Source: Navy (2023).

To meet the unique mission sets and demanding logistics considerations associated with EABO, which include condensed timelines, significant geographic distance, and astounding amounts of equipment, the Marine Corps relies heavily on assault support aircraft for inter-theater lift (USMC, 2025). The current fleet of assault support aircraft consists of the KC-130J "Super Hercules," MV-22B "Osprey," UH-1Y "Huey," and CH-53E "Super Stallion," each of which serves a unique purpose (USMC, 2025). As the only fixed-wing aircraft, the KC-130J has the most cargo capacity of any of the USMC assault support aircraft and can travel the greatest distance. However, the EABO construct has limitations, notably the inability to land on remote islands without sufficiently flat landing areas or improved surfaces (USMC, 2025). The MV-22B is a tiltrotor aircraft that can travel significant distances at very high speeds compared to other rotary aircraft, and it can linger on station for extended periods of time and has a modern communications suite, making it a great choice as a C2 asset (Department of Test and Evaluation (DOT&E), 2010). The MV-22B's primary limitation is its inability to carry significant cargo over long distances, compounded by multiple reliability issues (O'Rourke, 2009). The UH-1Y typically flies in conjunction with the AH-1Z as CAS assets, and while the Huey does serve as another capable armed C2 asset, it is limited by the cargo weight that it can embark and the time on station that it is limited to, making it a better fit for CAS and Special Operations type missions (NAVAIR, 2023).

To make EABO work, the Marine Corps needs an aircraft that can move heavy equipment, like JLTVs, radar systems, bulk fuel, and artillery, across hundreds of miles of ocean (Athey, 2022). The aircraft must operate from ships, austere shorelines, or makeshift bases, all while under threat (Athey, 2022). This is the mission for which the CH-53K was built. The almost 37,000-pound payload capacity, the range, and the ability to self-deploy over long distances are all tailored for EABO (Athey, 2022).

Despite the impressive capabilities, it can be argued that the requirements themselves may be overkill, and that the Marine Corps has become so enamored with the perfect aircraft for tomorrow's fight that it is forgotten what can fly today.

B. STAY THE COURSE (CH-53K KING STALLION)

Within USMC and in the CH-53K Program Management Office (PMO), support for the CH-53K is unwavering. In their opinion, the CH-53K is not just a good fit for USMC requirements; it is a critical enabler of future operations. To them, no other platform can deliver the required combination of payload, range, survivability, and shipboard compatibility (Harkins, 2019). They see the CH-53K not as a luxury, but as a necessity.

From a performance standpoint, the numbers speak for themselves. A CH-53K can lift more than any other rotary aircraft at almost 36,000lbs (Hill, 2025). It can carry a JLTV externally, fly it 110 nautical miles, and return without refueling (DOT&E, 2018). It can carry triple the external load of the CH-53E and operate in hot/high environments, making it particularly valuable in the Indo-Pacific (DOT&E, 2018). Its fly-by-wire system offers greater precision during sling-load operations in challenging weather or terrain. Most importantly, maintenance hours are down, and reliability is up when compared to the CH-53E due to 63% fewer parts (Hill, 2025).

Figure 5. CH-53K Conducting an Aerial Refueling Test with an External Load. Source: Sikorsky (2020).

From a survivability perspective, it is a generational leap (DOT&E, 2018). Pilot armored seats, cabin armor for the floor and sidewalls, fuel tank inerting, self-sealing fuel bladders, and 30-minute run-dry capable gearboxes offer great survivability to the aircraft against hostile fire (DOT&E, 2018). The CH-53K also features enhanced threat detection and countermeasures to survive against adversarial threats (DOT&E, 2018).

Continuing the CH-53K program means accepting high costs now for long-term advantage. The DoD expects to spend over $31 billion for 200 CH-53K helicopters, with a quarter of the money being spent on RDT&E (Mizokami, 2017). Most of that RDT&E funding will be considered as “wasted” as sunk costs if the program is canceled. Staying on the path is also important to preserving the defense industrial base, including a specialized supply chain for heavy-lift rotorcraft (Mizokami, 2017). Additionally, pushing forward signals to allies and adversaries that the U.S. is committed to fielding the best capabilities.

Unfortunately, the price is steep when compared to alternative options. The per-unit cost of the CH-53K has nearly doubled since program inception (Athey, 2022). Continued development challenges and design deficiencies have led to significant delays, resulting in only a fraction of the planned 200 aircraft being funded so far (Athey, 2022). If procurement slows, costs could climb further. Given the significant cost of the CH-53K and the shift towards precision fires and autonomous systems, the USMC may find itself struggling to afford both the CH-53K and new capabilities like long-range missiles, autonomous systems, and unmanned logistics (Athey, 2022). Figure 6 and Tables 5–7 show the current acquisition program baseline (APB) for the CH-53K. The APB is an agreed upon document that sets the cost, schedule, and performance goals for the program and provides a benchmark for measuring program progress (DAU, 2022).

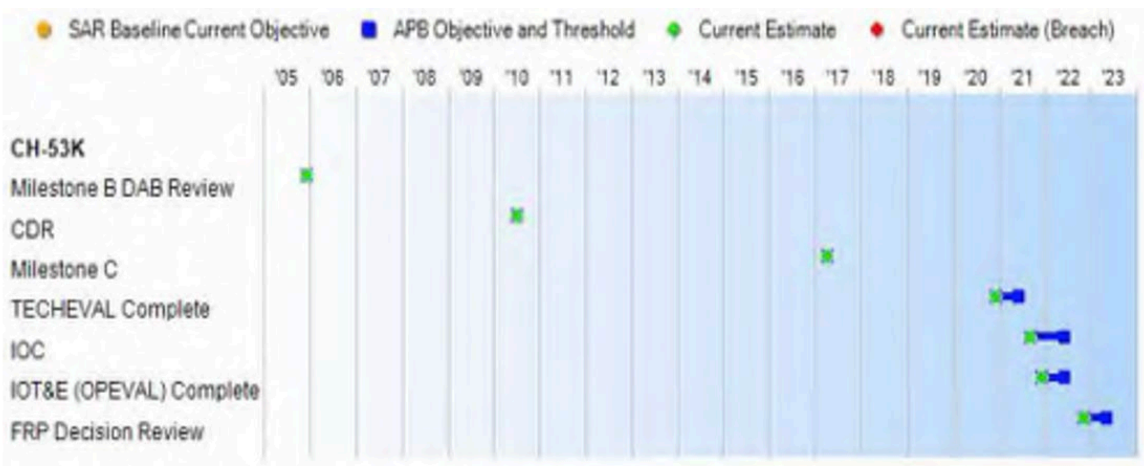

Figure 6. CH-53K APB Timeline. Source: Perrin (2019).

Table 5. CH-53K APB Schedule. Source: Perrin (2019).

Schedule Events					
Events	SAR Baseline Production Estimate	Current APB Production Objective/Threshold		Current Estimate	
Milestone B DAB Review	Dec 2005	Dec 2005	Dec 2005	Dec 2005	
CDR	Jul 2010	Jul 2010	Jul 2010	Jul 2010	
Milestone C	Mar 2017	Apr 2017	Apr 2017	Apr 2017	
TECHEVAL Complete	Apr 2019	Dec 2020	Jun 2021	Dec 2020	(Ch-1)
IOC	Dec 2019	Sep 2021	Jun 2022	Sep 2021	
IOT&E (OPEVAL) Complete	Dec 2019	Dec 2021	Jun 2022	Dec 2021	(Ch-1)
FRP Decision Review	Sep 2020	Nov 2022	May 2023	Nov 2022	(Ch-1)

Table 6. CH-53K APB Performance. Source: Perrin (2019).

Performance Characteristics					
SAR Baseline Production Estimate	Current APB Production Objective/Threshold		Demonstrated Performance	Current Estimate
Net Ready (NR)				
Satisfy 100% of NR reqts in JIA	Satisfy 100% of NR reqts in JIA	Satisfy 100% of NR reqts designated as enterprise-level or critical in JIA	TBD	Satisfy 100% of NR reqts in JIA
Range and Payload (nm)				
110 w/30,000 lbs external load, no refuel	110 w/30,000 lbs external load, no refuel	110 w/27,000 lbs external load, no refuel	TBD	110 w/27,000 lbs external load, no refuel
Mission Reliability (MR)				
90%	90%	89%	TBD	89%
Logistics Footprint				
10% reduction from current CH-53E	10% reduction from current CH-53E	<= current CH-53E	TBD	<= current CH-53E
Sortie Generation Rate (SGR)/Average Sortie Duration (ASD)				
(T=O) 2.6 sorties/ 2.25 hrs	(T=O) 2.6 sorties/ 2.25 hrs	2.6 sorties/ 2.25 hrs	TBD	2.6 sorties/ 2.25 hrs

Table 7. CH-53K APB Cost. Source: Perrin (2019). The approved APB quantity is for 200 CH-53K aircraft.

Total Acquisition Cost							
Appropriation	BY 2017 $M			BY 2017 $M	TY $M		
	SAR Baseline Production Estimate	Current APB Production Objective/Threshold		Current Estimate	SAR Baseline Production Estimate	Current APB Production Objective	Current Estimate
RDT&E	7265.0	8233.3	9056.6	8274.0	6957.8	8048.2	8097.8
Procurement	20427.5	21295.7	23425.3	21446.1	24263.3	25812.5	25925.2
Flyaway	--	--	--	18590.3	--	--	22513.4
Recurring	--	--	--	18059.0	--	--	21867.1
Non Recurring	--	--	--	531.3	--	--	646.3
Support	--	--	--	2855.8	--	--	3411.8
Other Support	--	--	--	2173.7	--	--	2618.3
Initial Spares	--	--	--	682.1	--	--	793.5
MILCON	13.3	13.3	14.6	13.3	13.2	13.3	13.2
Acq O&M	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	27705.8	29542.3	N/A	29733.4	31234.3	33874.0	34036.2

C. FIND AN ALTERNATIVE (CH-47F BLOCK II)

The CH-47 Chinook helicopter has been a familiar sight in the U.S. Army for over 60 years (Ahmed, 2025). The twin rotor aircraft is considered the workhorse of the U.S. Army, known as a reliable, battle-proven, and employed not only by the U.S. but also by countless allies across the world (Boeing, n.d.). When the CH-53K program was initiated in 2003, the CH-47 was undergoing its own upgrade from the CH-47D to the CH-47F, which was designed to carry 16,000 lbs., below that of the CH-53E, making it an unviable option (Bratt, 2016). That was until 2017, when the Army awarded Boeing the contract for the CH-47F Block II upgrade that significantly increased lift, improved fuel efficiency, and updated digital avionics (Thompson, 2020).

Figure 7. A U.S. Army CH-47F Block II Chinook Conducts a Sling Load Test. Source: U.S. Army Aviation Flight Test Directorate (2024).

To some in the Pentagon, the choice is obvious. Why not buy into a proven, lower-cost system that can meet most of the USMC requirements? The CH-47F Block II can fulfill many, though not all, of the USMC operational needs. It has a payload capacity of approximately 27,000lbs. This includes 19,000–20,000 pounds externally, which is enough to carry a JLTV in a 110 NM radius and makes it suitable for most logistics missions (Fortier, Schmitt, and Naigle, 2017). The design is stable and nearing full-rate production, and the sustainment and training systems already exist (Trevithick, 2020). Additionally, numerous allies use the aircraft and are seeking to purchase the Block II variant, making sustainment operations abroad less challenging (Parsons, 2020). Most importantly, it comes at significantly less cost than the CH-53K (Edwards, 2024).

The case for the CH-47F Block II is built on cost and risk. At approximately $40–60 million per unit, the Chinook costs less than half of a CH-53K (Edwards, 2024). It is on pace to reach Full Operational Capability (FOC) before the CH-53K is projected to reach FOC in 2029, meaning the CH-47F Block II is faster and cheaper to deliver to the force (Eckstein, 2022). An additional benefit is the shared platform with the Army, whose logistics pipeline could potentially be shared with the USMC. The Chinook may not meet every CH-53K requirement, but the slight trade-off may be worth the risk, especially if paired with operational changes or unmanned augmentation. If adapted, the Marine Corps could modify EABO doctrine slightly and accept reduced payloads in exchange for broader availability and faster fielding.

Despite all the benefits, the limitations are apparent. The Chinook's lift capacity is less than the CH-53K (Trail, 2020). Its maritime compatibility is limited because it was not built with the same corrosion resistance or shipboard design as the CH-53 family (Trail, 2020). The Block II upgrade does not include automatic rotor blade and pylon folding capability like the CH-53K features, which could complicate deck operations on amphibious ships where space is already at a premium (Trevithick, 2019). There is also the matter of joint compromise. While a shared platform across the services offers some benefits, the Army's mission set differs from the Marine Corps. A "one-size-fits-all" aircraft could leave both services with suboptimal outcomes (Trail, 2020).

Overall, to critics of the CH-53K, the CH-47F Block II offers a safer, cheaper, faster route to operational capability that meets enough of the needs for the USMC. For others, it is a solution that solves today's budget problem at the expense of future operational readiness. Tables 8–10 show the current APB for the CH-47F Block II.

Table 8. CH-47F Block II APB Schedule. Source: Niles Jr. (2022).

UNCLASSIFIED

CH-47F Block II SAR DEC 2022

Events	Milestone Baseline Objective	Current Baseline Objective/Threshold		Current Estimate/Actual	Deviation
PDR				May 2016	
Milestone B				Jul 2017	
CDR				Dec 2017	
Developmental Test					
Developmental Test-Start	Jul 2019	Jul 2019	Jan 2020	Jul 2019	
Developmental Test - Finish	May 2021	May 2021	Nov 2021	May 2023	Yes
Milestone C	Aug 2021	Aug 2021	Feb 2022	Aug 2023	Yes
IOT&E					
IOT&E - Start	Nov 2023	Nov 2023	May 2024	Nov 2023	Yes
IOT&E- Finish	Mar 2024	Mar 2024	Sep 2024	Mar 2026	Yes
Initial Operational Capability	Nov 2024	Nov 2024	May 2025	Nov 2026	Yes
Full Rate Production Contract Award	Dec 2024	Dec 2024	Jun 2025	Dec 2026	Yes

Table 9. CH-47F Block II APB Performance. Source: Niles Jr. (2022).

CH-47F Block II

Performance Characteristics					
Milestone Baseline	Current Baseline Objective/Threshold		Demonstrated Performance	Current Estimate/Actual	Deviation
(KSA) Reliability: - Mean Time Between Essential Maintenance Actions (MTBEMA) (flt hrs)					
	3.5	3.3		3.5	
(KPP) Transport combat equipped troops: - Number of Troops					
	44	31	32	32	
(KPP)Transport combat equipped troops: - Range (NM)					
	150	100	100	100	
(KPP) - Self-deploy with 30 minute fuel reserve (NM)					
	1260	1056	1162	1162	
(KSA) Maintenance: - Total Maintenance Ratio (mmh/flt hr)					
	9.2	9.8		9.2	
(KPP) - Transport 16,000 lbs of internal/external cargo at 4K/95F with 30 minute reserve (NM)					
	100	50	50	50	

Table 10. CH-47F Block II APB Cost. Source: Niles Jr. (2022).

Total Acquisition Cost

Category	Base Year	Milestone APB Objective (BY$M)	Current Baseline Objective (BY$M)	Current Baseline Threshold (BY$M)	Budget Estimate PB 2024 BY$M	Budget Estimate PB 2024 TY$M	Deviation
RDT&E	2017	766.2	766.2	842.8	760.2	811.2	
Procurement	2017	15,208.8	15,208.8	16,279.7	14,753.8	21,296.2	
MILCON	2017	0	0	0	0	0	
Acq. O&M	2017	244.8	244.8	269.3	34.2	34.2	
Total		16,219.8	16,219.8	17,391.8	15,548.2	22,141.6	
PAUC	2017	29.926	29.926	32.088	28.687	40.852	
APUC	2017	28.217	28.217	30.204	27.373	39.511	

D. BUY TIME TO LEAP AHEAD (UPGRADE CH-53E AND INVEST IN AUTONOMOUS CAPABILITY)

The hangar doors at Marine Corps Air Station Miramar groaned open slowly, revealing a CH-53E Super Stallion pulled into the early morning light. Its frame, streaked with wear and corrosion, still carried the unmistakable posture of raw strength. Despite its age, the aircraft had recently emerged from months of intensive maintenance, which was enough to make it airworthy again, though hardly modern. Given the continued delays and rising cost of the enhanced CH-53K King Stallion, a new proposal was taking shape, inspired by the U.S. Coast Guard.

Rather than push forward with the CH-53K or pivot to another manned platform, a new path was being modeled, one inspired by the U.S. Coast Guard's (USCG) success with its MH-60T Jayhawk service life extension program (SLEP) (USCG, 2024), in this USCG program, legacy UH-60 Black Hawk airframes were stripped, rewired, digitized, and rebuilt with modern sensors, glass cockpits, and structural enhancements (USCG, n.d.). This program is projected to increase the USCG MH-60T fleet from 48 to 127 aircraft for $3.9 billion (GAO, 2025). The program is currently projected to cost $3.5 billion (GAO, 2025). The Marine Corps could do something similar with the CH-53E.

Figure 8. USCG MH-60T Completes SLEP. Source: USCG (2024).

Using this approach, the CH-53E fleet would undergo a limited but focused modernization. Each aircraft would be pulled from the line and rebuilt to include new digital cockpits to replace analog instruments. Aging wiring would be removed and replaced to eliminate chronic maintenance issues. Upgraded threat detection and countermeasure systems would be integrated. Structural fatigue repairs would restore thousands of flight hours to key airframes. The concept is not to match the capabilities of the CH-53K, but to stabilize the Marine Corps' heavy-lift capacity long enough to prepare for something fundamentally new.

The fundamental shift under this concept would come in parallel by investing in autonomous vertical heavy-lift platforms. Across the industry, prototypes of unmanned cargo rotorcraft and hybrid vertical take-off and lift (VTOL) vehicles are already being tested (Mishra, 2025). Autonomy is the future of warfare, and the same revolution that upended how the military conducts intelligence, surveillance, and reconnaissance using unmanned aerial systems is slowly creeping toward heavy-lift.

Currently, VTOL drones are capable of carrying approximately 1500lbs (Mishra, 2025). In the near future, autonomous platforms could be capable of transporting 5,000lbs to 15,000lbs, a technology that will only improve with time. These platforms will not need human crews or require hardened landing zones and complex logistics trails. They could be deployed in swarms, programmed for specific routes, and even sacrificed to avoid risking Marines. The challenge is getting there, something that will take time. That is what the CH-53E upgrade is meant to buy. Not to cling to the past, but to create breathing room for innovation.

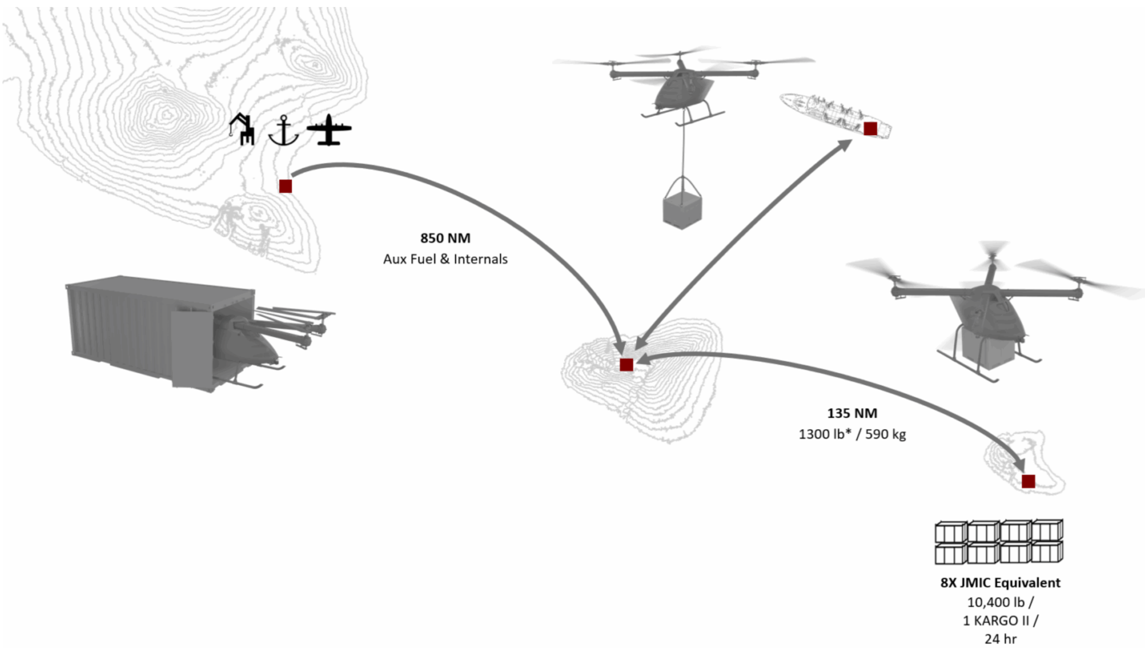

Figure 9. Rendering of How a Piasecki KARGO II Unmanned Aerial Vehicle Can Support Sustainment Operations. Source: Piasecki (2025).

Critics of this plan are quick to identify the risks. The CH-53Es are already decades old. Even a complete overhaul will not remove the fundamental risk of airframe fatigue. While autonomous lift is promising, there are currently no viable options, and it is not guaranteed when the technology will be available. The technological, doctrinal, and operational challenges of fielding unmanned cargo helicopters at scale are formidable. No current autonomous system can lift a JLTV, let alone do so, ship-to-shore transport under enemy threats such as GPS denial or active jamming.

Despite the risks, the costs of continuing with the CH-53K, or adopting another manned system altogether, are steep both financially and doctrinally. Upgrading the CH-53E would cost far less per unit and could be done incrementally, avoiding large procurement spikes and allowing the Marine Corps to experiment aggressively with autonomy in parallel. This hybrid approach to sustain today’s capability long enough to unlock tomorrow’s appeals to those wary of both sunk costs and strategic stagnation. It is a significant risk, but in an era of rapid technological disruption and constrained defense budgets, the riskiest choice may be moving forward with legacy systems that cannot compete on the future battlefield. The CH-53E Super Stallion's final mission could be to buy time.

E. CANCEL THE CH-53K PROGRAM AND SUSTAIN THE CH-53E FLEET

In an increasingly constrained budget environment, the Marine Corps may be compelled to pursue the most fiscally conservative option available, canceling the CH-53K King Stallion program and continuing to operate the legacy CH-53E Super Stallion fleet in its current form. This status quo approach avoids the significant costs required to procure the new CH-53K or develop next-generation systems, allowing limited defense funds to be reallocated to other high-priority areas such as long-range fires and cyber capabilities.

The CH-53E, despite its age, remains the heaviest-lifting helicopter currently in operational service within the Department of Defense (Dineen, 2016). With its triple-engine configuration, it is still capable of transporting substantial external loads under a variety of mission profiles (Dineen, 2016). Continuing to rely on this platform would involve maximizing the use of existing inventory while making only minor sustainment investments to ensure basic airworthiness and compliance with safety regulations (Dineen, 2016). This may include cannibalization of airframes for parts, selective depot maintenance, and targeted repairs to extend life cycles without fundamentally altering aircraft systems or capabilities (Dineen, 2016).

Figure 10. CH-53E Super Stallion. Source: NAVAIR (2025).

This option has some advantages. First, it minimizes immediate costs and avoids further delays and frustrations of fielding a new platform. Second, it maintains fleet continuity, which could reduce training burdens and sustainment overhead (Dineen, 2016). Last, it allows the Marine Corps to shift funds to other pressing requirements.

However, the trade-offs of this option are significant. The CH-53E fleet is already operating well beyond its intended service life, with high maintenance hours per flight hour, persistent readiness challenges, and ongoing parts obsolescence (Dineen, 2016). Retaining this aging platform risks a steep degradation in operational availability and mission reliability (Dineen, 2016). Further, the CH-53E lacks many of the survivability and capability enhancements found in modern systems, such as fly-by-wire controls, advanced threat detection, and improved lift-to-weight efficiency, which may limit its effectiveness in near-peer conflict environments (DOT&E, 2018). This approach also risks sending a message that the USMC is willing to accept capability limitations in exchange for cost savings. Additionally, it risks signaling to adversaries and allies alike that the Marine Corps is retreating from its commitment to modernization, which could erode deterrence and reduce coalition interoperability in future joint operations.

Overall, canceling the CH-53K and sustaining the CH-53E in its current form offers a low-cost, low-risk path in the short term, but at the potential expense of long-term operational effectiveness, readiness, and technological parity. It is a gamble on endurance rather than advancement.

F. STRATEGIC IMPLICATIONS

Continuing the CH-53K program delivers unmatched lift capacity and mission compatibility with the Marine Corps' existing expeditionary doctrine. It is the most capable heavy-lift helicopter ever built. It was designed around USMC heavy-lift requirements now and in the future, making integration into Marine Corps operations an easy task. That capability comes at a steep cost. Committing fully to the CH-53K may prevent investments in other emerging areas, such as long-range fires, unmanned systems, or contested logistics. It also risks anchoring the Marine Corps to an expensive manned platform at a time when autonomy may rewrite the rules of battlefield mobility.

Switching to the CH-47F Block II offers near-term cost relief and proven reliability. It is a mature, multi-service aircraft with excellent range and payload capacity. The downside comes in decreased lift capacity compared to the CH-53K, and it is not optimized for shipboard use, which would require reworking both doctrine and amphibious operations. Choosing the Chinook may save money, but it may also limit the Marine Corps' ability to execute its own concept of operations, particularly in a contested Pacific theater.

Upgrading the CH-53E offers a third way, a hybrid, that preserves essential lift capacity at a fraction of the cost of new production, while buying time to accelerate investment in unmanned systems. This strategy is not without its own risk. It relies on rebuilding aging airframes that are already operating beyond their intended lifespan, as well as on technological breakthroughs in autonomy that have not yet arrived. If unmanned systems fail to mature quickly or are outpaced by adversaries' countermeasures, the Marine Corps could find itself with an aging fleet and no viable successor, making it a very risky venture.

Canceling the CH-53K program and maintaining the CH-53E is the lowest short-term cost but comes at the most significant future risk. The USMC will lose approximately $8 billion in RDT&E if the program is cut but will save approximately $23 billion for allocation to other priorities (Mizokami, 2017). Meanwhile, the CH-53E may serve as a temporary solution but may prove an ineffective option given the advanced age and poor maintainability. Saving money in the present and relying on a relic of the past may prevent the USMC from being operationally capable in future operations. In this context, the decision becomes more than just a question of which helicopter the Marine Corps should move forward with. It becomes a referendum on the kind of force the Marine Corps is trying to be and how quickly it is willing to adapt to an uncertain future.

G. DECISION SCENARIO

The CH-53K PM just got off the phone with the Commandant of the Marine Corps. He is concerned with the program's continued delays and projected constraints on the USMC budget. He has requested a recommendation on the best approach to meet USMC heavy-lift requirements within 60 days. The decision could define USMC warfighting capabilities in the present and future. Congress is also voicing concerns and awaiting a response. The task is to recommend how the Marine Corps will fulfill its heavy-lift requirement for the next 20 years and beyond, balancing operational effectiveness, affordability, timeliness, and future relevance, given the following options:

1. Proceed with full-rate production of the CH-53K King Stallion.

Accept the high procurement cost and resource trade-offs to retain a purpose-built, shipboard-capable, heavy-lift aircraft that directly supports current USMC expeditionary doctrine. The trade-off of this decision includes the highest cost of all options, and lowest flexibility for emerging technology investment.

2. Shift to the CH-47F Block II.

Select a proven, affordable aircraft in wide use across DoD and allied partners. While it cannot meet all USMC heavy-lift requirements, it covers most scenarios at a lower cost. The trade-off of this decision is a possible operational compromise in lift capacity and shipboard compatibility.

3. Upgrade the CH-53E fleet while funding development of autonomous heavy-lift systems.

Buy time to develop autonomous heavy-lift capability. The CH-53E models are given digital systems, structural repairs, and limited upgrades that preserve heavy-lift capabilities while aggressively investing in unmanned alternatives for fielding post-2030. The trade-off of this decision is the high technical and operational risk. No guarantee upgraded CH-53E models can sustain long-term reliability, and unmanned systems may not mature in time.

4. Cancel the CH-53K program and sustain the CH-53E

Sustain the existing CH-53E aircraft through routine maintenance and selective part replacement without pursuing major upgrades or new procurement. This decision avoids further investment in the CH-53K program and minimizes short-term costs, allowing the Marine Corps to reallocate funds to other priorities. The trade-off of this decision is increasing operational risk in the future. The CH-53E fleet is aging, with high maintenance demands, reduced readiness rates, and limited survivability against modern threats. Continued reliance on this platform may lead to declining mission effectiveness and increasing life cycle costs as availability decreases.

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V. CASE STUDY ANALYSIS

In this chapter, a capabilities-based assessment, DOTMLPF-P analysis, and analysis of alternatives will determine the best path forward for the CH-53K program and how best to fulfill USMC heavy-lift requirements.

A. CAPABILITIES-BASED ASSESSMENT

The CBA is the initial analysis used to identify capability gaps within the USMC heavy-lift community. It establishes traceability to strategic guidance, such as the National Defense Strategy and USMC Force Design 2030. It assists in the development of JCIDS documents that will be used in the development of materiel and non-materiel solutions (Joint Chiefs of Staff, 2021). This mini-CBA begins from a known baseline, the CH-53E, and examines whether recapitalization, replacement, or evolution to meet future requirements is necessary to meet emerging operational demands. The study links strategic guidance, operational missions, and service concepts to determine whether the current force can meet the lift, range, altitude, temperature, interoperability, compatibility and survivability requirements of EABO.

1. Traceability and Focus

Consistent with the JCIDS traceability requirements, this CBA ties heavy-lift needs to DoD strategic guidance and Service concepts to identify mission-driven requirements to fulfill any identified capability gaps (Joint Chiefs of Staff, 2021). It aligns with the 2018 National Defense Strategy's line of effort to "Build a More Lethal Joint Force" by modernizing key capabilities and deliver resilient, agile logistics with a prioritization of strategic mobility and joint lethality and survivability in contested environments (Department of Defense, 2018). This translates into requirements for reliable ship-to-objective heavy lift, joint interoperability, and high aircraft availability to execute core heavy-lift mission essential tasks. These tasks include CAT for long-range air assault of combat-loaded Marines, AD of outsized equipment and sustainment supplies, integrating C2 to deconflict with escort aircraft, and TRAP and AE for airframe recoveries and mass-casualty movement, which frequently occur across extended distances, in high/hot conditions, and to austere or unimproved landing zones. At the

Service level, Force Design 2030 operationalizes these demands through EABO and contested maritime logistics, which further supports the requirements for heavy-lift attributes with payload sufficient for CAT loads and heavy external AD, operationally relevant range in high/hot environments, high availability/sustainment, and seamless integration with naval C2 and logistics networks while supporting TRAP and AE. (U.S. Marine Corps, 2023).

The 2001 Quadrennial Defense Review, 2004 National Military Strategy, and 2005 National Defense Strategy all prioritized sea-based, rapidly deployable, agile expeditionary operations, which established demand for reliable ship-to-objective heavy-lift capabilities (Department of Defense, 2001; Chairman of the Joint Chiefs of Staff, 2004; Department of Defense, 2005). Using this strategic guidance for initial traceability, the USMC formalized its heavy-lift replacement need in late 2005 with the January 2006 NAVAIR's notice which identified CH-53E limitations, including a 6,120-hour service-life cap due to transition section bulkhead fatigue, and shortfalls in operating effectively at long range in high/hot, heavy, and austere environments (NAVAIR, 2006).

2. Requirements Derived from Strategic Guidance

The USMC requires the following for assured ship-to-objective heavy lift to enable EABO:

- external payload sized for critical loads
- operational radius/range in high/hot conditions
- survivability in contested environments
- high availability/sustainment
- seamless joint/naval C2 interoperability
- United States Navy shipboard compatibility

3. Capability Gaps and Risk

Measured against the CH-53E baseline, limitations include a 6,120-hour service-life cap due to transition section bulkhead fatigue, indicating aircraft availability and sustainability gaps. The CH-53E is further constrained by performance, including a max range of 200 NM at 3,000' pressure altitude while carrying 7,600 lbs. when operating at temperatures of 91 degrees Fahrenheit or more. These constraints highlight capability gaps at long range in high/hot, heavy, austere conditions. Collectively, the CH-53E gaps translate into elevated risk to mission and to force under JCIDS' risk framework and substantiate the need for recapitalization/replacement analysis (Joint Chiefs of Staff, 2021).

B. DOTMLPF-P ANALYSIS

A Doctrine, Organization, Training, materiel, Leadership and Education, Personnel, Facilities, and Policy (DOTmLPF-P) analysis will evaluate whether non-materiel solutions, such as changes in doctrine, training, or sustainment, could improve USMC heavy-lift capabilities or whether a materiel solution is required to meet requirements.

1. Doctrine

Changes to doctrine, such as updates to flight and fuel planning, aircraft utilization and configuration, emphasis on training in high, hot, and heavy conditions, or alterations of NATOPS limitations will change the performance envelopes of the CH-53E; however, these results will vary. Updates to flight and fuel planning processes may increase the operational range of the CH-53E, while changes to aircraft configurations can increase the cargo weight that the aircraft is able to carry. A greater emphasis on training in high, hot, and heavy conditions increases aircrew knowledge of aircraft limitations in non-standard environments. Additionally, changes to NATOPS publications and prescribed limitations could allow for longer operational time limits under high-power conditions. Each of these offer marginal improvements but are not adequate to sufficiently meet the needs of USMC heavy lift assets.

2. Organization

Organizational considerations include the consolidation of CH-53E fleet squadrons, to bring each operational squadron closer to full aircraft capacity and increase the number of maintainers available to conduct preventative and restorative maintenance. The benefits would include more aircraft operating closer to full mission capability and additional preventive work on engines to bring them closer to factory specifications. Not only would this fail to change the prescribed performance envelope of the CH-53E, but consolidation of squadrons places a greater burden on the remaining squadrons to fulfill deployment rotations. Organizational changes are not a viable option to fill the identified gaps in heavy lift operations.

3. Training

Improvements to training include initial maintenance training, pilot flight planning, and aircrew proficiency. Enhancing initial training provides more qualified maintainers to the fleet, while pilot flight planning and aircrew proficiency could improve the efficiency of flights and ultimately reduce strain placed on the aircraft. This could result in lower maintenance time required per flight hour, but does not change the capabilities of the aircraft, and does not provide a solution to the capability gap.

4. Materiel

A materiel solution, whether it be the development of an entirely new aircraft, adoption of an aircraft that is already in service, or modification to existing aircraft, has the most likely potential to address the USMC heavy lift requirements. New aircraft development would allow the USMC to outline the capabilities necessary for its role in combat operations, which then drive the KPPs necessary to support mission requirements including lift capacity, altitude, range, and maintainability. Additionally, the development of a new aircraft allows for the integration of modern avionics, ASE, and ensures shipborne compatibility. Similarly, the adoption of an existing platform allows the USMC to compare these same KPPs with performance data of aircraft across the services. The benefit of pursuing a non-developmental solution is lower cost, with the drawback being that it might not fully support every KPP or compatibility requirement. The option to modify the existing CH-53E fleet with upgraded engines, avionics, and structural enhancement would provide increased performance, but is limited to the age of the aircraft and the fatigue that has been placed on the airframe. A materiel solution is the only viable option to fill the capability gap that currently exists in the USMC for heavy lift operations and employment.

5. Leadership and Education

Alterations to current leadership practices may result in greater parts availability, and the emphasis on continued maintenance education could result in more efficient practices. This, however, addresses many of the previously mentioned maintenance issues, but fails to meet the performance requirements identified through continued use of the CH-53E.

6. Personnel

Fleet-wide shortages of personnel place a strain on maintenance operations and aircrew proficiency. Bringing these billets to full capacity will increase the efficiency and capabilities of the squadrons but does not address the aircraft limitations. An increase in personnel, while beneficial to the squadron, is not a significant fix to the identified capability gap, pertaining to heavy lift capabilities.

7. Facilities

Aging hangars and airfield facilities do have an impact on USMC aviation across the board, key contributors being lack of equipment, inability to house aircraft, and inefficient airfield storage of vital assets. Current configurations of aircraft hangars are limited in the number of cranes and heavy equipment required to remove and replace aircraft components. The small footprint and limited hangar space results in a majority of aircraft being parked on the line, which ultimately results in faster aircraft deterioration. Limited storage space for ground support equipment (GSE) on the airfield often leads to delays during multiple phases of aircraft operations. Improvement of airfield facilities would be beneficial to the overall mission of USMC aviation but does not directly impact the performance capability shortfall of the CH-53E, thus, is not a viable option.

8. Policy

Policy impacts on the USMC heavy lift program primarily concern budget allocation and SLEPs. An increase in budget for the CH-53E could provide the production and delivery of essential parts, which would increase annual flight hours of the airframe fleet-wide. A SLEP would keep the CH-53E in service longer to ensure a heavy lift asset is available to the Marine Corps. However, neither account for the increased performance requirements that have been identified. Changes to policy alone are not sufficient to meet the needs of USMC heavy lift but will play a crucial role should a materiel solution be selected. If implemented, budget lines need to be allocated to the replacement airframe that is selected.

Table 11. DOTmLPF-P Assessment Summary

Domain	Assessment Summary	Viability for Closing Capability Gap
Doctrine	Minor improvements to planning, training emphasis, and limits; does not increase aircraft performance.	No
Organization	Consolidation increases aircraft availability but does not change CH-53E lift, range, or environmental performance.	No
Training	Improves pilot, aircrew and maintenance proficiency and efficiency, but does not alter aircraft capability.	No
Materiel (m)	New aircraft, adoption of existing platforms, or upgrades are the only options that affect lift, range, survivability, and shipboard compatibility.	Yes
Leadership and Education	Improves maintenance culture and parts availability but does not affect aircraft performance.	No
Personnel	More personnel improve maintenance and aircrew efficiency and capability but cannot overcome aircraft limitations or aging airframes.	No
Facilities	Hangar/GSE improvements help sustainment but do not improve lift, range, or aircraft performance.	No
Policy	Budget/SLEP changes help sustainment but do not solve lift or environmental performance shortfalls.	No

C. ANALYSIS OF ALTERNATIVES

To accurately gauge all possible alternatives to the current shortfall that the USMC is facing considering its heavy lift capabilities, this study considers the evaluation criteria of cost, schedule, performance, compatibility, technical risk, and interoperability. The cost aspect will look at both program cost and individual airframe projected costs. Schedule will examine development, testing, and procurement timelines and compare potential IOC and FOC timelines. The performance aspect will consider the factors of maximum altitude, range, lift capacity, and maintainability to accurately determine aircraft capabilities. Compatibility refers to the ability to operate with existing USMC equipment without fleet-wide changes and the ability to meet existing deployment requirements. Interoperability considers domestic and allied partners and the impact that a uniform aircraft platform has during employment and sustainability.

1. COA 1: Proceed to Full Rate Production of the CH-53K

This options proceeds with procurement of the CH-53K along the current acquisition program baseline.

a. Cost

Projected costs for the CH-53K program make it one of the most expensive platforms to consider and one of the costliest per airframe. Because of the complete redesign of the CH-53E and the newly incorporated components like flight controls, avionics, and engines, the RDT&E costs of the CH-53K are significantly higher than most other options, tied only with the funding of an autonomous system development.

b. Schedule

Similarly, the same redesign factors associated with cost remain true for schedule. Significant delays in the development of the CH-53K have prolonged the program, but it did achieve IOC in 2022, although FOC was once again delayed until 2032.

c. Technical Risk

The technical risk associated with the decision to move the CH-53K into FRP remains high, due to the incorporation of advanced fly-by-wire technology, gearbox immaturity, and the integration of modern ASE. Both the fly-by-wire and ASE technologies require robust software development and system integration, while the strength of the gearboxes must be sufficient to withstand the increased stress placed on the drivetrain.

d. Performance

Designed specifically to fill the capability gap that exists in Marine Corps' heavy lift program, the CH-53K features the best performance specifications when compared to the other possible options.

(1) Altitude

The maximum altitude of the CH-53K is 16,000', which exceeds the CH-53E, but falls short of the CH-47F Block II.

(2) Range

The CH-53K features the longest straight-line range capability at 460 NM, compared to approximately 400 NM from the competitors. Additionally, the CH-53K is designed with a combat radius of 110 NM carrying a 27,000-pound load during high, hot, heavy configurations, greatly exceeding other options.

(3) Lift Capacity

With a maximum external load capability of 36,000 pounds, the CH-53K outperforms its competitors. While the CH-53E is equipped with an external hook that rates 36,000 pounds, the performance of the aircraft does not allow it to meet these weight specifications. The CH-47F Block II is limited to 26,000 pounds of external lift.

(4) Maintainability

Designed with components to reduce maintenance requirements and shorten the length of time to conduct maintenance procedures, the CH-53K has a large advantage over the CH-53E when it comes to maintainability. Examples include a rotor head that is designed to reduce wear, a drastic reduction in total engine parts, and advanced sensors to monitor the aircraft's health.

e. Compatibility

Like the CH-53E, the CH-53K was designed for shipboard operations, thus shares an equal score with other options that keep the CH-53E in service. The primary includes the blade and tail-fold capability that reduces the footprint of the aircraft, allowing more to operate from the ship and be transported on the ship elevator in and out of the hangar.

f. Interoperability

As a newly designed aircraft, proliferation to other countries has not been established yet. While allied countries have expressed interest in the aircraft, the U.S. is the first and only to operate it, and the USMC is the first and only service to operate it.

2. COA 2: Shift to CH-47F Block II

This option cancels the CH-53K program and the USMC purchases the CH-47F Block II instead for heavy-lift requirements.

a. Cost

Compared to the development and acquisition of an entirely new airframe or the future development of autonomous technology, the shift to the CH-47F Block II is the most cost-efficient option, in terms of both program cost and individual airframe cost. Of the options available, the only cheaper option is to sustain the existing CH-56E fleet, which does not solve the capability shortfall.

b. Schedule

The CH-47F Block II is in use by other branches of the military and has a substantially faster timeline than the development of a new airframe or the future development of autonomous technology. This aircraft is schedule to reach IOC in 2026.

c. Technical Risk

Currently in use by the U.S. Army and in numerous countries throughout the world, the aircraft features mature technology and well tested airframe. In its current configuration, the technology risk is low for the CH-47F Block II. However, to be used in USMC applications, the aircraft would require shipboard compatibility modifications. Of those required, the biggest technical risk is the blade-fold capability necessary for storage and movement of the aircraft across the flight deck.

d. Performance

A highly capable aircraft, the CH-47F Block II has been used as the backbone of U.S. Army heavy lift. Its verified performance data and characteristics during operations has provided valuable insight and proven it to be a viable contender for the USMC.

(1) Altitude

The CH-47F Block II features the highest maximum altitude of any of the options, with the capability to reach 20,000’, compared to the 16,000’ of the CH-53K and 10,000’ of the CH-53E.

(2) Range

Comparable to the CH-53E, the CH-47F Block II has a maximum strain line distance of approximately 400 NM, and an approximate 165 NM combat radius. It narrowly falls short of the CH-53K capabilities, under the same conditions.

(3) Lift Capacity

Rated to a maximum external load of 26,000 pounds and a maximum gross weight of 54,000 pounds, the CH-47F Block II has a lower total lift capacity compared to both models of the CH-53.

(4) Maintainability

Already in service with other branches and other allied partners, the CH-47F Block II maintenance procedures, equipment, and techniques have already been established. There is also a larger industrial base for spare parts and the preexisting knowledge of parts that experience high fatigue levels or require frequent replacement. One downfall is the time required to retrain maintainers on the new airframe and the lack of inherent systems knowledge.

e. Compatibility

Unlike the CH-53, the CH-47 was not specifically designed to operate from a ship. While the landing profiles and ship limitations do already exist, the larger issue is the storage and movement of the aircraft around the ship. To effectively operate on an ARG/MEU deployment, the CH-47F Block II would require automatic and manual blade fold capabilities and validation of takeoff and landing wind limitations for all ships in the ARG.

f. Interoperability

Variants of the CH-47 are used by partner and allied nations all around the world and by sister services in the U.S. Integration of this aircraft in the USMC would allow a more seamless joint operation capability, and the larger industrial base would afford greater sustainability.

3. COA 3: Upgrade the CH-53E fleet, while Funding Development of Autonomous Heavy-Lift System

This option cancels the CH-53K and upgrades the CH-53E fleet to extend the life cycle of the aircraft while investing in autonomous VTOL heavy-lift aircraft.

a. Cost

In the near-term, the cost to upgrade the existing CH-53E fleet would be cheaper than purchasing the new CH-53K. In the long-term, the RDT&E cost for a heavy-lift autonomous platform is unknown but predictably very expensive given the low TRL of the technology. Combining both the costs to upgrade the CH-53E and develop an autonomous platform makes this option the most expensive of all four COA's.

b. Schedule

Upgrading the CH-53E will take an extended period because not all aircraft can be removed from service at the same time to complete upgrades. Development of an autonomous replacement that can match heavy-lift performance requirements is years away from reality making this option the slowest in schedule.

c. Technical Risk

Technical risk associated with the development of an autonomous system must consider not only the development of a new system, but also the risk associated with upgrading the current CH-53E fleet. In terms of upgrading the existing aircraft, the technical risk is medium due to the age of the airframe, and compatibility between legacy systems and advanced technologies. The development of an autonomous system to fill the USMC heavy lift requirements presents a very high technical risk due to data-link limitations, current size limitations of unmanned systems, and immature automated deck landing technology.

d. Performance

Upgrades to the CH-53E will improve performance of the aircraft while still falling short of CH-53K performance attributes. The SLEP for the CH-53E would upgrade avionics and survivability of the aircraft while reducing maintenance concerns but is not intended to drastically improve the heavy-lift capabilities of the aircraft. An autonomous system may provide improved performance over the CH-53K, but it is difficult to predict given the lack of current technology.

(1) Altitude

The CH-53E has the lowest maximum altitude of any of the options, with the capability to reach 10,000'. An autonomous system may have the ability to fly at a higher altitude than the CH-53K, but there is no basis to make an accurate prediction.

(2) Range

The CH-53E has a straight-line range capability of approximately 400 NM, which is approximately 60 NM less than the CH-53K and equal to the CH-47F Block II. An autonomous system may provide the longest-range capability of any current heavy-lift aircraft depending on the proposition system and given no human flight time constraints.

(3) Lift Capacity

SLEP upgrades to the CH-53E will not improve the lift-capacity of the aircraft. An autonomous system may provide more lift-capacity than the CH-53K in the future, but currently the maximum lift of an autonomous VTOL aircraft is approximately 1500 pounds.

(4) Maintainability

Upgrades to the CH-53E will reduce some of the maintenance issues plaguing the aircraft but not eliminate them. The CH-53E is still an aging aircraft that will require extensive maintenance to maintain air worthiness. An autonomous system could be designed with maintainability in mind that requires less maintenance than even the CH-53K.

e. Compatibility

The CH-53E was designed to operate from U.S. Navy vessels giving it high compatibility. An autonomous system could require an even smaller footprint than the CH-53 family of aircraft making this a highly compatible option.

f. Interoperability

The CH-53E is only operated in the U.S. military by the USMC and limited allies around the world making it less interoperable than the CH-47F Block II. An autonomous system could be adapted by all U.S. military components and eventually sold to numerous allies across the world.

4. COA 4: Cancel the CH-53K Program and Sustain the CH-53E

This option cancels the CH-53K program without purchasing or fielding any aircraft.

a. Cost

This COA is the cheapest of all four options. Cancelling the CH-53K program would result in a sunk-cost of the RDT&E for the program but would not cost anything further for the purchase of the aircraft or life cycle costs.

b. Schedule

This is the quickest option because there is nothing to be delivered to the fleet and the USMC would continue using the legacy CH-53E in service.

c. Technical Risk

While comparatively low, maintaining the current CH-53E fleet still faces technical risk in relation to the age of the aircraft. Decades of flight operations have placed strain and fatigue along critical sections of the airframe, resulting in additional maintenance hours required and longer downtime between flights. Additionally, legacy avionics and electrical systems limit the compatibility that the aircraft has with modern weapons systems.

d. Performance

Cancelling the CH-53K program would leave the USMC with the legacy CH-53E that falls short of current USMC heavy-lift requirements.

(1) Altitude

The CH-53E has the lowest maximum altitude of any of the options, with the capability to reach 10,000’.

(2) Range

The CH-53E has a straight-line range capability of approximately 400 NM, which is approximately 60 NM less than the CH-53K and equal to the CH-47F Block II. The CH-53E struggles in combat environments under high/hot conditions compared to the CH-53K.

(3) Lift Capacity

While the CH-53E has a maximum lift capacity of 36,000 pounds the performance of the aircraft does not allow it to meet this weight specification, while the CH-53K is designed and tested to carry 36,000 pounds. The CH-53E lift capacity is greater than the CH-47F Block II that can carry approximately 26,000 pounds.

(4) Maintainability

The main weakness of the CH-53E is the maintainability of the aircraft. The aging aircraft are frequently grounded for maintenance and replacement parts are no longer in production for the aircraft due to the shift to the CH-53K. This results in extended maintenance delays and large numbers of unavailable aircraft.

e. Compatibility

The CH-53E has equal ship compatibility as the CH-53K. Both aircraft feature the blade and tail-fold capability that reduces the footprint of the aircraft, which allows more aircraft to fit on the ship and easier maneuverability around the hangar.

f. Interoperability

The USMC is the only U.S. service to operate the aircraft. The few allies that previously operated the CH-53E already placed orders for the CH-53K meaning interoperability is low if the CH-53K program is cancelled for the USMC but allies proceed with their CH-53K purchases.

5. Data Comparison

Table 12 compares the raw data of each COA and aircraft. Cost is split between APUC, RDT&E, and O&S. IOC is the expected date each aircraft is expected to reach this milestone. Performance is depicted by max altitude, max range, and lift capacity under operational environments in high/hot conditions traveling 110 NM. Maintainability demonstrates the ability to keep the aircraft operational with spare parts and available maintenance facilities. Ship compatibility is the ability for the aircraft to fit and maneuver on a U.S. naval vessel without requiring additional space. Interoperability is the ability for the aircraft to operate with other U.S. services and foreign partners.

Table 12. COA Data Comparison

Aircraft Data Comparison Matrix											
Criteria / Options	APUC $M	RDT&E $M	O&S $M*	IOC	Technical Risk**	Max Altitude	Max Range	Lift Capacity***	Maintainability	Ship Compatability	Interoperability
CH-53K	$90.74	$8,097.40	$9.02	2022	High	16,000'	460nm	27,000 lbs	63% fewer engine parts than CH-53E	Automatic Blade/Tail Fold	Only Israel purchasing
CH-47F Block II	$39.51	$811.20	$1.86	2026	Medium	20,000'	400nm	16,000 lbs	Established supply chain from Army	No automatic folding blades	Numerous allies and U.S. Army
Autonomous VTOL****	$75	Very High	$1.75	2050	Very High	18,000'	375nm	22,000 lbs	Fewer parts than manned aircraft	Smaller footprint than CH-53	Adopted by Army and Allies
Legacy CH-53E	$0 No Purchase	*****$8097.40	$7.29	In Service	Low	10,000'	400nm	9628 lbs	Lack of new replacement parts	Automatic Blade/Tail Fold	Only Japan operates variant
* Average annual O&S cost per aircraft											
** TRL/MRL/integration risks											
*** Lift capacity based on operational conditions flying 110nm under high/hot conditions											
**** Autonomous VTOL figures are fictional for the purpose of this case study and for educational purposes only											
***** Sunk cost from CH-53K program											

6. Decision Matrices

After comparing the data of each aircraft, each COA was ranked according to the criteria previously described. Each COA was given a ranking of one to four with one being the best score and the lowest cumulative score being the best option. Table 13 depicts the rankings of each COA. In this ranking, all the criteria were equally weighted and COA 2, the CH-47F Block II, received the lowest cumulative score. This shows that if all criteria were given equally importance in the decision-making process, the CH-47F Block II would be the best choice for the USMC.

Table 13. Unweighted Qualitative Ranking of COAs

Qualitative Ranking of Options												
Options \ Criteria	APUC	RDT&E	O&S	IOC	Technical Risk	Max Altitude	Max Range	Lift Capacity	Maintainability	Ship Compatability	Interoperability	Total Score (Lower Better)
CH-53K	4	3	4	2	3	3	1	1	2.5	2.5	3.5	29.5
CH-47F Block II	2	1	2	3	2	1	2.5	3	2.5	4	1	24
Autonomous VTOL	3	4	1	4	4	2	4	2	1	1	2	28
Legacy CH-53E	1	2	3	1	1	4	2.5	4	4	2.5	3.5	28.5

Assigning equal weight to all the criteria is unrealistic as there is normally some criteria given added importance to the decision-making process. Tables 8–11 demonstrate how different weighting of criteria will affect the outcome of the decision matrix and reflects how each COA could theoretically become the choice for the USMC in these scenarios.

Table 14 placed additional weighting to cost, schedule, and performance while keeping them all equal. As seen previously in Table 13, giving equal importance to cost, schedule, and performance once again gives the CH-47F Block II the best score. In this scenario, ship compatibility is not given additional weight which is a main detractor from the CH-47F Block II. If ship compatibility were not given increased importance, the CH-47F Block II would provide the USMC an adequate heavy-lift VTOL option within the triple constraint of cost, schedule, and performance, although some performance would be sacrificed to remain within those constraints.

Table 14. Equal Triple Constraint Decision Matrix

Decision Matrix (Cost Weighted)														
Criteria / Options		APUC	RDT&E	O&S	IOC	Technical Risk	Max Altitude	Max Range	Lift Capacity	Maintainability	Ship Compatability	Interoperability	Option Scores (Lower is Better)	
Criteria Weight		3	3	3	3	2	3	3	3	3	3	1	Unweighted Score	Weighted Score
COA 1	Unweighted	4	3	4	2	3	3	1	1	2.5	2.5	3.5	29.5	
	Weighted	12	9	12	6	6	9	3	3	7.5	7.5	3.5		78.5
COA 2	Unweighted	2	1	2	3	2	1	2.5	3	2.5	4	1	24	
	Weighted	6	3	6	9	4	3	7.5	9	7.5	12	1		68
COA 3	Unweighted	3	4	1	4	4	2	4	2	1	1	2	28	
	Weighted	9	12	3	12	8	6	12	6	3	3	2		76
COA 4	Unweighted	1	2	3	1	1	4	2.5	4	4	2.5	3.5	28.5	
	Weighted	3	6	9	3	2	12	7.5	12	12	7.5	3.5		77.5

COA 1: Proceed to Full-Rate Production of CH-53K
COA 2: Shift to CH-47F Block II
COA 3: Upgrade CH-53E Fleet, while funding development of autonomous heavy-lift system
COA 4: Cancel the CH-53K program and sustain the CH-53E

Table 15 placed additional weight on schedule and risk while lessening the importance of cost and performance. In this scenario the legacy CH-53E would remain the heavy-lift VTOL aircraft for the USMC because it is already in-service and eliminates any technical risks that come with the development, testing, and integration of a new aircraft. This option would provide the USMC with an immediate solution and eliminate the cost of purchasing new aircraft while sacrificing substantial performance upgrades and risking aircraft availability due to maintenance concerns.

Table 15. Schedule Weighted Decision Matrix

Decision Matrix (Schedule Weighted)														
Criteria / Options		APUC	RDT&E	O&S	IOC	Technical Risk	Max Altitude	Max Range	Lift Capacity	Maintainability	Ship Compatability	Interoperability	Option Scores (Lower is Better)	
Criteria Weight		2	2	2	5	5	2	2	2	2	3	1	Unweighted Score	Weighted Score
COA 1	Unweighted	4	3	4	2	3	3	1	1	2.5	2.5	3.5	29.5	
	Weighted	8	6	8	10	15	6	2	2	5	7.5	3.5		73
COA 2	Unweighted	2	1	2	3	2	1	2.5	3	2.5	4	1	24	
	Weighted	4	2	4	15	10	2	5	6	5	12	1		66
COA 3	Unweighted	3	4	1	4	4	2	4	2	1	1	2	28	
	Weighted	6	8	2	20	20	4	8	4	2	3	2		79
COA 4	Unweighted	1	2	3	1	1	4	2.5	4	4	2.5	3.5	28.5	
	Weighted	2	4	6	5	5	8	5	8	8	7.5	3.5		62

COA 1: Proceed to Full-Rate Production of CH-53K
COA 2: Shift to CH-47F Block II
COA 3: Upgrade CH-53E Fleet, while funding development of autonomous heavy-lift system
COA 4: Cancel the CH-53K program and sustain the CH-53E

Table 16 placed heavy weight on performance while still placing some additional weight to cost and schedule. In this scenario the CH-53K would be the best choice. While cost and schedule are factored into the decision-making process, extra emphasis is placed on performance to ensure the USMC receives an aircraft that meets all KPP's. If the USMC wants an aircraft that can be delivered in the near future with significantly increased performance and maintainability, then the CH-53K is the best choice even if it requires increased cost.

Table 16. Performance Weighted Decision Matrix

Decision Matrix (Performance Weighted)														
Criteria / Options		APUC	RDT&E	O&S	IOC	Technical Risk	Max Altitude	Max Range	Lift Capacity	Maintainability	Ship Compatability	Interoperability	Option Scores (Lower is Better)	
Criteria Weight		2	2	2	4	3	3	5	5	4	3	1	Unweighted Score	Weighted Score
COA 1	Unweighted	4	3	4	2	3	3	1	1	2.5	2.5	3.5	29.5	
	Weighted	8	6	8	8	9	9	5	5	10	7.5	3.5		79
COA 2	Unweighted	2	1	2	3	2	1	2.5	3	2.5	4	1	24	
	Weighted	4	2	4	12	6	3	12.5	15	10	12	1		81.5
COA 3	Unweighted	3	4	1	4	4	2	4	2	1	1	2	28	
	Weighted	6	8	2	16	12	6	20	10	4	3	2		89
COA 4	Unweighted	1	2	3	1	1	4	2.5	4	4	2.5	3.5	28.5	
	Weighted	2	4	6	4	3	12	12.5	20	16	7.5	3.5		90.5

COA 1: Proceed to Full-Rate Production of CH-53K
COA 2: Shift to CH-47F Block II
COA 3: Upgrade CH-53E Fleet, while funding development of autonomous heavy-lift system
COA 4: Cancel the CH-53K program and sustain the CH-53E

Table 17 placed significant weight on performance while reducing weight to cost, schedule, and risk. In this scenario, the USMC would choose the autonomous VTOL aircraft. This option would only be the choice if the USMC wanted the potential to provide the best performance possible if cost, schedule, and risk were not major factors in the decision-making process. The autonomous VTOL aircraft has such a low technical readiness level that the RDT&E cost would be substantial, the schedule would be drawn out, and the program would come with very high risk for failure. While promising in the future, this option is the least rationale or realistic.

Table 17. Acceptance of Risk for Performance Decision Matrix

Decision Matrix (Acceptance of Risk for Performance)														
Criteria / Options		APUC	RDT&E	O&S	IOC	Technical Risk	Max Altitude	Max Range	Lift Capacity	Maintainability	Ship Compatability	Interoperability	Option Scores (Lower is Better)	
Criteria Weight		2	1	2	1	1	4	4	4	4	4	3	Unweighted Score	Weighted Score
COA 1	Unweighted	4	3	4	2	3	3	1	1	2.5	2.5	3.5	29.5	
	Weighted	8	3	8	2	3	12	4	4	10	10	10.5		74.5
COA 2	Unweighted	2	1	2	3	2	1	2.5	3	2.5	4	1	24	
	Weighted	4	1	4	3	2	4	10	12	10	16	3		69
COA 3	Unweighted	3	4	1	4	4	2	4	2	1	1	2	28	
	Weighted	6	4	2	4	4	8	16	8	4	4	6		66
COA 4	Unweighted	1	2	3	1	1	4	2.5	4	4	2.5	3.5	28.5	
	Weighted	2	2	6	1	1	16	10	16	16	10	10.5		90.5

COA 1: Proceed to Full-Rate Production of CH-53K
COA 2: Shift to CH-47F Block II
COA 3: Upgrade CH-53E Fleet, while funding development of autonomous heavy-lift system
COA 4: Cancel the CH-53K program and sustain the CH-53E

D. SUMMARY

From the DOTMLPF-P analysis conducted, it is evident that many of the solutions have the capability to increase readiness of the CH-53E, improve the maintenance capacities within the squadrons, or provide efficiencies to increase overall flight hours. However, all but one fails to remedy the identified capability gap that exists of providing long-range, ship-based heavy lift operations to austere environments to meet the modern threat. To completely bridge this gap, a materiel solution is the only viable mitigation of the current fleet shortfall.

Similarly, the Analysis of Alternatives conveyed similar information. It suggests that the development or adoption of a new helicopter is required to meet the needs of the modern heavy lift requirements that the CH-53E cannot accomplish. The CH-53K and the CH-47F Block II have similar lift capabilities and performance characteristics. However, the ability to operate from a ship presents a major disadvantage for the CH-47F Block II.

As the decision matrix indicates, unweighted scores of aircraft selection suggests that the CH-47F Block II presents a sound solution. Once different weighting is assigned to each criteria the best choice can easily change between all four COA's. The path forward for the USMC will be determined by which factors are given increased weight during the decision-making process.

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VI. CONCLUSION AND RECOMMENDATIONS

As confirmed during combat operations over the past two decades and shortfalls noted on an airframe dating to the 1980s, the CH-53E is falling short of modern heavy-lift requirements. Where this is particularly relevant is in reference to the EABO mission outlined in Force Design 2030 and to operations in austere environments, such as the mountains of Afghanistan, the deserts of Iraq, and the demanding climates associated with the MEU. Aging airframes, the increasing weight of modern equipment, and the exponential growth in airframe sustainment costs further demonstrate the need for a solution to meet the heavy-lift requirement.

A. SUMMARY

After evaluation of a DOTMmLPF-P assessment, only a materiel solution can effectively address the current issues associated with an aging fleet and the identified gap in heavy-lift capability. Across the DOTmLPF-P domains, the only actionable options lie in improving CH-53E maintenance, storage, flight-hour management, and operational efficiency; the remaining domains offer no credible means of closing the heavy-lift gap. Furthermore, although these improvements enhance the current fleet, they fail to meet the lift requirements associated with Force Design 2030 and the heavy lift capacity required in austere battlefields, where the most significant shortfalls were noted during recent conflicts. For these reasons, only a materiel solution can provide the lift, range, and operational capacity required.

Upon determining that a materiel solution is the only means to close the capability gap, numerous options emerged, each offering varying abilities to fulfill requirements. Potential courses of action include proceeding to FRP of the CH-53K, shifting to the CH-47F Block II, upgrading the existing CH-53E fleet while developing an autonomous capability, and cancelling the CH-53K program while maintaining the current CH-53E fleet. Continuing with FRP for the CH-53K is more expensive than other alternatives and falls short on schedule and interoperability. However, it is the only aircraft that delivers every KPP, as its design specifically addresses lift requirements, range, and shipboard capability. The CH-47F Block II is substantially cheaper than the CH-53K, is used by partner nations worldwide, and has a shorter delivery schedule than other options. Where this aircraft falls short is the ability to operate from Navy ships. While they can land on them and already do, the lack of blade-fold technology in the rotor head presents issues with the storage and movement of aircraft across the flight deck and elevators. Despite the push for autonomous technologies on the battlefield in recent years, significant development remains required to address the heavy-lift capability gap. The option to upgrade the current CH-53E fleet and simultaneously fund development of a future autonomous system has a high program cost, the longest schedule of the options under consideration, and untested performance capabilities. Given the TRL of the required emerging technologies and the rapidly aging airframe of the CH-53E, autonomous technology replacement is not a viable option.

Additionally, the cost, schedule, and aircraft downtime required to upgrade the CH-53E fleet pose significant challenges to combat capability. The decision to cancel the CH-53K program and sustain the CH-53E fleet provides an immediate solution at a comparably low cost to other alternatives. Still, it fails to meet the performance requirements outlined in the KPPs. Furthermore, the aircraft's age plays a significant role in its ability to remain the backbone of heavy-lift operations. Decades of airframe strain, desert operations, and saltwater intrusion are affecting the aircraft's performance and capabilities, making the current fleet's sustainment unfeasible. Maintaining the current fleet does not address the identified capability gaps and threatens the implementation of Force Design 2030.

B. CONCLUSIONS

Based on the information and considerations provided, the most appropriate course of action to address the USMC heavy-lift capability gap is to send the CH-53K to FRP. This solution meets all identified KPPs, supports the long-range lift requirements of Force Design 2030, and provides a compatible platform for integrating with existing shipping and deployment factors. The CH-53K outperforms the CH-47F Block II, providing the lift capability required on the modern battlefield. This requirement is due to the increased weight of equipment, the necessity to transport a larger number of troops, and the ability to do so in high, hot, humid climates. Autonomous technology to replace any variant of the CH-53 remains immature, and the aging airframe's life cycle does not align with development timelines, further widening the capability gap and leaving no viable solution in the interim. Maintaining the current CH-53E fleet addresses the immediate need for a heavy-lift asset but fails to address lift limitations, increased maintenance requirements, and, most importantly, airframe fatigue.

In summary, full-rate production of the CH-53K remains the most credible solution to the USMC's heavy-lift capability gap documented across two decades of conflict. Balancing the triple constraints of cost, schedule, and performance, along with the additional factors of compatibility and interoperability, the CH-53K is the obvious choice. The program adheres to the identified KPP to deliver an aircraft that can operate in every climate in which the USMC may be deployed and align with future planning guidance. Despite delays in schedule and cost increases, and the number of extensions, the CH-53K remains the most capable helicopter to accomplish the USMC's mission. The ship-based, highly modernized workhorse of the CH-53K provides the USMC a capability that exceeds those of adversaries and proves to be a strategic investment that will shape the outcome of conflict for decades to come.

C. FUTURE WORK

The information presented is not exclusive to USMC acquisitions and similar decision criteria are evident in a wide variety of programs across the U.S. military. This case study provides options to meet an identified shortfall and a basis to evaluate criteria, while also opening the door for future research to validate assumptions made throughout the acquisitions process.

Operational information gathered during the first years of fleet utilization allows a comparative cost analysis to be conducted between the CH-53K, CH-47F Block II and the remaining CH-53E squadrons. Comparing and studying relevant statistics such as cost per flight hour, cost per maintenance hour, and cost per pound of cargo delivered provides updated life cycle costs and insight into similar acquisitions strategies for the future. Similarly, the long-term analysis of predicted versus actual figures associated with the CH-53K will identify program shortfalls, provide a basis to update life cycle costs, and influence future replacement capability decisions. Total Operations and Sustainment costs, spare parts availability, maintenance hours per flight hour conducted, and the Fully Mission Capable and Partially Mission Capable readiness rates provide the basis to track program success.

Further studies into the adoption of additional joint or international airframes using R&D and TRL information not available at the time of this study will identify potential avenues to reduce redundancy across the services and the industrial base. Additionally, an analysis of cost sharing capabilities and platform commonality requirements will be required prior to the development of a joint project. As shown, differences in requirements between the branches for factors such as shipborne capability, altitude, and lift capacity significantly influenced evaluation of decision criteria.

Another key avenue of research is the value of incremental upgrades to existing fleet aircraft. While variants of incremental upgrades exist in the U.S. military already, there were limited resources in relation to aviation and obvious gaps in the information that was available. Further analysis of the CH-53E airframe life cycle and its extension timelines can provide valuable insight to the implementation of incremental fleet upgrades. Research points to emphasize in future studies include factors influencing maximum aircraft service life, the impact of extension programs on aging airframes, and the determination of when diminishing returns appear in the program. At some point in the life cycle, it will become cheaper to replace the aircraft instead of upgrading it, but incremental upgrades have the potential to maximize service life and maintain advanced technology on the battlefield.

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