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A Cost Effectiveness Analysis of a Three Pattern Family of Uniforms for the USMC

March 2026

Capt Stephen A. Sulentic, USMC

Thesis Advisors: Dr. Robert F. Mortlock, Professor
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Naval Postgraduate School

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ABSTRACT

In the face of a potential conflict with a peer threat, U.S. forces seek out new ways to mask physical and electronic signatures in a battlespace to avoid the enemy targeting cycle. This practice, called signature management, teaches American warfighters the importance of blending into their surroundings. At the most basic level, the camouflage uniform aids service members in signature management by offering physical concealment. The U.S. Marine Corps (USMC) currently has a two-pattern family for camouflage: woodland and desert. However, the USMC has no pattern for transitional environments that exist on a 21st century battlefield. This thesis provides a cost-effectiveness analysis to fielding a three-family pattern of camouflage to the USMC. In doing so, this research seeks to ensure the lethality, survivability, and effectiveness of Marines in the future fight. This research paper uses standard cost estimating and cost effectiveness practices to provide valuable insights to decision makers. It establishes an objective, logical evaluation model pitting warfighter effectiveness against cost in five courses of action. The results of this analysis find that any of the proposed courses of action result in increased effectiveness for the warfighter while costs vary above and below the status quo. This research paper is recommended for use in buying decision trade space for stakeholders when they consider numerous courses of action for future uniforms.

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ABOUT THE AUTHOR

Capt Stephen Sulentic Upon graduating and commissioning into the Marine Corps from the US Naval Academy, then Second Lieutenant Sulentic was assigned to the US Naval Academy Leadership and Development department to research virtual reality learning assets for three months before attending The Basic School, Company G, from September 2019 – April 2020.

In April 2020, 2ndLt Sulentic checked into Marine Corps Communications and Electronics School, 29 Palms. He graduated the Basic Communications Officers Course in December 2020, earning the MOS of 0602 Communications Officer. He then executed orders to Headquarters Battalion, 1st Marine Division where he served as the Division Help Desk OIC, Division G-6 Assistant Operations Officer (interim), and finally the Division Network Operations Center (DNOC) OIC. As DNOC OIC with the collateral billet of Division Communications Control Center OIC, 1stLt Sulentic executed two Service Level Training Exercises and several field operations. Additionally, he led a provisional infantry platoon as an adversary force during Mountain Training Exercise 5-21.

In July 2022, 1stLt Sulentic executed orders to 1st Battalion, 1st Marines to serve as the Battalion Communications Officer. There, he executed communications planning, employment, light infantry tactics/operations, and amphibious operations through 10 field exercises, two Service Level Training Exercises, and deployment with BLT 1/1 on the 31st Marine Expeditionary Unit Patrol 24.1 (OCT23-APR24).

Upon return from deployment, Captain Sulentic executed orders to Naval Postgraduate School where he currently pursues a Master's of Science in Management concentrated on Defense Systems Analysis. His thesis covers a "Cost Effectiveness Analysis of a Three Pattern Family of Uniforms for the USMC." His follow-on assignment will be at Headquarters Marine Corps, Programs and Resources, Program Analysis and Evaluation Office, Warfighting Branch in the Pentagon.

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Above all else, I thank God for His everlasting love and give thanks for the all the blessings He has placed in my life.

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AI DISCLOSURE

In the creation of this thesis, artificial intelligence was used to model generic structure and formatting of the thesis. ChatGPT was used to recommend organization of chapters and sections to comply with Naval Postgraduate School thesis norms. It was also used to explain styling and formatting methods in Microsoft Word. Specifically, ChatGPT was used to answer questions regarding how to use various Microsoft Word styles and formats.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACU	Army Combat Uniform
AO	Area of Operations
BDU	Battle Dress Uniform
CBA	Cost-Benefit Analysis
CEA	Cost Effectiveness Analysis
CER	Cost Effectiveness Ratio
COA	Course of Action
CUIP	Camouflage Uniform Improvement Project
DCU	Desert Camouflage Uniform
DMDC	Defense Manpower Data Center
DoD	Department of Defense
DTC-1	Digital Transitional Camouflage 1
DTC-2	Digital Transitional Camouflage 2
ECR	Effectiveness-Cost Ratio
ICE	Infantry Combat Equipment
INDOPACOM	U.S. Indo-Pacific Command
JIC	Joint Inflation Calculator
KPP	Key Performance Parameter
MARPAT	Marine Pattern
MARPAT-D	MARPAT Desert
MARPAT-W	MARPAT Woodland
MCCUU	Marine Corps Combat Utility Uniform
MOE	Measure of Effectiveness
MOP	Measure of Performance
NDAA	National Defense Authorization Act
NIR	Near-Infrared
NSRDEC	Natick Soldier Research, Development, and Engineering Center
OCP	Operational Camouflage Pattern
OCIE	Organizational Clothing and Individual Equipment
OD	Olive Drab

OEF-CP	Operation Enduring Freedom Camouflage Pattern
OMB	Office of Management and Budget
PMC	Procurement Marine Corps
SIGMAN	Signature Management
SWIR	Short-Wave Infrared
UCP	Universal Camouflage Pattern
US	United States
USMC	United States Marine Corps

I.   INTRODUCTION

The essence of the problem is to select a promising course of action with an acceptable degree of risk and to do it more quickly than our foe. In this respect, 'a good plan violently executed now is better than a perfect plan executed next week.' (United States Marine Corps, 1997, p. 87)

A.   PROBLEM IDENTIFICATION

As the U.S. military prepares to engage in a fight for its existence against a peer adversary, managing the signature of military units across all domains constitutes a critical factor in achieving overall success (Department of Defense, 2022). The 21st century battlefield is full of sensors and precision weapon systems that seek to destroy adversary capabilities. On this battlefield, to be sensed or detected is to be targeted, and to be targeted is to be killed. Therefore, signature management must be practiced across all domains, including the physical domain. A key component to managing a physical signature on the front lines is proper field craft. Field craft is defined as "the techniques involved in living, traveling, or making military or scientific observations in the field, especially while remaining undetected" (Schwartz, 2020, p. 2). From field craft, frontline warfighters learn the importance of camouflage in every aspect of avoiding observation, detection, and sensing. Gear, vehicles, weapon systems, and personnel all require effective camouflage to avoid discovery by the enemy. The camouflage uniform comprises the main means by which personnel conceal themselves from physical observation and detection.

With the close of the Global War on Terror, the U.S. Marine Corps shifted its focus away from combat in Afghanistan against a non-peer threat. Now, the Marine Corps focuses on preparing for the future fight against the United States' peer, existential threat: China (Gershaneck, 2020, p.64). Signature management, field craft, and camouflage all play critical roles in the Marine Corps' preparation for this pending conflict. The Marines who will do the fighting across the Pacific's vast expanse require equipment and uniforms that will enable them to effectively fight these battles. These uniforms must mitigate their risk of detection and being targeted. Throughout Marine Corps history, the camouflage uniform has played a critical role in field craft and the

success of Marines. The same reality faces Marines today as they lean into preparations for a future fight.

Part of pivoting to a future fight against China involves the Marine Corps restructuring under an initiative called Force Design (United States Marine Corps [USMC], 2020, p. 1-15). The Marine Corps' Force Design has restructured infantry battalions, removed antiquated battlefield assets from the Marine Corps' inventory, and increased quantities of capabilities that analysis shows as vital in the next conflict. Under Force Design, Marines are developing new operating concepts, strategies, tactics, and means of waging warfare across every warfighting domain (USMC, 2020, p.7). As with any versatile organization in the face of a new threat, all these shifts address the current and future threats that must be overcome to achieve victory when the time comes. Through Force Design, the Marine Corps is transforming into a more agile, flexible, and lethal fighting force of the future.

B.   PROBLEM STATEMENT

In stark contrast to the Marine Corps' changes initiated by Force Design, the Marine Corps Combat Utility Uniform (MCCUU) has not changed in over 2 decades. The Marine Corps currently has a two-pattern family for camouflage: woodland and desert. However, the 21st century battlefield does not remain divided between the two bookends of desert and woodland environments, particularly in the first and second island chains of the Pacific area of operations. In 2020, Dr. Robert Mortlock wrote an article referencing a study by the Army Corps of Engineers that "classified the Army military operating environments across the combatant commands as 44% transitional, 37% woodland/jungle, and 19% desert/arid environments" (p. 359). Because the Army and the Marine Corps, along with the other branches of the armed forces, fight as a joint-combined team, the same assertion can logically be made for the Marine Corps' operating environments. Therefore, the Marine Corps ought to investigate the addition of a third, transitional pattern of camouflage, making a three-family pattern of camouflage for its uniforms. In doing so, the Marine Corps may determine whether a tactical need exists for a third, transitional pattern to better enable Marines to conduct physical signature management in combat.

With that practical reason in mind for the use of a third pattern of camouflage, the Marine Corps must also balance the cost and effectiveness of investing in such an additional pattern. Currently, there is no cost effectiveness analysis (CEA) of a three-family pattern of camouflage for the Marine Corps. However, the time for change is upon the Marine Corps. Marines across the force are focused primarily on preparation for combat against a near-peer, and the MCCUU's camouflage effectiveness plays an important role in this process.

This research's primary objective is to inform key decision-makers within the Marine Corps of the effectiveness of current and potential future camouflage options for the force. Additionally, this research project provides decision-makers with a quantitative cost effectiveness analysis for fielding a three-family pattern of camouflage to the U.S. Marine Corps. This entails analyzing multiple courses of action against measures of effectiveness, risks and costs of potential implementation. Such courses of action focus on ensuring the lethality, survivability, and effectiveness of Marines in the future fight while ensuring the responsible use of taxpayer dollars.

C.   RESEARCH QUESTIONS

This thesis addresses the following questions:

1.   How effective are the current patterns of camouflage in use by the Marine Corps today?
2.   What options are available to address the challenges raised by current camouflage capabilities?
3.   How can the U.S. Marine Corps invest in a three-family pattern of camouflage for the Marine pattern (MARPAT) MCCUU and Flame Retardant Operational Gear (FROG) variants?
4.   What is the best and most cost-effective method to invest in effective camouflage uniforms for the future?

D.   SCOPE AND LIMITATIONS

The goal of this research is to quantify the effectiveness of a three-pattern family of camouflage for MARPAT MCCUUs and flame-resistant versions and compare it against the effectiveness of the current two-family pattern of MARPAT MCCUUs. Use cases therefore are limited to only those that the Marine Corps may employ. Focus rests on the camouflage color family rather than the pattern of the color scheme. For example,

the options do not include the fielding of Battle Dress Uniform patterns for Marines but instead contain only MARPAT "digital" patterns with different colorations to blend into different environments. Application use cases for Marines encompass the entire range of military operations, from full-scale war to training and partner nation peacetime operations. This research does not address the effectiveness of Marine Corps gear and equipment known as Infantry Combat Equipment (ICE) that may be worn over the camouflage uniform, such as plate carriers, packs, helmets, and chest rigs.

E.   METHODOLOGY

This research project is presented as a cost effectiveness analysis of a three-family camouflage pattern for Marine Corps uniforms. The Office of Management and Budget's (2023) *Circular A-94* governs the structure of the cost effectiveness analysis. To properly inform the reader of various camouflage capabilities and the effectiveness of the uniforms presented, this report establishes background information regarding the science of camouflage. Additionally, a brief history of camouflage use in military forces is necessary to understand its value. Then, a discussion of U.S. military camouflage use provides context for how the Marine Corps arrived at its current camouflage uniform status quo. The research presents data from camouflage testing conducted by the U.S. Army, which assists in objectively assigning value to effectiveness criteria for the analysis. The analysis establishes an organized quantification of costs for each course of action paired with its effectiveness. Finally, the analysis is subjected to a sensitivity analysis and the study's findings are presented.

F.   BENEFITS OF THE STUDY

Overall, this research benefits the Marine on the front lines by informing decision-makers about the effectiveness and trade-offs for current and alternative camouflage fielding options. Additionally, this project benefits the Marine Corps by informing the decision-maker of the most effective ways to objectively employ taxpayer dollars. Lastly, this work benefits the taxpayer by providing contextual insight into the application of their tax dollars. With the changing battlefield and changing Marine Corps, uniforms must keep up with the shifts in operational requirements. This research provides

analysis of the effectiveness of the Marine Corps' current uniform inventory and possible alternatives. Chapter II establishes the background of camouflage, camouflage uniforms, and current data. Chapter III is a literature review establishing theoretical frameworks of camouflage evaluation and the latest research regarding camouflage uniform effectiveness. Chapter IV presents the analysis methodology and employment of the data. Chapter V displays the results of the analysis and presents further exploration of each course of action. Chapter VI concludes the thesis, providing a summary of the findings within the current context and addressing potential areas for future research.

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II. BACKGROUND

A. OVERVIEW

The Marine Corps' status quo MARPAT, employed on MCCUUs, currently comes in two colorations, woodland and desert, which are pictured in Figure 1. For combat environments like Afghanistan and Iraq, these patterns tend to make logical sense. However, with the focus on combat in the Pacific, a shortfall comes to light when considering the transitional environment that exists in this area of operations (AO). Materially the MCCUU is 50% cotton, 50% nylon, and treated with permethrin, making it an insect repellent for up to 25 wash cycles (United States Navy Small Business Innovation Research, 2016, p. 17).

The Marine Corps employs a variation of the MCCUU known as Flame Retardant Operational Gear (FROG). FROGs are generally issued prior to the execution of a deployment or large-scale exercise. FROGs have the digital MARPAT design in both the woodland and desert color schemes. The FROG was created out of an urgent need for such a material due to Marines' increased risk of encountering vehicle-born improvised explosive devices in Iraq and Afghanistan in the late 2000s. The material on the sleeves and trousers of the uniform is 65% flame resistant rayon, 25% para-aramid, and 10% nylon, meaning it is a tough, rip resistant, flame-retardant material (Marine Corps Systems Command, 2007, p. 1). On the body of the blouse, the uniform is 80% modacrylic fiber, 15% Tencel fiber and 5% silver fiber, making it a breathable, lightweight, and quick-drying material while avoiding the highly flammable nylon and cotton mixes found in conventional uniforms (Marine Corps Systems Command, 2007, p. 1). Because the FROG is more breathable than the MCCUU and is also quick-drying, it became the preferred choice of many Marines in hot, humid operational environments. Examples can be seen in Figure 2.

Using incorrect or ineffective camouflage in the Pacific AO risks loss of life, loss of mission success, and loss of initiative at the tactical, operational, and strategic levels. Because the Marine Corps plans to operate while distributed across vast areas, small units that usually would not have strategic impacts now become strategic actors. How well

they camouflage themselves may result in how well they succeed. Identifying the correct camouflage for the AO means that the Marine Corps can capitalize on an opportunity to achieve success, equipping frontline warfighters with effective camouflage prior to engaging in kinetic conflict.

Figure 1.   Marine Corps Combat Utility Uniform in woodland (left) and desert (right) variations. Source: Marine Corps University (2018).

Figure 2.   Flame Retardant Operational Gear in woodland (left) and desert (right) variations. Source: Alegria (2023).

B.   POLICY, PATENT, AND TRADEMARK

The Marine Corps must operate within several legal and policy-related confines while pursuing uniform-related changes and improvements. The first is the National Defense Authorization Act (NDAA) for Fiscal Year (FY) 2014 (2013). The second concerns the Marine Corps' previous actions surrounding MARPAT. Regardless of any

change or lack thereof in the current uniform repertoire for the Marine Corps, these two concerns must act as guidelines for decision-makers invested in providing proper uniforms for Marines.

The 2014 NDAA (2013) directly addressed and limited what the Marine Corps can do regarding uniforms. In December 2013, the 113th Congress passed the NDAA with a vital section regarding service-specific uniforms. Section 352 of the 2014 NDAA bars any service branch from adopting any "new camouflage pattern design or uniform fabric for any combat or camouflage utility uniform or family of uniforms for use by an Armed Force" (p. 72). The law goes on to provide certain caveats allowing for the reuse of camouflage patterns and uniforms already in existence and use by other branches. In his article "Digitize or Die: The Quixotic Battle for Camouflage Patterns in the United States Military," T. R. Farrell (2022) explained that Congress did this to curb the massive spending by military branches laterally pursuing new camouflage patterns. Because of this law, the Marine Corps is limited to camouflage patterns and research that already exists within the Department of Defense (DoD) to find a solution that fits the Pacific AO properly.

In 2002, the Marine Corps adopted the MARPAT-style uniform for fielding across the service (Farrell, 2022). T.R. Farrell (2022) explains further that those in charge of the selection desired not only a uniform that worked in combat but also a pattern that made Marines stand apart from their Army, Navy, and Air Force counterparts. In selecting the MARPAT woodland and desert camouflage variations for their uniforms, they achieved this goal. Additionally, they ensured no other branch of Service could use MARPAT since

> The Marine Corps both trademarked the pattern in MARPAT and obtained a patent for the manufacturing process of the uniform. This intellectual property protection served various purposes. First, the Marine Corps believed such intellectual property protection would prevent other military branches from using the Marine Corps' design. Additionally, this protection allowed the Marine Corps to license its uniform design as a means to obtain revenue via sales of licensed merchandise bearing the Marine Corps' insignia. (Farrell, 2022, p. 7)

By owning the MARPAT patent and trademark, the Marine Corps effectively reduced its flexibility regarding which uniforms it can issue while still making good on its investment of taxpayer dollars. Additionally, Marine Corps decision-makers' desire to ensure that Marines stand apart would naturally make them hesitant to abandon the MARPAT.

The restrictions emplaced on Service branches by the 2014 NDAA (2013) and the parameters established by previous Marine Corps decisions around MARPAT narrow the viable options for Marine camouflage and uniform improvements. The Service cannot develop a new uniform pattern because of the 2014 NDAA (2013). Additionally, the Service has reason to retain MARPAT as its pattern simply based on the pattern's revenue-generating trademark and the patent that distinguishes MARPAT as uniquely "Marine." Therefore, the best option for finding an effective camouflage pattern may be in changing the color variation to a transitional pattern while retaining the MARPAT pattern scheme for the uniform. For the purposes of this research, the assumption is made that changing the color of a camouflage pattern is not creating a "new" pattern. By remaining MARPAT but modifying the coloration of the MARPAT to a transitional color scheme, the Marine Corps can stay within the law and still use its patented pattern in future combat operations.

C.   HISTORY OF CAMOUFLAGE RESEARCH

To understand the importance of camouflage, a brief historical account of camouflage is necessary. Camouflage in nature exists for very similar reasons that it exists on the modern battlefield. Western artists and naturalists first seriously studied camouflage in the early 1900s (Behrens, 2009). However, humans have employed camouflage in certain cultures for centuries. In a 2009 article, Roy Behrens discusses the development of a camouflage study by a man named Abbott Thayer, described as a "young artist-scientist" who elevated the "importance of artistic principles in the understanding of military camouflage" (p. 497). Thayer's work largely included the study of countershading and what he termed "dazzle" camouflage in animals (Behrens, 2009, p. 497). These principles enable prey in the animal kingdom to appear smaller than they are (through countershading) and break up their appearance (through dazzle camouflage) so

that predators cannot identify their presence. Thayer demonstrated this through differently painted duck decoys and worked in conjunction with an entomologist named Edward Poulton to advance research on camouflage. The military later employed this research on large pieces of equipment such as battleships, which were painted with a zigzag of different paint colors (see Figure 3). These colors were intended to break up the outline of the ship, making it much harder to tell the ship's course bearing from the periscope of a would-be enemy submarine (Behrens, 2009, p. 499).
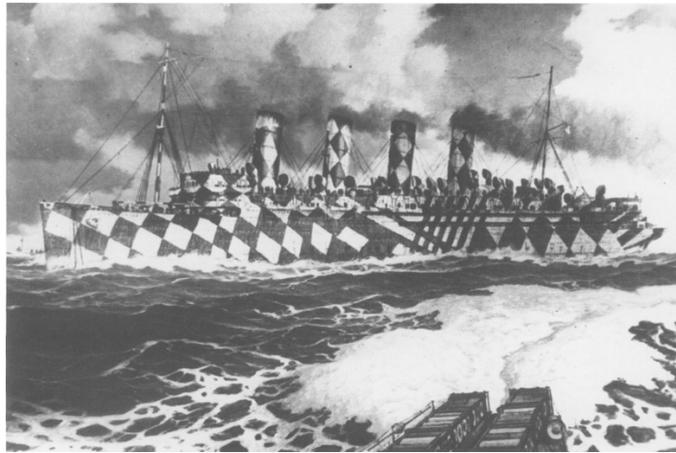
Figure 3.   A 1924 rendition of a ship painted with dazzle method. Source: Behrens (2009).

However important Thayer's work was to military camouflage in the 20th century, humans have used camouflage long before 1909. Steve Gilliand (2008) discusses the camouflage skill of Native Americans in an article titled "The Fine Art of Camouflage," titling them "masters of camouflage, from walking crouched beside their horse while creeping closer to an elk, to draping themselves with a buffalo hide and skull to crawl nearer a herd of grazing bison" (p. 1). Additionally, Native Americans would use these camouflage skills against British colonists and troops who "marched in perfect columns onto the battlefield, their bright red coats gleaming in the sun, only to be picked off in droves" (Gilliland, 2008, p. 1). The historical application of camouflage tactics can be traced back to the very beginnings of civilization across almost all cultures. Camouflage's use in combat is exhaustive, so this thesis focuses further on the modern application of camouflage from World War I onward, now that the given context is set.

D. HISTORICAL EVOLUTION OF MILITARY CAMOUFLAGE

Among land forces, the modern history of camouflage starts with World War I. Though camouflage was largely uncommon at the time due to prevailing European cultural norms of colorful, formal battle uniforms, Rajesh Nambiar (2022) observes that "German "Pickelhaube" helmets" were used to prevent glint (today known as shine) from the sun (p. 5). Additionally, the French Army created "a Section de Camouflage in 1915. The experts were for the most part, painters, sculptors and theatre-set artists" who were employed to paint snipers' uniforms to blend into their surroundings (Nambiar, 2022, p. 5). After World War I, more industrialized efforts by European and western militaries led to the development of greater camouflage capabilities. The Germans and Russians both developed camouflage uniforms for their snipers in winter terrain. U.S. naval vessels were more commonly painted to reduce their signature as well. By World War II, camouflage had entirely entered the military scene (Nambiar, 2022, p. 7). In a 1985 article concerning the history of camouflage research from an American military perspective, Malcolm Keown et al. discuss the Fixed Installation Camouflage Research Program, which was an attempt to increase the focus on camouflage after World War II. The attempts to advance camouflage technology were not limited to just uniforms. Rather, Keown et al. (1985) state that the program "initially led to the production of a multispectral camouflage design procedure and, ultimately, will give the designer or installation commander an automated camouflage effectiveness evaluation system to assess the worth of a given camouflage measure against multispectral threats within an attack scenario" (p. 452). This evaluation system represents an example of applied military science in camouflage. As decision-makers started incorporating more scientific research and system engineering into DoD acquisitions in the mid-20th century, camouflage research grew in scientific backing.

E. MODERN U.S. CAMOUFLAGE USE

The DoD has slowly incorporated more effective means of camouflage employment for the better part of a century in the modern military context. As the force further professionalized over time, so did the means of evaluation used to assess programs. The uniform effectiveness evaluations were no exception to that change over

time. Scientific frameworks governed the development, testing, and selection of uniforms to ensure objective means of evaluation. This process of professionalizing and developing objective bases for camouflage evaluation are critical to understanding the effectiveness of a three-pattern family of camouflage in the Marine Corps.

Looking specifically at modern warfare throughout the last century, a common trend surfaces in the advancement of camouflage practices. Peter Suciu (2015) authored an article detailing "the evolution of U.S. military camouflage" in which he notes that the British were the first to notably adopt camouflage when "irregular units adopted drab colors, as did gamekeepers, to hide from game and poachers" (p. 2). Furthermore, the British were the first of western modern forces to employ khaki in order to blend in better with desert environments, a practice that the U.S. armed forces adopted soon after. An example of British armed forces' khaki uniforms is shown in Figure 4.

Figure 4.   This is a common depiction of a World War I–Era British Soldier in Khaki. Source: Khaki (n.d.)

Suciu (2015) further states that the U.S. military really started developing camouflage uniforms at the beginning of World War II, when the need for camouflage arose in the Pacific Theater. The camouflage pattern that was chosen came from "Norvell Gillespie, a horticulturist and garden editor of *Better Homes and Gardens*. It consisted of a spot design of greens and browns and was reversible to a tan/brown variation that could be used in fall and early spring conditions. It featured five colors in total and was nicknamed 'frogskin' for its spotty pattern" (Suciu, 2015, p. 3). After that development

for jungle warfare uses, the War Department (later renamed the DoD) declared that all military forces would be uniformed in a standard olive drab (OD) green working uniform. Apart from some special operations units that required special camouflage capabilities for their long-range reconnaissance patrols, there was very little change to this policy until the end of the Vietnam War. Figure 5 shows two uniform variations from this time.

Figure 5.   Marines shown here wear olive drab uniforms during the Vietnam War. Source: Getty (2025).

From the 1980s to 2002, the U.S. military wore two standard camouflage uniforms regardless of Service branch. In his thesis on the Navy and Marine Corps uniform commonality, Bryce Hicks (2018) discusses the non–Service-specific uniform development and observes that uniform programs were joint efforts that were overseen primarily by the Army (p. 6). Uniforms that provided camouflage value were split between the Desert Camouflage Uniform (DCU) with the desert camouflage pattern and the Battle Dress Uniform (BDU) with a woodland camouflage pattern (see Figure 6 on page 19 for visuals of DCU and BDU). As the names imply, there was one pattern designed for desert employment and another that was to cover all other use cases. The Navy, Marine Corps, Air Force, and Army used these uniforms from 1981 until 2002, with some variations during the wars in the Middle East, in which different desert camouflage variations surfaced as well (Hicks, 2018, p. 6).

With this background information regarding the history and context of military camouflage, along with a legal and regulatory foundation, further discussion specific to Marine uniforms and American military uniform research can begin. Understanding camouflage's background development, its origins, and how it works is essential to understanding its relevance on the battlefield. Marines rely on camouflage heavily in combat, as have warfighters for hundreds of years. Modern advancements in camouflage use starting during World Wars I and II were powered by scientific applications. As the modern battlefield's sensing and detection capabilities increase in effectiveness, so too should the military services' technical and scientifically backed camouflage capabilities.

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III.   LITERATURE REVIEW

A.   PURPOSE

The purpose of this literature review is to examine relevant and current research related to the topic of military camouflage and military uniforms. In doing so, this literature review informs the context of the research in this thesis and further reveals the gap in research that this thesis seeks to fill. An understanding of current research standing and data is explained through an examination of research by Wharton (2017), Hicks (2018), Mazz (2015), Fiorelli (2025), Mortlock (2020), and Cellini & Kee (2015). The theoretical frameworks used in each piece of research validate the use of the cost effectiveness analysis in this field and, specifically, this topic.

B.   LITERATURE

a.   *Robin Wharton (2017): Barriers to Implementing a Single Joint Combat Camouflage Uniform*

In 2002, the Marine Corps revealed its own specific pattern of camouflage called MARPAT (Wharton, 2017). This departure from the BDU and DCU marks the beginning of the Marine Corps' efforts to enhance camouflage effectiveness for Marines in combat. Robin Wharton explains in his 2017 thesis that this departure led to a new precedent for Service branches to create their own branch-specific uniforms. The following decade was fraught with duplicated uniform development efforts, yielding at least 10 different uniform designs as service branches strived to create their own effective uniforms (Wharton, 2017). Wharton argues that these attempts led to a waste in government and taxpayer dollars due to simultaneous and asynchronous efforts that expended money on uniforms of little use, effectiveness, or need. Figure 6 shows BDU and DCU camouflage patterns.
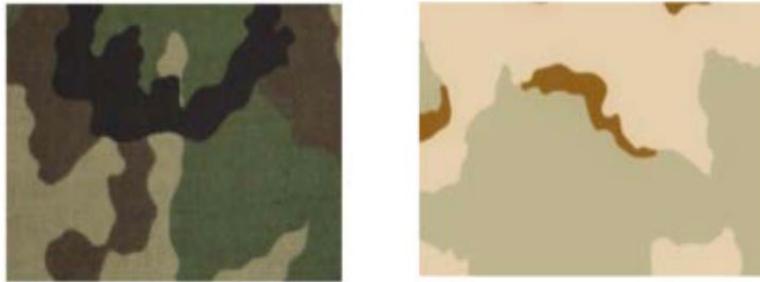
Figure 6.   Battle Dress Uniform M81 Camouflage Pattern (left) and Desert
Camouflage Uniform (right) Source: Wharton (2017).

One of these efforts was the fielding of the Army's Universal Camouflage Pattern (UCP) on the Army Combat Uniform (ACU). After the Marine Corps created its own Service-specific camouflage uniforms, the Army adopted the ACU in 2005 (Wharton, 2017). However, as Wharton (2017) notes, the Army chose to field a singular pattern that, while more cost-effective than multiple patterns, sacrificed some effectiveness in individual concealment of soldiers (p. 9). This "cheap" option ended poorly for the Army 4 years later when Congress issued a mandate to develop a more effective camouflage pattern since soldiers were not blending in properly in Afghan terrain (Government Accountability Office, 2012). The new efforts to increase the Army's camouflage pattern effectiveness for use in Afghanistan resulted in the development of the trademarked MultiCam pattern, among other patterns (Wharton, 2017, p.10). This process led to the development of the Army's modern camouflage evaluation methods. These methods are critical to understanding the most up-to-date methods of camouflage evaluation. As for the Afghanistan-specific pattern, after extensive test and evaluation, the Army adopted MultiCam and called the pattern Operation Enduring Freedom Camouflage Pattern (OEF-CP) (Wharton, 2017, p.10).

b.   Dr. Robert Mortlock (2020): "Camouflage Combat Uniform"

Mortlock's (2020) case study about the Camouflage Combat Uniform and its development outlines the ways in which the Army methodically evaluated camouflage patterns. Essentially, "two different criteria existed to compare the effectiveness of camouflage: detection and blending. Camouflage testing determined detection and blending scores for various camouflage patterns in relevant military operating

environments" (Mortlock, 2020, p. 360). The Army methodically tested different patterns in different environments, focusing on detection and blending through photographic tests. Results were quantified to provide the best-to-worst scale of effective uniforms based on the different backgrounds and lighting available. The U.S. Army Natick Soldier Research, Development, and Engineering Center (NSRDEC) played a large role in facilitating these simulations: According to Mortlock (2020),

> Based on work performed by the NSRDEC and completed in 2009, the Army knew that environmentally specific camouflage patterns outperformed (meaning provided more effective concealment) than a single 'universal' pattern (Hepfinger et al., 2010). The objective of Phase IV was to develop a 'family' of three uniform camouflage patterns with a single coordinated pattern for OCIE to provide effective concealment across the globe in woodland/jungle, transitional, and desert/arid environments. (p. 366)

The phase IV objective sets a precedent for forming a three-pattern family of uniforms to cover military operating environments across the combatant commands apart from arctic conditions (in which standard combat uniforms would not be used). Furthermore, in late 2012–early 2013, the Army conducted an extensive test that compared the Army UCP, OEF-CP, MARPAT, and Navy Pattern Camouflage, and four commercial vendor uniform families for the arid, transitional, and woodland environments (refer to Figure 7) (Mortlock, 2020, p. 368). The testing included the Marine Corps' MARPAT Desert (MARPAT-D) and MARPAT Woodland (MARPAT-W) patterns.
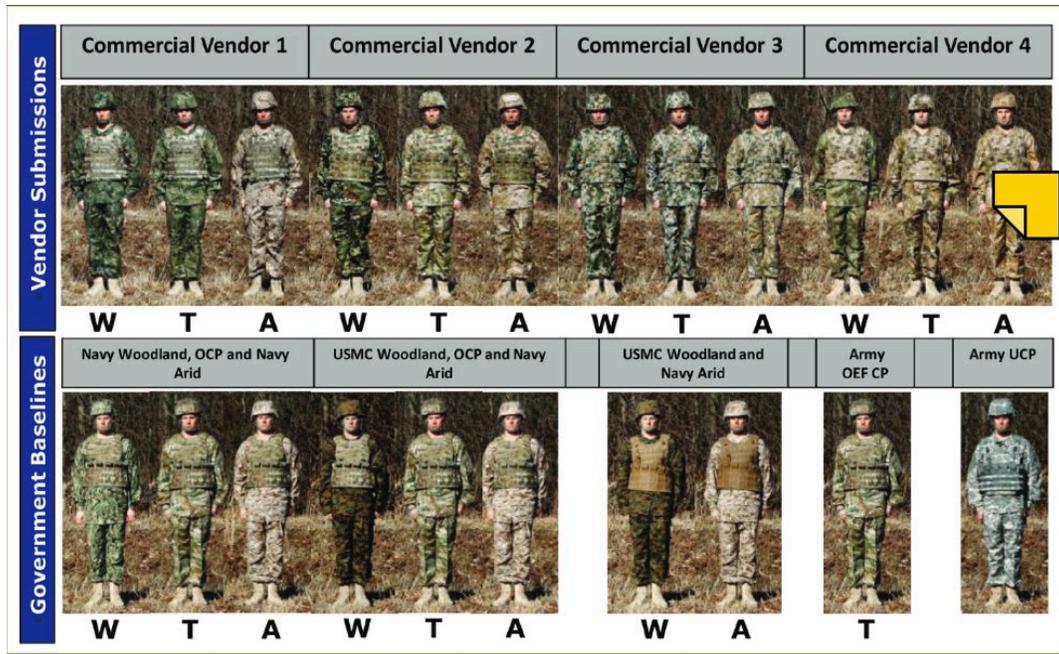
Figure 7. Camouflage patterns tested in combination sets from camouflage case study. Source: Mortlock (2020).

The results of this test showed several important outcomes. Overall, the test gathered 91,486 data points on blending and detection in various light conditions and 39 backgrounds representing seven different areas of the globe (Mortlock, 2020, p. 368). Mortlock (2020) describes the tests criteria further:

> Field tests for static observation detections were conducted at three different locations, resulting in the collection of an additional 25,415 data points Operational field tests with force-on-force soldiers were conducted at two locations, gathering another 973 data points. Finally, the spectral reflectance measurements were conducted by the U.S. Army Night Vision Laboratory (now the U.S. Army Night Vision and Electronic Sensors Directorate) to assess pattern "brightness" in visual, near infrared (NIR), and short-wave infrared (SWIR) bands. (p. 369)

With these parameters, the tests resulted in some detailed and applicable results for future uniform development. The UCP was outperformed in every category, which, after anecdotal reports from soldiers in the field, was not surprising. From the Army's examination of the full menu of uniform patterns, Mortlock (2020) concludes that "slight improvement was evident in the effectiveness of a family of patterns in their intended backgrounds over the performance of a single transitional pattern across the three background classes; however, the operational relevance of this improved performance

proved difficult to quantify" (p. 369). The Army did allow the OEF-CP pattern to be employed beyond its original purpose, but no uniform change decision was implemented immediately. Right after that test, the 2014 NDAA barred the development of further Service-specific uniforms, which created significant challenges to the development of new uniforms for Services across the DoD.

In the wake of the 2014 NDAA (2013), the program manager in charge of uniform development for the Army was authorized to test transitional camouflage patterns out of patterns that were already owned by the DoD. This testing would help determine a better alternative to the UCP. The patterns "were the ScorpionW2 pattern and two digital transitional camouflage patterns—referred to as DTC1 and DTC2—patterns based on USMC MARPAT but with four earth-tone-based colors" (Mortlock, 2020, p. 378). This specific test carries increased significance because of its evaluation of MARPAT against other patterns that may be classified as effective in transitional environments. The test of these transitional patterns assessed "the operational relevance of the patterns in operational field tests and 106 soldiers as observers of the patterns in 46 separate backgrounds in photo simulation evaluations—collecting 19,474 data points" (Mortlock, 2020, p. 379). While the MARPAT-W and MARPAT-D performed well in their intended environments, the transitional patterns outperformed them in their intended backgrounds. The data gathered from the testing done in this series of evaluations led the program office to put together decision matrixes that offered various options with which the Army could proceed.

The Army sought a pattern that worked well in transitional environments and did not violate the 2014 NDAA (2013). Ultimately, it chose to select and field the Scorpion2 pattern and named the pattern Operational Camouflage Pattern (OCP) to highlight the fact that the pattern was extended to military operating environments beyond Afghanistan. The OCP performed well in transitional environments across the globe and outperformed its prior service-wide uniform, the ACUs that had UCP. Mortlock (2020) observes that "choosing OCP resulted in soldiers' benefiting from an effective camouflage pattern and the nation benefiting from the best use of limited resources" (p. 388). This also sets a precedent of quantitatively backed tests that show the effectiveness of OCP in transitional environments over MARPAT-W and MARPAT-D, creating a use

case for OCP in transitional environments. Because of the 2014 NDAA (2013), the OCP is accessible to all Services, not just the Army. Other Services may still access the MARPAT pattern and color scheme if they remove the eagle, globe, and anchor emblem from the pattern. Of note, the other Services could use MARPAT but generally they choose to respect the Marine Corps' desire to keep MARPAT uniquely for Marine Corps use.

c. *John Mazz (2015): "Data Analysis for the Army Camouflage Uniform Improvement Project"*

The case study that Mortlock wrote in 2020 regarding the Army's uniform development and the events surrounding it was largely based on reports from the testing itself. That testing was captured in a report by John Mazz (2015) titled *Data Analysis for the Army Camouflage Uniform Improvement Project*. This report provides comprehensive and in-depth data on the testing that the Army conducted, serving as the primary insight into the use of transitional camouflage patterns across the DoD. Not only does the project include an examination of transitional patterns, but it also includes woodland and desert (arid) patterns of a variety of combinations, areas, and foliage levels. Mazz's (2015) report captures a significant amount of data regarding the test results of the OCP and transitional patterns in different variations. This data serves a major role in the comparison of different camouflage products in the Analysis chapter of this thesis.

Mazz's (2015) report on military camouflage patterns has foundational implications that form the basis of modern assessment for military camouflage effectiveness using data. Because he focuses on effectiveness in an empirical way, this research is essential to performing a cost effectiveness analysis. Because the study combined photographic simulations and operational testing, it has legitimate backing in both the scientific field of study and operational units. In operational testing, "A total of 196 U.S. Army Ranger Regiment soldier observers participated in the photo-simulation and 120 infantry soldiers participated" (Mazz, 2015, p. 11). Ultimately, Mazz concluded that when strictly focusing on effectiveness, arid and woodland patterns performed better than transitional patterns did in their respective environments. This finding reinforces the

original intent of the Army's study, which was to investigate the effectiveness of fielding a three-pattern (arid, transitional, woodland) family of uniforms to the force. It also directly applies to doing the same investigation for the Marine Corps, just using a different pattern scheme.

d. John Fiorelli (2025): A Cost effectiveness Analysis of Camouflage Patterns on USMC Plate Carriers

In his 2025 thesis on the cost effectiveness of the camouflage plate carrier, Captain John Fiorelli makes competent assessments of the use of camouflage in modern Marine Corps applications that are relevant to the fielding of camouflage uniforms. He investigates the lack of camouflage on Marine Corps plate carriers, which currently are only in a coyote brown color. His research, like this one, seeks to improve the signature management of Marines who may find themselves on the front lines of future combat. He captures the status of military studies of camouflage, completes an analysis of adopting camouflage patterns into the Marine Corps for use in future combat, and promotes signature management capabilities. In his analysis, Fiorelli (2025) "uses multi-objective decision-making through an objective hierarchy" (p. 44). Essentially, he creates a cost effectiveness analysis for issuing a camouflage plate carrier to Marines. Additionally, Fiorelli (2025) uses a process that "incorporates cost-estimation techniques to provide reasonable and credible cost estimates for each COA" (p. 45). Using data from Mazz (2015) and other relevant research, he creates an objective hierarchy to lay out standard measures of effectiveness (MOEs). He focuses on blending and detectability as the primary MOEs and examines six different courses of action for the plate carrier solution.

His methods for cost effectiveness analysis create a model for this analysis to follow to determine realistic outcomes. Additionally, Fiorelli (2025) uses the data provided from the Mazz (2015) study to analyze the feasibility of employing camouflage on plate carriers in the Marine Corps. Ultimately, Fiorelli (2025) does not recommend one course of action over another but seeks to inform the decision-maker who reads the research so that, given the circumstances at the time, the correct decision can be made with a proper understanding of the trade-offs at hand.

e. Paul Moreau (2022): A Cost effectiveness Analysis of C-12 Variant Airborne ISR Capabilities in the Marine Corps

Paul Moreau's research at the Naval Postgraduate School presents a very well-organized cost effectiveness analysis. Moreau (2022) compares an unmanned air vehicle called the RQ-21A Blackjack to the MC-12W Liberty, a manned aircraft, based on their effectiveness as Marine Corps intelligence, surveillance, and reconnaissance platforms. He provides a valuable baseline to employ and learn from for this cost effectiveness analysis, similar in utility to Fiorelli's (2025).

After providing the background information regarding the capabilities and costs of the different alternatives along with considerations on interoperable fit and mission readiness, Moreau (2022) explains the validity of the cost effectiveness analysis as opposed to the cost–benefit analysis (CBA). He directly states that "the fundamental difference between a CBA and a CEA is that while a CBA monetizes and compares both costs and benefits, a CEA monetizes and compares costs, but for multiple reasons does not monetize and compare benefits" (Moreau, 2022, p. 15). He goes on to explain that in military decision-making, it is often the case that cost effectiveness analyses are conducted rather than CBAs. He explains the history behind CEAs and CBAs as well. The most applicable aspect of Moreau's (2022) work regarding this research lies in how he set up an objective hierarchy, assigned value functions, and weighted measures of effectiveness. These aspects of his analysis served as an example for Fiorelli's (2025) work to follow and serve as a model for this work as well.

f. Cellini and Kee (2015): "Cost effectiveness and Cost Benefit Analysis"

Stephanie Cellini and James Kee's (2015) chapter in the *Handbook of Practical Program Evaluation,* published in 2015, provides detailed step-by-step processes to conduct either a cost effectiveness analysis or a cost–benefit analysis. Cellini and Kee (2015) provide examples of the processes and explain that these tools "can greatly assist decision makers in assessing a program's efficiency" (p. 636). They walk through a total of 10 steps from beginning to end, explaining how to conduct each step, how to avoid common mistakes, and how to present the data appropriately.

Cellini and Kee (2015) explain the nuances behind marginal cost and marginal effectiveness (or marginal benefits). Additionally, they discuss proper methods of monetization and how to assign values accordingly in an analysis. The main example they use to illustrate their explanations focuses on a high school dropout study, which provides insights to analysts. The details of this work are explained in great depth in the methodology, as Cellini and Kee's literature serves as the bedrock for the analysis in this thesis. The work produced by Cellini and Kee guides and directs the work of this analysis to ensure proper representation of costs, measures of effectiveness, and results.

C.   CONCLUSION

Because Fiorelli (2025) focuses on plate carriers and patterns already in circulation while other research does not focus on the Marine Corps at all, there remains a gap in the body of knowledge for Marine Corps uniform effectiveness in the future fight. Combining this current research concerning camouflage uniforms and the research in Fiorelli's study of plate carrier effectiveness could make a significant impact on the effectiveness of the overall Marine's camouflage in a future combat environment.

Additionally, throughout all the literature examined during research into matters of camouflage in the U.S. armed forces, there is a gap that has yet to be addressed. No current or past research addresses the need for the Marine Corps to field a transitional uniform in some capacity or how such a plan would be implemented. For over 20 years, the Marine Corps has used the MARPAT two-pattern family of uniforms. But with the close of the Global War on Terror and the rejuvenation of Great Power Competition, the need for that Marine Corps transitional uniform is more relevant than ever before. This research seeks to fill that gap in the body of knowledge that surrounds uniform use and effectiveness for the U.S. Marine Corps. In doing so, this research may be able to contribute in small part to saving American lives on the front lines in the next fight.

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IV. METHODOLOGY

A. OVERVIEW

Government projects require strict evaluation and inspection to ensure the proper and responsible use of taxpayer dollars. To accurately assess prospective programs, the U.S. government often conducts either a cost–benefit analysis (CBA) or a cost effectiveness analysis (CEA). The choice between a CEA and a CBA almost always comes down to appropriate fit for the program in question. This research establishes a CEA modeled largely after the one in Fiorelli's 2025 work, in which he conducted a very similar analysis of plate carriers. Because Fiorelli so successfully uses a CEA to analyze plate carriers, uses similar resources, and focuses on the same population, this study replicates many of the mechanisms used to determine outcomes in Fiorelli's work. In this research analysis, the processes of cost estimation and cost effectiveness analysis follow industry-wide accepted standard steps. Furthermore, the analysis is informed by widespread literature that explains the process of cost effectiveness analysis.

To understand CEA, first it is important to understand the difference between CEA and CBA. The Office of Management and Budget (OMB; 2023) produced a document called *Circular No. A-94*, which "provides general guidance for conducting benefit-cost and cost effectiveness analyses of certain Federal activities" (p. 3). The document provides clarity that the "cost effectiveness analysis is appropriate whenever it is unnecessary or impractical to consider the dollar value of the benefits provided by the alternatives under consideration" (OMB, 2023, p. 5). Because of the nature of defense systems that are being considered in an analysis, and their alternatives, the benefits associated with each alternative often cannot be appropriately enumerated. Therefore, most defense systems fall into the category of a CEA rather than a CBA, which might be more appropriate for building an interstate or a bridge, for example. The steps of a CEA are depicted in Figure 8.

1. Set the framework for the analysis.
2. Decide whose costs and benefits should be recognized.
3. Identify and categorize costs and benefits.
4. Project costs and benefits over the life of the program, if applicable.
5. Monetize (place a dollar value on) costs.
6. Quantify benefits in terms of units of effectiveness (for CEA) or monetize benefits (for CBA).
7. Discount costs and benefits to obtain present values.
8. Compute a cost-effectiveness ratio (for CEA) or net present value (for CBA).
9. Perform sensitivity analysis.
10. Make a recommendation where appropriate.

Figure 8.   Steps in a standard Cost Effectiveness Analysis. Source: Cellini & Kee (2015).

As previously mentioned, Stephanie Cellini and James Kee wrote a 2015 article explaining CBA and CEA, including the 10 steps in a CEA, which this paper conducts. In doing such an analysis, this thesis relates the "costs of a program to its key outcomes" in a way that informs a decision-maker on all of the available alternatives (Cellini & Kee, 2015, p. 636). Part of informing the decision-maker is producing the cost effectiveness ratio (CER), which Cellini and Kee (2015) describe as a ratio "dividing costs by units of effectiveness" (p. 636). A unit of effectiveness is a standardized measure of "any quantifiable outcome central to the program's objectives" (Cellini & Key, 2015, p. 637). Figure 9 shows the equation that represents the CER. The equation presents the comparison of total cost to units of total effectiveness.

$$\text{Cost-Effectiveness Ratio} = \frac{\text{Total Cost}}{\text{Units of Effectiveness}}$$

Figure 9.   The cost effectiveness ratio. Source: Cellini & Kee (2015).

This CEA focuses on evaluating the effectiveness of the transitional camouflage pattern applied to the MARPAT design. It does not evaluate material toughness, cut, design, new camouflage patterns, or other qualities that are important for a uniform but beyond the scope of this project. This CEA seeks to inform decision-makers who ask the following questions:

1.   How effective are the current patterns of camouflage in use by the Marine Corps today?

2.   What options are available to address the challenges raised by current camouflage capabilities?

3.   How can the U.S. Marine Corps invest in a three-family pattern of camouflage for the MARPAT MCCUU?

4.   What is the best and most cost-effective method to invest in effective camouflage uniforms for the future?

To properly inform these research questions, it is important to define the alternatives or courses of action (COAs) that are to be evaluated. The COAs include the status quo as one alternative, which is to leave the current uniform program as it is. The following is the comprehensive list of alternatives, from COA 1 (status quo) to COA 5.

- COA 1: Status Quo – The Marine Corps continues to employ the two-pattern family of uniforms for the MCCUU and FROG, with both desert and woodland coloration. This option creates a baseline against which all other alternatives are compared.

- COA 2: Three-Pattern Family Fielding – The transitional coloration is added to the MARPAT's desert and woodland coloration schemes to make a three-family pattern that is fielded to Marines across the force. This includes adding an MCCUU and a FROG transitional uniform.

- COA 3: Combatant Command–Specific Fielding – Only those Marines deploying to INDOPACOM are fielded the transitional pattern MCCUU and FROG. This ensures Marines are prepared for combat in the diverse environments that cover the world's largest area of operations and the expected stage for the next great power conflict.

- COA 4: One-Pattern Family – Transitional MARPAT replaces the woodland and desert coloration of MARPAT, creating a one-pattern family of uniforms for both MCCUU and FROG. This option offers a juxtaposition to the three-family pattern and eliminates woodland and desert coloration from the USMC inventory.

- COA 5: FROG Transitional Uniform –Marines worldwide are fielded the FROG transitional uniform when deploying. This option focuses on providing Marines with the FROG's flame-retardant capabilities that are often valued during amphibious operations.

There are three different types of CEAs based on when they are conducted. The *ex ante* CEA is conducted before a project or program is initiated. An *ex post* CEA is conducted at the end of a program to total its cost accurately and assess its effectiveness in relation to those costs, often for future analysis or examination of lessons learned. Lastly, there is the *in medias res* CEA, which is done in the middle of executing a program or project and evaluates the effectiveness against some known and some projected costs (Cellini & Kee, 2015, p. 639). For this study, the CEA conducted serves

as an *ex ante* since the effectiveness of a three-family pattern of camouflage is projected prior to the execution of the program.

B.   COST FRAMEWORK

Estimating costs for the purpose of a CEA requires detailed consideration and calculation. Estimating costs allows the analyst to associate a monetary value to each cost that allows for easy comparison at the conclusion of the CEA (Cellini & Key, 2015, p. 646). Furthermore, it is essential to consider only the costs that are "over and above those that would have occurred without any action" (Cellini & Key, 2015, p. 639). Therefore, any costs that are incrementally below the status quo are removed from consideration. This principle leaves us with what is known as incremental or marginal costs.

In their book *Cost Estimation: Methods and Tools*, Mislick and Nussbaum (2015) define cost estimation as "the process of collecting and analyzing historical data and applying quantitative models, techniques, tools, and databases in order to predict an estimate of the future cost of an item, product, program, or task" (p. 11). The Government Accountability Office published a guide to cost estimation, which Mislick and Nussbaum (2015) cover, and which directs this CEA's cost-estimating process. Because this is an *ex ante* CEA, the cost estimations use historical data to predict 30-year life-cycle costs for the uniform program. As Cellini and Kee (2015) point out in their discussion of timing, a CEA needs to incorporate analysis covering the period over which the program would reasonably be conducted (p. 639). Service-wide programs have a history of spanning several decades, and, historically, uniforms are updated every 20–30 years. Additionally, Fiorelli's (2025) CEA covers a 30-year timespan, which further provides precedent for 30-year estimations in this CEA.

To estimate costs 30 years into the future, it becomes essential to consider inflation and its role in DoD programs. The Cost Assessment Data Enterprise created a tool to assist cost estimators in taking inflation rates for certain DoD-focused indices into consideration. This tool, called the Joint Inflation Calculator, provides historically based inflation rates for the projection of costs into the future. In this thesis, the JIC uses the Marine Corps Procurement (PMC) index to estimate inflation of uniform costs into the future. Certain assumptions must be made when conducting predictive cost estimates.

Such assumptions include the steady decrease in the value of the dollar. Additionally, the projections assume that no massive financial crash or boom occurs in those 3 decades. Additionally, the assumption is made that the resources that make up the product are not subject to volatile price changes.

The cost data in this research comes from Defense Logistics Agency (DLA) reports along with published information concerning government contracts in Marine Corps uniform procurement. In addition, the quantity estimations used to determine total price are based on information gathered from the Defense Manpower Data Center. Lastly, through an understanding of the force distribution of the Marine Corps and its posture in the Indo-Pacific, along with the standard organization of Marine Corps units, this thesis provides uniform procurement totals for Marines stationed and deployed in that region.

## C.	EFFECTIVENESS FRAMEWORK

The effectiveness framework makes up the main body of the CEA. The effectiveness framework is often subject to individual opinion and judgement. Therefore, it must be scrutinized and backed up with data as much as possible. When "categorizing as many of the known benefits and costs of the program as possible," an efficient way to organize those items is the objective hierarchy (Cellini & Kee, 2015, p. 642). Of course, different qualities are measured in different ways; therefore, it becomes necessary to normalize units by assigning value functions. After that, weights are required if there are certain elements of the objective hierarchy that are more important than others. This is largely subjective, as Cellini and Kee (2015) point out that to determine an appropriate weight is "a subjective factor that is ultimately the judgement of policymakers" (p. 667). After building the function, the resulting output provides MOE scores. These scores must be subjected to a sensitivity analysis, and the assumptions made in the CEA must be examined thoroughly.

### 1.	Objective Hierarchy

In Moreau's 2022 thesis focusing on a CEA of unmanned aircraft, an objective hierarchy "developed based on Key Performance Parameters" enabled him to present the decision criteria in an organized fashion (p. 37). Additionally, Fiorelli (2025) employs a

similar objective hierarchy on his work with plate carriers "to establish a measure of overall effectiveness" (p. 40; see Figure 10). Through this process of establishing an objective hierarchy, the overall mission or objective of the project must be determined. Then, the key MOEs that contribute to the overall mission/objective of the program are identified in the first tier of the hierarchy. Following that, as needed, are further means of determining those MOEs as quantifiable attributes.
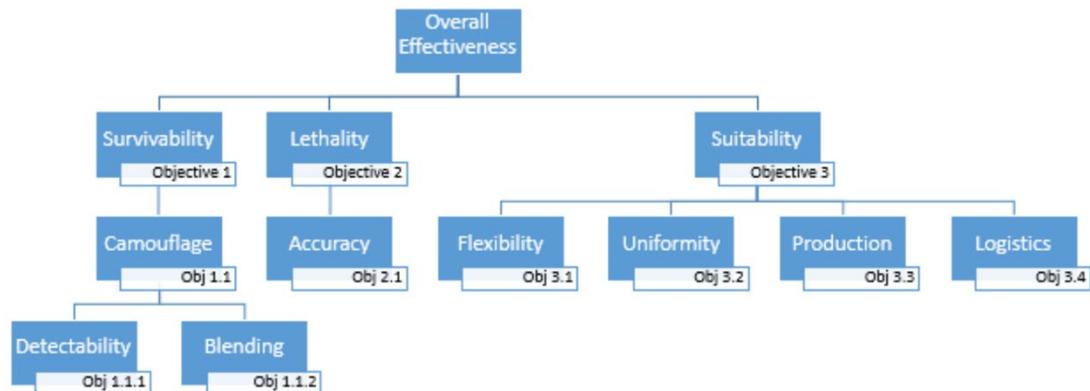
Figure 10.   Fiorelli's objective hierarchy for a camouflage plate carrier.
Source: Fiorelli (2025).

As seen in Figure 10, Fiorelli (2025) populated his objective hierarchy with the factors he deemed most important for analysis when examining the USMC plate carrier. This step of establishing the effectiveness framework lays the foundation for all follow-on steps. In this analysis, the objective hierarchy is used to address the effectiveness of different camouflage patterns in a similar way to Fiorelli (2025) because both this study and Fiorelli's (2025) rely on Mazz's (2015) data and how he classifies that data. Additionally, this objective hierarchy includes details in production and distribution to encompass all vital aspects of effectiveness. Like most systems in the Marine Corps, overall combat effectiveness for the force is the primary concern for the objective hierarchy.

2. Value Functions

As Fiorelli (2025) and Moreau (2022) both explain, the value function is a critical step in normalizing the different measurements associated with different parts of the objective hierarchy. Moreau (2022) explains that "to develop this value function with

marginal differences in attributes accounted for, the incremental value of each attribute must be determined and then divided by the cumulative value of all the attributes to arrive at a value between zero and one for each" (p. 39). He assigns each objective value a value function that reflects its utility when an input is provided to it. This allows the creator of the value function to control the scoring for each objective in accordance with the value of each input. Figure 11 shows an example of a value table using aircraft dwell time as a measure that is being scored and, as a result, normalized. The results of these scores do not have to be linear if there is more value associated with a certain range or segment of scores that is much greater than that of a different segment (as seen in Table 1).

Table 1.   Moreau's Dwell Time example. Source: Moreau (2022).

Dwell Time	Cumulative Value	Value
0-3 hours	2	2/41 = .049
4-5 hours	2+6 = 8	8/41 = .195
6-7 hours	2+6+8 = 16	16/41 = .390
8-9 hours	2+6+8+9 = 25	25/41 = .610
10-11 hours	2+6+8+9+7 = 32	32/41 = .780
12-15 hours	2+6+8+9+7+5 =37	37/41 = .902
16+ hours	2+6+8+9+7+5+4 =41	41/41 = 1

Moreau's Dwell Time example shows the cumulative values assigned, divided by the total of all possible values.

3.   Weights

CEA analysts assign weights to the objective hierarchy attributes to show that some characteristics are more important to the analysis calculations than others. Weights are determined by the analyst and are often the focus of sensitivity analysis for that reason. Weights are assigned in a uniform manner by totaling the number of attributes and then prioritizing them from largest value to smallest value. Finally, they are divided by the sum of all the attributes to produce a normalized weight for each item. The normalized weight is "simply the weight assigned divided by the sum of all weights" (Moreau, 2022, p. 42). In this thesis, some weights are confined within each "level one attribute" in the objective hierarchy, and some are assigned to the overall objective

hierarchy external of each level one attribute that comprise the weighting of the entire system.

4. Measure of Effectiveness Scores

The MOE scores are the final results of the value functions combined with the weights to provide actual comparison data for each COA when they are pitted against each other. Fiorelli (2025) described the MOE scores as "the sum of the lowest attributes in the objective hierarchy after they have been normalized and multiplied by their corresponding importance weights" (p. 42). These scores, when compared against each other, reveal the marginal differences in effectiveness, otherwise known as marginal effectiveness, for each individual COA. This is the terminal result and overall objective produced from the effectiveness framework.

5. Cost Effectiveness Solution

Once an MOE score is produced and the effectiveness of each COA is determined in the analysis, the analyst can create a cost effectiveness solution for each COA. This is done by creating a ratio between the total cost of the COA and the effectiveness of the COA. Often, these solutions are represented on a graph where effectiveness is represented on the y-axis and cost is depicted on the x-axis. The representation can be swapped on either axis, and the ratio can be presented in either way—it does not matter. The only essential part of arriving at a solution for each COA is ensuring that each COA's cost effectiveness solution is calculated the same way, uniformly.

The first method for depicting the ratio is creating a cost effectiveness ratio, which depicts the total cost divided by the measure of effectiveness for that alternative. The second method of depicting the ratio is simply flipping the numerator and denominator, creating an effectiveness-cost ratio (ECR) by dividing the MOE by the total cost of the alternative. These ratios are depicted in Figure 11.

$$\text{Cost-Effectiveness Ratio (CER)} = \frac{\text{Total Cost}}{\text{Measure of Effectiveness}} \qquad \text{Effectiveness-Cost Ratio (ECR)} = \frac{\text{Measure of Effectiveness}}{\text{Total Cost}}$$

Figure 11.   Depiction of the Cost Effectiveness Ratio and the Effectiveness Cost Ratio. Source: Fiorelli (2025).

6. Assumptions and Sensitivity Analysis

Because of the methods used to determine effectiveness and the complex requirements surrounding the cost-estimation process, assumptions must be made during a CEA. Weights, cost predictions, inflation index percentages, and production quantities are all valid estimations that require assumptions. Because assumptions are made in the CEA process, there is a necessary requirement for a sensitivity analysis. During the sensitivity analysis portion of the CEA, the assumptions that are critical to the analysis outcomes are tested to determine if the CEA produces dramatically different results. The assumptions and results of the sensitivity analyses must be examined and explained for the analysis to be complete. By understanding the sensitivity of the outcomes, decision-makers can better grasp the variables and risks associated with the CEA, especially because it is future-oriented (Fiorelli, 2025, p. 44).

D. SUMMARY

The CEA presents a valuable way to evaluate defense programs and systems. In this context, the CEA is critical to inform decision-makers concerning camouflage for Marines in future peer conflicts. Just as Fiorelli's (2025) and Moreau's (2022) studies were best-suited to the CEA, so too is this research, since it is "impractical to monetize the benefits" of a three-pattern family of MARPAT camouflage (Fiorelli, 2025, p. 44). Furthermore, the analysis of camouflage COAs for this CEA concerns certain measures of performance that are derived from the MOEs. Value functions normalize all items depicted in the objective hierarchy. Weights assigned to each objective signify which objectives are deemed more important than others, and their assignment is justified in the analysis of this paper. Furthermore, the MOE scores are compiled and included in a CER that provides decisionmakers with an understanding of the marginal costs and marginal effectiveness associated with each COA. These CERs are subjected to a sensitivity analysis based on key assumptions so that decision-makers understand the risks associated with each COA.

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V. ANALYSIS

A. OVERVIEW

The analysis chapter of this thesis presents the results of the CEA along with an explanation of the rationale to achieve those results. Ultimately, the CEA is a tool for a decision-maker to gain clarity and insight into a complex question. This analysis clearly informs the decision-maker with the results and the reasons why those results exist. First, this chapter presents an analysis of the effectiveness calculations through a detailed examination of the objective hierarchy followed by the value functions and weights of the different objectives. Then, the cost calculations associated with each COA are explained. The results of each COA and the related CERs are then produced. Following that, a sensitivity analysis must be applied to the results.

In the 2014 NDAA, Congress barred individual Services from developing any more uniforms that were explicitly for their own Service's use unless the uniforms were joint-applicable. The assumptions for this research included: (a) the DTC-1 and DTC-2 transitional patterns are MARPAT with transitional coloration, and they already existed within the government inventory prior to 2014, and (b) the Marine Corps would not be changing the actual uniform that is fielded to the force but rather simply changing the coloration of that same uniform. Originally, the topic of legality was considered when evaluating different COAs. However, legality became non-discriminating criteria between COAs because any option the Marine Corps might pursue would have to be legal. Rather than criteria for evaluation, legality is a barrier to entry for any COA that might make it to a decision maker. Therefore, legality blankets all COAs as an assumed factor.

B. EFFECTIVENESS

When conducting the effectiveness analysis for this CEA, each COA is submitted to the same effectiveness evaluation. The criteria outlined in this section provide the rationale for which each COA is independently submitted for evaluation. Under this evaluation, each COA is measured against the other and costs are applied to each COA. This action produces for the decision-maker a monetized array of options pitted against

the options' differences in effectiveness. The decision criteria that follow dictate the outcomes of the analysis, and any criteria outside of the criteria considered is beyond the scope of this paper (e.g., criteria such as the cut or size of the uniform).

Each objective, or criterion, outlined in the objective hierarchy is a factor that relates to the overall effectiveness of each COA. The Marine Corps seeks to increase the lethality of the individual rifleman at every opportunity. This pursuit means the survivability of the camouflage uniform the Marine wears and the logistical simplicity to get the individual Marine that uniform must increase their ability to fight effectively. Understanding the strong positive correlation between a Marine's survivability and lethality is critical to understanding a Marine's overall effectiveness. Therefore, when considering "effectiveness" as the overall score from the objective hierarchy, effectiveness's near synonymity with lethality in the Marine Corps context must be considered and remembered.

1. Objective Hierarchy

The objective hierarchy of this analysis outlines the key performance parameters that must be considered when evaluating the different COAs for this decision. Each level one attribute is broken down into sub-level attributes that are measurable and quantifiable. When considered together, these criteria both organize and drive the breakdown of each COA based on the abilities of each COA under the following criteria. The criteria itself were selected based on scientific data, past research, and basic principles of economics. This objective hierarchy is broken into three levels. Level one is the broadest, while level three is the most specific and contains a numerical value. Level three consists of a MOE, which makes it able to hold a numerical value. The overall (level one) criteria that drive this model are survivability, suitability, and USMC optics. Considered together, these criteria produce outcomes that provide a comprehensive effectiveness rating for each COA. Figure 12 shows the objective hierarchy of this CEA.
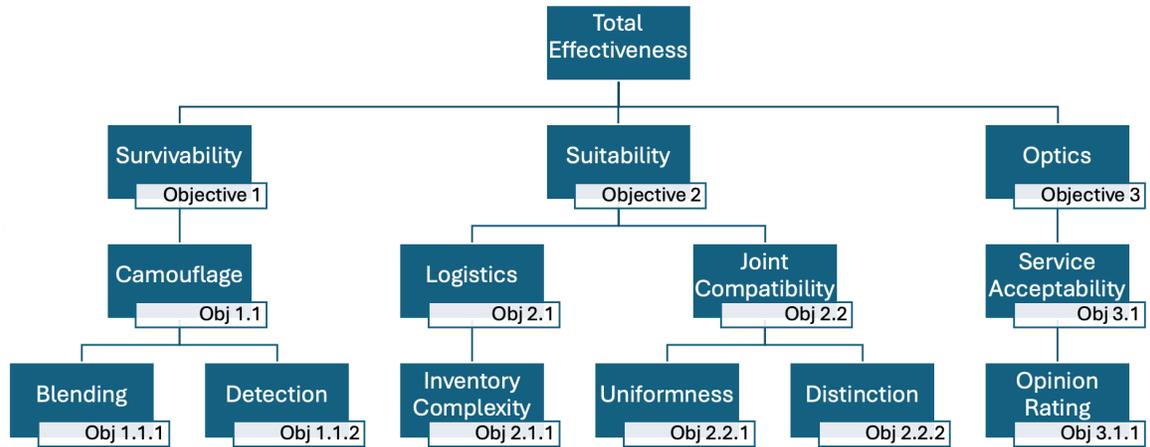
Figure 12.   This graphic figure represents the objective hierarchy used in this Cost Effectiveness Analysis.

Table 2 displays the objective hierarchy for this research as a spreadsheet that brings together all the objective tiers and its results in the case when survivability is weighted the most. Table 2 is one of the key pillars of this research as it shows all the different tier 1, 2, and 3 objectives and how they interact for each COA. It represents the outcome of this effectiveness analysis for one weighting scenario but is used across all weighting scenarios to generate results shown later in this chapter. Table 2 brings all the factors explained in this chapter together into one table. The objective hierarchy criteria, normalized data, weightings, and scores can all be seen together in this table. Then, they are explained in detail following this table. As a model, decision-makers who are only interested in effectiveness without the impact of cost can use it to assess COAs.

Table 2.   Objective Hierarchy for Marine Corps Three-Pattern Family of Uniforms (data depicted weights survivability)

COA-1 — Status Quo

Level 1	Level 2	Level 3 (MOE)	Units of Measure	Objective Total (pre-overall weight)	Unweighted Total	Weights (for overall OH)	Weighted Scores	COA Total Effectiveness
								63.64
Survivability	Camouflage	Blending	Score (Mazz)	66.06	215.66	0.70	46.24	
		Detection	Pd (Mazz)					
Suitability	Logistics	Inventory Complexity	#req'd per Marine (3,2,1)	49.60		0.25	12.40	
	Joint Compatability	Uniformness	Binary 0/1					
		Distinction	Binary 0/1					
Optics	Service Acceptability	Opinion rating	1-2-3 (3 is best)	100.00		0.05	5.00	

COA-2 — Add Transitional Pattern (FROG and MCCUU, force-wide)

Level 1	Level 2	Level 3 (MOE)	Units of Measure	Objective Total (pre-overall weight)	Unweighted Total	Weights (for overall OH)	Weighted Scores	COA Total Effectiveness
								64.80
Survivability	Camouflage	Blending	Score (Mazz)	66.50	192.30	0.70	46.55	
		Detection	Pd (Mazz)					
Suitability	Logistics	Inventory Complexity	#req'd per Marine (3,2,1)	59.80		0.25	14.95	
	Joint Compatability	Uniformness	Binary 0/1					
		Distinction	Binary 0/1					
Optics	Service Acceptability	Opinion rating	1-2-3 (3 is best)	66.00		0.05	3.30	

COA-3 — Combatant Command Specific Deployer Bundle (FROG and MCCUU)

Level 1	Level 2	Level 3 (MOE)	Units of Measure	Objective Total (pre-overall weight)	Unweighted Total	Weights (for overall OH)	Weighted Scores	COA Total Effectiveness
								70.25
Survivability	Camouflage	Blending	Score (Mazz)	63.50	219.50	0.70	44.45	
		Detection	Pd (Mazz)					
Suitability	Logistics	Inventory Complexity	#req'd per Marine (3,2,1)	90.00		0.25	22.50	
	Joint Compatability	Uniformness	Binary 0/1					
		Distinction	Binary 0/1					
Optics	Service Acceptability	Opinion rating	1-2-3 (3 is best)	66.00		0.05	3.30	

COA-4 — Add transitional pattern - remove MARPAT woodland and desert (Force-wide, MCCUU and FROG)

Level 1	Level 2	Level 3 (MOE)	Units of Measure	Objective Total (pre-overall weight)	Unweighted Total	Weights (for overall OH)	Weighted Scores	COA Total Effectiveness
								68.60
Survivability	Camouflage	Blending	Score (Mazz)	63.50	186.50	0.70	44.45	
		Detection	Pd (Mazz)					
Suitability	Logistics	Inventory Complexity	#req'd per Marine (3,2,1)	90.00		0.25	22.50	
	Joint Compatability	Uniformness	Binary 0/1					
		Distinction	Binary 0/1					
Optics	Service Acceptability	Opinion rating	1-2-3 (3 is best)	33.00		0.05	1.65	

COA-5 — Add a FROG Transitional Pattern Only (Deployers, worldwide)

Level 1	Level 2	Level 3 (MOE)	Units of Measure	Objective Total (pre-overall weight)	Unweighted Total	Weights (for overall OH)	Weighted Scores	COA Total Effectiveness
								70.25
Survivability	Camouflage	Blending	Score (Mazz)	63.50	219.50	0.70	44.45	
		Detection	Pd (Mazz)					
Suitability	Logistics	Inventory Complexity	#req'd per Marine (3,2,1)	90.00		0.25	22.50	
	Joint Compatability	Uniformness	Binary 0/1					
		Distinction	Binary 0/1					
Optics	Service Acceptability	Opinion rating	1-2-3 (3 is best)	66.00		0.05	3.30	

a.   Survivability

Survivability is the first consideration in the objective hierarchy. It is based on Mazz's (2015) test results captured in his study of camouflage and Mortlock's (2020)

case study that also compiled Mazz's (2015) results. The ultimate function of the pattern on a military uniform is to conceal the Marine operating in it. That ability to conceal and break up a Marine's outline is paramount to the evaluation of the different COAs for effectiveness.

Camouflage is broken down into a blending score and a detection score. Both scores together are compiled to reflect overall camouflage effectiveness. The woodland, desert, and transitional patterns of MARPAT refer to the scoring from the USMC Woodland and Desert MARPAT patterns and the DTC-1 and DTC-2 patterns in the Mazz (2015) study. Taken together, the blending and detection scores of the different COAs reflect the overall expected effectiveness of each COA. This is why any COA with transitional pattern involvement is higher rated than one with no transitional pattern included at all. Additionally, COAs that offer versatility between all three pattern options yield the highest overall camouflage effectiveness score unless the AO in question is dominated by a certain background.

The blending score measures how well the camouflage pattern conceals a Marine in their relevant background. The raw score is gathered as a percentage, which is translated into points scored out of 100 for normalization. Each blending score takes the score of the camouflage pattern measured against its relevant environment as its principal score. For example, MARPAT woodland would not be used in a desert environment, so its score in a desert background is not considered. Then, for an AO-specific application of camouflage, the camouflage effectiveness is calculated by weighting the effectiveness of the camouflage patterns against their relevant dominant background. For example, if considering a heavily arid environment, the scoring average would reflect the desert camouflage environment. Since the INDOPACOM AO is dominantly transitional and the AOs that U.S. military forces expect to operate in are also dominantly transitional environments, the transitional pattern dominates the average scoring. As a result, COAs including a transitional pattern always end up higher than the status quo, which does not include a transitional pattern option.

Detection, as defined by Mazz (2015), is the probability that a Marine is seen at 450m by a panel of test subjects. Since it is a probability calculation, it is reflected as a

percentage score that is then translated into a 100-point scale to normalize the results. Detection consists of the overall detection scores in the dominant terrain background that a Marine would operate in. As a result, like the blending score, COAs with a transitional pattern always yield a higher score than those with only woodland and desert options. This stands to reason, as having access to more camouflage patterns also increases the ability to remain undetected. Table 3 depicts the raw and normalized data that was used to calculate the overall camouflage and survivability scoring for each COA while Table 4 shows the scores for each COA. Of note, in their own environment, MARPAT Desert and MARPAT Woodland do score better than a transitional pattern in its own environment. However, that is not to say that a woodland or desert pattern scores better when compared against a transitional environment. These scores play a significant role in the overall effectiveness scores calculated using the objective hierarchy.

Table 3.   Survivability raw and normalized data for blending and detection.

Camouflage	Blending Score	Detection Score	Blending Score (Normalized to 100)	Detection Score (Normalized to 100)
MARPAT Desert	55.25	0.15	55.25	86.00
MARPAT Woodland	61.00	0.40	61.00	62.00
Transitional	62.00	0.36	62.00	65.00

Table 4.   Survivability scores by COA.

COA	Blending (normalized)	Detection (normalized)	Camouflage Scores (combined)
COA 1	58.13	74	66.06
COA 2	62	71	66.50
COA 3	62	65	63.50
COA 4	62	65	63.50
COA 5	62	65	63.50

b.   *Suitability*

Suitability is the next first-tier objective considered within the objective hierarchy for this thesis. Suitability is considered by taking a realistic look at the complexity of manufacturing, storing, and fielding the different uniforms as well as how the uniforms fit into the overall joint force. Suitability is broken down into logistics and joint compatibility to further differentiate the number of uniforms required per Marine while also determining how uniform and distinct the COA is for the joint environment. Joint compatibility enables a hard look at uniform effectiveness from a perspective of operating with other friendly forces in the AO. Marines need to be able to recognize each

other as friendly forces in an operating environment. Likewise, other joint forces in the AO must also be able to distinguish Marines as friendly forces and friendly formations. Making clear distinction internal to Services and inter-Service is critical to operational effectiveness and avoiding blue-on-blue (friendly fire) incidents.

When considering logistics within the framework of this thesis, the critical issue to measure the effectiveness of each COA is the amount of uniforms required per Marine. This is scored on a scale of 3, 2, or 1. This score represents the complexity involved in the number of uniforms each Marine may need regardless of whether the Marine has one of each uniform, two of each uniform, or three of each uniform. When considering the amount required per Marine, the complexity score reflects exactly that—complexity— rather than how many uniforms each Marine possesses in their individual footlocker or seabag.

Joint compatibility is comprised of two measures of effectiveness. Together, these measures describe how successfully Marines can wear a certain pattern when operating with Army, Navy, Air Force, Space Force, etc., personnel in a shared battlespace. The future conflict expected to take place against peer adversary forces in the Pacific AO is described within military circles as a "joint fight." Therefore, the impact of a new Marine pattern must be considered under this new focus on "jointness." To do that, the "uniformness" factor reflects how uniform the Marines within a designated AO are internal to themselves and their formations. The only case where this may differ is the current status quo where Marines do not necessarily wear the same pattern during operations in the same AO. The uniformness factor is scored on a binary scale where either Marines do or do not meet the uniformness criteria. If they do, the score is normalized to 100, and if they do not, the score is normalized to 0.

Distinction in the joint environment is also a critical factor. The Marines serving alongside other joint forces need to be able to distinguish themselves from other friendly forces when operating in extremely demanding situations. Furthermore, other friendly forces need to be able to recognize Marines from other forces under high levels of duress as well. The woodland and desert patterns of MARPAT are distinct Marine identifiers and therefore result in a high level of distinction. A transitional pattern is currently in use

by the Air Force and the Army; therefore, the use of a transitional pattern by Marines would make them less distinct to friendly forces than their current patterns do. The scoring for distinction is also treated as binary since a pattern is either distinct, or it is not. The binary score is then normalized to 100 or to 0 depending on its respective result. Table 5 shows the raw and normalized data used for each COA regarding suitability spanning logistics and joint compatibility.

Table 5.   Suitability data used for each COA, raw and normalized.

Suitability	How Many Uniforms per Service Member?		
	Inventory Complexity	Raw Data	Normalized (Out of 100)
Logistics	COA 1	2	66
	COA 2	3	33
	COA 3	1	100
	COA 4	1	100
	COA 5	1	100
	Are Service Members Uniform In AO?		
	Uniformity	Raw Data	Normalized (Out of 100)
	COA 1	No	0
	COA 2	Yes	100
	COA 3	Yes	100
	COA 4	Yes	100
	COA 5	Yes	100
Joint Compatability	Are Service Members Distinct from other Members of the Joint Force?		
	Distinction	Raw Data	Normalized (Out of 100)
	COA 1	Yes	100
	COA 2	Yes	100
	COA 3	No	0
	COA 4	No	0
	COA 5	No	0

c.   Optics

Assessing optics as the final-tier one objective within the evaluation hierarchy allows quantification of the anticipated reaction to a uniform shift within the ranks of the Marine Corps. The optics evaluation is broken down into likelihood of acceptance by the Service, specifically by the Marines. This stakeholder perspective generates an understanding of the expected overall opinion regarding the acceptability of the COA in question.

The Service acceptability category of the objective hierarchy examines how well the Marine Corps is expected to react to the COA's proposed uniform change. The Marine Corps can be filled with certain strongly held opinions and is an organization

largely rooted in tradition and pride. That emphasis on tradition and pride is reflected in the uniform worn by Marines. Uniforms from the MCCUU to the Dress Blues are referred to by Marines as "the cloth of the nation," and a high level of importance and respect is placed in the uniform. Therefore, changes to the uniform may be polarizing at first. However, the Marine Corps promotes lethality as a core principle of its modern existence, so changes to the uniform in the name of increased lethality are more likely to be accepted. Additionally, the ratings given follow the size of the impact on the fleet at large. For example, fielding these uniforms to one AOR would have a smaller impact than fielding them to the entire force. Opinions would not be the same in these two situations. Taking all of these factors into consideration, the Service acceptability is measured by the MOE titled "opinion rating." This is scored on a 1–3 scale, where 1 is the lowest opinion rating and 3 is the highest. Normalized to scores of 33, 66, and 100, this MOE is captured in the objective hierarchy.

Some consideration may be given to public or constituent opinion by larger governing bodies like Congress or the DoD. However, in the scope of this research, there is no valid use for considering the public perception of the uniform when considering criteria such as optimal use in combat and the perception of the Marines who would wear the uniform. Therefore, considering the perception of lawmakers, politicians, or the public was not considered in this research as it did not apply in a meaningful way within the scope of this work. This research targets military decision makers in their decision trade space rather than civilian officials. Table 6 shows the raw and normalized data by COA for optics and the likelihood it is accepted within the organization.

Table 6.   Optics data by COA, raw and normalized.

Optics		Likelihood of Acceptance	Numerical Equivalent (Raw Data)	Likelihood of Acceptance (Normalized to 100)
Service Acceptability	COA 1	High	3	100
	COA 2	Mixed	2	66
	COA 3	Mixed	2	66
	COA 4	Low	1	33
	COA 5	Mixed	2	66

2. Unweighted MOE Scores and Normalization

Throughout the entire objective hierarchy, each MOE generated a different measurement on different scales. These are captured in their own raw scores and reflected in the objective hierarchy. To be able to compare all the criteria against each other in a fair and sensible way, the scores must be "normalized." To normalize the scores, each item that was evaluated was normalized onto a 100-point scale, where 100 is the best score and 0 is the worst score. In the case of the probability of detection, this meant that the normalized score went up when the probability of detection went down. Additionally, for logistics, as the number of uniforms required per Marine increased and therefore the inventory requirement became more complex, the normalized score went down. By placing everything on a normalized scale, each criteria showed its own score in relation to the others. Table 7 shows all different criteria for all the different COAs normalized to a 100 point scale.

Table 7.   Normalized scores for each criteria of each COA.

Survivability - Blending			Survivability - Detection		
	Raw	Normalized		Raw	Normalized
COA 1	58.13	58.13	COA 1	0.27	74.00
COA 2	62.00	62.00	COA 2	0.30	71.00
COA 3	62.00	62.00	COA 3	0.36	65.00
COA 4	62.00	62.00	COA 4	0.36	65.00
COA 5	62.00	62.00	COA 5	0.36	65.00
Suitability - Logistics			Suitability - Joint Compatability (Uniformity)		
	Raw	Normalized		Raw	Normalized
COA 1	2	66	COA 1	No	0
COA 2	3	33	COA 2	Yes	100
COA 3	1	100	COA 3	Yes	100
COA 4	1	100	COA 4	Yes	100
COA 5	1	100	COA 5	Yes	100
Suitability - Joint Compatability (Distinction)			Optics - Likelihood of Acceptance		
	Raw	Normalized		Raw	Normalized
COA1	Yes	100	COA 1	3	100
COA2	Yes	100	COA 2	2	66
COA3	No	0	COA 3	2	66
COA4	No	0	COA 4	1	33
COA5	No	0	COA 5	2	66

3. Weights

Weights are assigned to show which criteria are considered more important than others in the final calculation of the COA's effectiveness score. Internal to the first tier of the objective hierarchy, there are also weights assigned between second-tier objectives.

For example, logistics is weighted more heavily than joint compatibility because it is a more important consideration for overall suitability of a uniform. After internally weighting the MOE to produce an effectiveness score for each first-tier objective (survivability, suitability, and optics), weights are assigned to each first-tier objective to emphasize the importance of one criterion over another. In a scenario favoring survivability, for example, survivability is rated as the most important factor by far in the evaluation of each COA's effectiveness. Following that, the suitability of each COA is considered, and only small influence is given to the optics of each COA. These weights are subjective and therefore must be submitted to a sensitivity test later in this research paper. Four different weighting options are assessed in total. A weighting option that favors survivability, suitability, optics, and an option without weights all are assessed to provide maximum insight. Table 8 shows the differences in results after applying the weighting options.

4. Results

After considering the five COAs outlined for the potential fielding of a three-pattern family of camouflage for the Marine Corps and submitting the COAs to the effectiveness evaluation described previously, the following results were generated and shown in Table 8. Results will first be presented with unweighted MOE scores. Then, results will be shown with the weights that are applied in order to favor chiefly survivability, then suitability as the most important criteria. Table 8 depicts the outcomes of each COA in overall effectiveness respective to each weighting emphasis.

Table 8.   Effectiveness analysis results, unweighted results, weighted results, and sensitivity analysis.

Unweighted Results			Survivability Weighted		Suitability Heavy		Optics Heavy	
COA	Result	Rank	Result	Rank	Result	Rank	Result	Rank
COA1	215.66	3	63.64	5	56.24	5	89.00	1
COA2	192.30	4	64.80	4	61.79	4	65.82	4
COA3	219.50	2	70.25	2	82.18	2	66.58	3
COA4	186.50	5	68.60	3	80.53	3	43.48	5
COA5	219.50	2	70.25	2	82.18	2	66.58	3
			survivability = 0.7		survivability = 0.25		survivability = 0.25	
			suitability = 0.25		suitability = 0.7		suitability = 0.05	
			optics = 0.05		optics = 0.05		optics = 0.7	

Without any weights applied to the objective hierarchy, the best COA is a tie between COA 3 and COA 5. Coming in at a close third place is COA 1, the status quo. After that is COA 2 followed by COA 4. This result reveals that the status quo does not reign as the supreme choice, even without subjective weights applied to the objective hierarchy. Once the weighting that favors survivability is applied to the matrix, the results change. The top two COAs are still COA 3 and 5. However, COA 4 then comes in as a third-place holder followed by COA 2. This leaves the status quo in last place after weighting is applied. Note the difference in the results between COAs 1, 2, and 4. Note also the congruency between the two evaluations of COA 3 and 5.

Because weighting is a subjective practice, it is important to conduct a sensitivity analysis of the weights to see what impacts different weights may have on the result. Table 8 shows the sensitivity analysis on the effectiveness by shifting the weighting from one criteria to the next. The dominant weight was given to each of the three tier one criteria in a separate evaluation. Then, the results were noted to see the impact that the weights had on the results. When suitability was weighted dominantly, the outcome ranking of the COAs did not change in comparison to when survivability is favored. Notably, the score margins widened between COAs 1 and 2, and COAs 3, 4, and 5. When optics were given the dominant weighting, the status quo became the highest scoring COA followed by COA 3 and 5 from far off.

These results imply that the suitability and survivability outcomes, whether one is valued more than the other, both direct the decision maker towards a COA involving the introduction of a transitional pattern to compliment the bookend patterns of desert and woodland. The only situation where staying with the status quo is advantageous is when optics are given the dominant weight. Additionally, even when holding survivability as the dominant factor in the decision-making hierarchy, a decision maker would have to value optics equal to or more than suitability in order to have the status quo become the best COA available.

The two COAs that tied each other, COA 3 and COA 5, provide an interesting insight. COA 3 explicitly provides transitional MCCUU and FROG deployer bundles to only the INDOPACOM combatant command, while COA 5 provides the FROG in the

transitional pattern to all deployers world-wide. The key differences between the COAs that makes COA 3 and COA 5 stand out is the number of uniforms required for fielding uniforms only to deployers within a combatant command versus doing so to the whole force. The logistics scores play a significant role in the scoring of these two COAs compared to their competitor COAs. The effectiveness of the camouflage itself in expected operational environments does not change. Commanders who have access to the transitional uniform may elect to use them in transitional environments in either situation but of course would not elect to use them in, for example, arctic conditions. Therefore, even if one AO is more transitional than another, it is not possible to compare different AO transitional environments to generate a winner between the two COAs

C.   COST

1.   Overview

To generate cost, two key factors are examined for this analysis. The first factor is the average unit cost of each type of uniform, MCCUU and FROG. The second is the number of uniforms anticipated for each proposed COA. These numbers are examined in the confines of an annual cost of uniform production since the technology maturity level for these COAs is very high and the infrastructure to support these COAs already exists. Considering cost on an annual basis allows the COAs to be compared in a fair and clear way.

a.   *Average Unit Cost*

The average production unit cost of each uniform allows the understanding of how much each uniform costs as a set. A uniform set is considered the trousers, blouse, and cover. Joseph Parker, interim supervisor for Combat Uniforms at the DLA produced a 2023 report with slides from Marine Corps Systems Command that listed the MCCUU with an average unit cost of $122 in FY2023 dollars (Parker, 2023). The average unit cost of a FROG set was $184 (in FY2023 dollars), as reported in a *Marine Corps Times* article covering the topic (Seck, 2023). These two average unit cost values show that the FROG is more expensive compared to the MCCUU due to the FROG's fire-retardant capability but not due to the camouflage pattern it bears. These costs are converted into FY2025

dollars for the purpose of this analysis using the Joint Inflation Calculator for USMC Procurement. That brings the adjusted average unit cost in FY2025 dollars to $128 for the MCCUU and $193 for the FROG.

b.   *Force Strength Numbers*

When calculating quantities for each COA to multiply the AUCs by, and thus providing the final dollar amounts per COA, different means of calculation were required for each COA. For the status quo, the DLA report stated that 285,000 MCCUUs were produced force-wide per year (Parker, 2023). Based on this information, the assumption is that approximately 142,000 FROG uniforms—half the amount of MCCUUs—are required per year for the force as it currently stands. Half the amount of MCCUUs is used for calculating the expected inventory of FROGs across the force because a Marine is issued one set of FROGs before deployment to augment their MCCUU inventory. While the Marine may have two patterns of MCCUU, they will only have one pattern of FROG for their respective deployment.

In COA 2, both the FROG and MCCUU quantities are increased by one third of the original quantities to simulate adding a third pattern of camouflage into both the MCCUU and FROG inventories. COA 3 is calculated using the number of personnel stationed and deployed in the INDOPACOM combatant command to determine the necessary quantity, which comes out to 31,500 (USMC, 2021). COA 4 is justified by taking the current two pattern numbers and halving them to supply the single pattern COA. This assumes that uniforms will wear out in the same amount of time that they currently do. Lastly, COA 5 uses the same numbers as COA 2 but strictly for fielding FROGs, not MCCUUs. However, the production of the status quo MCCUUs and FROGs must also be considered in COA 5 because COA 5 would add an additional FROG to be produced as opposed to replacing any item already fielded.

Since officers, both selected reserve and active duty, buy their uniforms without any kind of stipend, that capital is regained by the Marine Corps. Therefore, each MCCUU quantity must be adjusted with a 12.94% discount, or the percentage of the Marine Corps (both selected reserve and active duty) that is made up of officers (Defense

Manpower Data Center, n.d.). This does not apply to FROGs, as they are issued to all without the requirement that officers buy them outright.

2. Cost Estimates

By taking the AUC and the production numbers that are described previously while being mindful of the force strength numbers and the nuances of each COA, cost estimates for each COA can be produced. Considering that each COA has a different number of total uniforms that must be produced, each outcome for the cost estimates ends up being different. This is positive, as it makes it easier to differentiate the qualities and costs of each COA. Table 9 shows the outcome of multiplying the AUC of the FROG and MCCUU with the associated quantities and then provides the total cost estimates for each COA. Ultimately, the most expensive COA is COA 2. Following COA 2, COA 3 comes into second place, trailed by COA 5, COA 1, and, lastly, COA 4.

Table 9. Costs, Production Numbers, and Average Unit Costs of each course of action.

Average Unit Cost (AUC)	MCCUU AUC	FROG AUC			
(FY23$)	$ 122	$ 184			
(FY25$)	$ 128	$ 193			
Annual Production Numbers (APN)	**COA 1**	**COA 2**	**COA 3**	**COA 4**	**COA 5**
MCCUU AVERAGE	285000	379905	316,500	142500	285,000
FROG AVERAGE	142,500	189525	174,000	142,500	189,525
APN x MCCUU AUC					
FY25$	$ 36,508,500	$ 48,665,831	$ 40,543,650	$ 18,254,250	$ 36,508,500
AD + SELRES Officer Percentage discount (12.94%)	$ 31,784,300	$ 42,368,472	$ 35,297,302	$ 15,892,150	$ 31,784,300
APN x FROG AUC					
FY25$	$ 27,502,500	$ 36,578,325	$ 33,582,000	$ 27,502,500	$ 36,578,325
TOTAL COST ESTIMATES					
FY25$ AVERAGE	$ 59,286,800	$ 78,946,797	$ 68,879,302	$ 43,394,650	$ 68,362,625
FY25$ UPPER BOUND (+10%)	$ 65,215,480	$ 86,841,477	$ 75,767,232	$ 47,734,115	$ 75,198,888
FY25$ LOWER BOUND (-10%)	$ 53,358,120	$ 71,052,117	$ 61,991,372	$ 39,055,185	$ 61,526,363

D. COST EFFECTIVENESS RATIOS

The CERs of this analysis show the relationship between the cost of each COA and its effectiveness score on the objective hierarchy. Ultimately, the CERs shown in Table 10 reveal that the relationship between the COAs' costs and their effectiveness. The majority of CERs place COA 4 as the most cost-effective option, meaning the it achieves the most value out of each unit of effectiveness. Because there are four different

weighting scenarios used in the effectiveness scoring of this research, there are four different CER tables produced as seen in Table 10.

Table 10.   Cost Effectiveness Ratios of each course of action, pitting cost against effectiveness score for each weighting scenario.

Unweighted CER Table					
COAs		**Costs**	**Effectiveness Score**		**CER**	**Ranking of CERs**
COA 1	$	59,286,800	215.66	$	274,905	2
COA 2	$	78,946,797	192.30	$	410,540	5
COA 3	$	68,879,302	219.50	$	313,801	4
COA 4	$	43,394,650	186.50	$	232,679	1
COA 5	$	68,362,625	219.50	$	311,447	3

Survivability Weighted CER Table					
COAs		**Costs**	**Effectiveness Score**		**CER**	**Ranking of CERs**
COA 1	$	59,286,800	63.64	$	931,542	2
COA 2	$	78,946,797	64.80	$	1,218,315	5
COA 3	$	68,879,302	70.25	$	980,488	4
COA 4	$	43,394,650	68.60	$	632,575	1
COA 5	$	68,362,625	70.25	$	973,133	3

Survivability Weighting Preference is: survivability = 0.7, suitability = 0.25, optics = 0.05

Suitability Weighted CER Table					
COAs		**Costs**	**Effectiveness Score**		**CER**	**Ranking of CERs**
COA 1	$	59,286,800	56.24	$	1,054,257	4
COA 2	$	78,946,797	61.79	$	1,277,766	5
COA 3	$	68,879,302	82.18	$	838,203	3
COA 4	$	43,394,650	80.53	$	538,897	1
COA 5	$	68,362,625	82.18	$	831,915	2

Suitability Weighting Preference is: survivability = 0.25, suitability = 0.7, optics = 0.05

Optics Weighted CER Table					
COAs		**Costs**	**Effectiveness Score**		**CER**	**Ranking of CERs**
COA 1	$	59,286,800	89.00	$	666,177	1
COA 2	$	78,946,797	65.82	$	1,199,526	5
COA 3	$	68,879,302	66.58	$	1,034,612	4
COA 4	$	43,394,650	43.48	$	998,152	2
COA 5	$	68,362,625	66.58	$	1,026,851	3

Optics Weighting Preference is: survivability = 0.25, suitability = 0.05, optics = 0.7

E.   SENSITIVITY ANALYSIS

1.   Weights

The first sensitivity analysis to inspect the outcomes of this test is to adjust the weights of each first-tier objective in the objective hierarchy. As previously discussed, and shown, the weights in the effectiveness calculation were subjected to detailed sensitivity analysis that did not impact the outcome of the COA rankings except when optics is given dominant weighting over survivability and suitability. This means a decision maker would have to heavily favor Service level optics over survivability and suitability in order to choose the status quo when simply evaluating effectiveness alone.

2. Costs

The next sensitivity test is to change the costs of each COA based on assumed criteria. The best way to go about this is to change the number of uniforms required per COA. For this test, the production numbers for each COA were modified to reflect another likely amount of production numbers. In this case, the amount selected for adjustment was the COA 4 MCCUUs and FROGs to address the assumption that they would wear out in the same amount of time. Additionally, COA 2 was adjusted to anticipate uniforms lasting longer because three would be in rotation instead of two.

3. New Cost Effectiveness Ratios

Taking these sensitivity tests together into consideration, a sensitivity analysis can produce new cost effectiveness ratios to determine the overall impact of the cost adjustments against the actual results of each weighting scenario. Table 11 shows the new cost effectiveness ratios given the new effectiveness scores and the new cost calculations done in the sensitivity analysis. This does provide different CER outcomes but only due to the difference in cost calculations because of the manipulation of production quantities in the sensitivity analysis. Decision-makers must be mindful, then, that production quantities are a significant factor in this analysis and any future analysis of cost in this decision-making process. Apart from when optics is weighted, COA 4 still holds its place in either calculation as the most cost-effective COA, making it a strong COA.

Table 11. Sensitivity Analysis Cost Effectiveness Ratios shown with rankings beside them.

COAs	Costs	Effectiveness Score	CER	Ranking of CERs
Sensativity Analysis CERs - Unweighted				
COA1	$ 59,286,800	215.66	$ 274,905	2
COA2	$ 59,286,800	192.30	$ 308,304	3
COA3	$ 68,879,302	219.50	$ 313,801	5
COA4	$ 44,465,100	186.50	$ 238,419	1
COA5	$ 68,362,625	219.50	$ 311,447	4
Sensativity Analysis CERs - Survivability Weighted				
COA1	$ 59,286,800	63.64	$ 931,542	3
COA2	$ 59,286,800	64.80	$ 914,920	2
COA3	$ 68,879,302	70.25	$ 980,488	5
COA4	$ 44,465,100	68.60	$ 648,179	1
COA5	$ 68,362,625	70.25	$ 973,133	4
Survivability Weighting Preference is: survivability = 0.7, suitability = 0.25, optics = 0.05				
Sensativity Analysis CERs - Suitability Weighted				
COA1	$ 59,286,800	56.24	$ 1,054,257	5
COA2	$ 59,286,800	61.79	$ 959,566	4
COA3	$ 68,879,302	82.18	$ 838,203	3
COA4	$ 44,465,100	80.53	$ 552,190	1
COA5	$ 68,362,625	82.18	$ 831,915	2
Suitability Weighting Preference is: survivability = 0.25, suitability = 0.7, optics = 0.05				
Sensativity Analysis CERs - Optics Weighted				
COA1	$ 59,286,800	89.00	$ 666,177	1
COA2	$ 59,286,800	65.82	$ 900,810	2
COA3	$ 68,879,302	66.58	$ 1,034,612	5
COA4	$ 44,465,100	43.48	$ 1,022,774	3
COA5	$ 68,362,625	66.58	$ 1,026,851	4
Optics Weighting Preference is: survivability = 0.25, suitability = 0.05, optics = 0.7				

F.   ASSUMPTIONS AND LIMITATIONS

In creating this CEA, multiple assumptions were made that must be outlined for clarity. As in any CEA or evaluation, assumptions are a clear part of the decision-making process. The first assumption is that when calculating cost, each Marine is in possession of the same amount of uniforms. Additionally, the assumption also follows that each Marine possesses one of each uniform, either during their deployment (for the COAs involving deployment bundles) or for their general careers. Additionally, for COAs that involve reducing uniforms from multiple colorations to one, such as COA 4, the assumption is made that the uniform lasts as long as it might when Marines have two

different color uniforms in their inventory. Because of the assumption that the uniform will last the same amount of time, the need to increase the basis of issue is addressed based on the assumption that the lifespan does not decrease.

This assumption is logical, as Marines tend to choose a pattern for a certain AO and stick to it, so the length that their uniform lasts should be the same as if they were wearing desert or woodland in that AO. Marines in COA 2, for example, may have the transitional pattern in their inventory and wear it daily in some areas of the world, but in other areas remain in their desert uniforms (such as in Twentynine Palms, CA).

The next assumption has to do with the weights of the objective hierarchy. These weights assume that Marine Corps decision-makers, and those other stakeholders involved in this decision will prioritize above all else the survivability of the camouflage patterns. In weighting that criteria heavily, the assumption is made that decision-makers understand and support the logical rationale that if a Marine has a highly effective camouflage pattern that increases their survivability, that in turn increases their overall lethality. Therefore, that criteria is the most desirable if the Marine Corps and all stakeholders prioritize Marines' warfighting lethality above all else.

The objective hierarchy and cost information face limitations in that there is no way to know how much inventory is truly expected to be produced in the coming years. Authorization acts, authorized end-strength numbers, and funding cuts will play roles in determining the number of uniforms made each year. Additionally, the negotiating power of those individuals involved in creating uniform contracts for the Marine Corps is an unknown, which limits the ability to precisely predict future unit costs. The same could be said about the room for error that exists when examining Congress's willingness to support a proposed uniform change or the reaction certain individuals may have to a proposed uniform shift.

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VI. CONCLUSION

A. SUMMARY OF FINDINGS

Ultimately, the findings of this research paper reveal that there is a wide spread of different options for a decision-maker to consider based on their understanding of DoD priorities. Moreover, USMC leaders can appreciate that under the current weighting in this decision analysis, the addition of a transitional pattern benefits Marines in operations. Figure 13 shows a graphical representation of all the cost-effective solutions. Four graphs pit each weighting scenario (unweighted, survivability-favored, suitability-favored, optic-favored) against the calculated cost of each COA. An additional four graphs show the same weighting scenarios arrayed against the cost sensitivity analysis outcome for each COA. Note that COA 4 provides the most effectiveness for the least cost but does not provide the absolute highest level of effectiveness across the board. For a higher level of cost, COA 2 offers a slight advantage in effectiveness. COA 1 (status quo) has the lowest level of effectiveness but not the lowest cost of the various COAs. COAs 3 and 5 offer the highest effectiveness for a median cost. Overall, COA 4 dominates the CER calculations for efficient use of funds but COAs 3 and 5 dominate for effectiveness.

There is a tradeoff between efficient use of dollars and performance that must be noted. If decision makers focus on efficiency in their budget, COA 4 may prevail. Meanwhile, COA 3 or 5 may prevail if decision makers are focused on effectiveness. The changes between cost options are largely reliant on production quantities. This further explains why COA 3 and COA 5 are less costly than COA 2 using the standard cost averages while that is not the case in the sensitivity analysis cost scenarios where increased quantities of procured items come into play.

In Figure 13, the trend across the first four graphs outlines that COA 3 and COA 5 provide the highest level of effectiveness. COA 4 is the least expensive in most cases, but it is not the least favorable in terms of effectiveness.
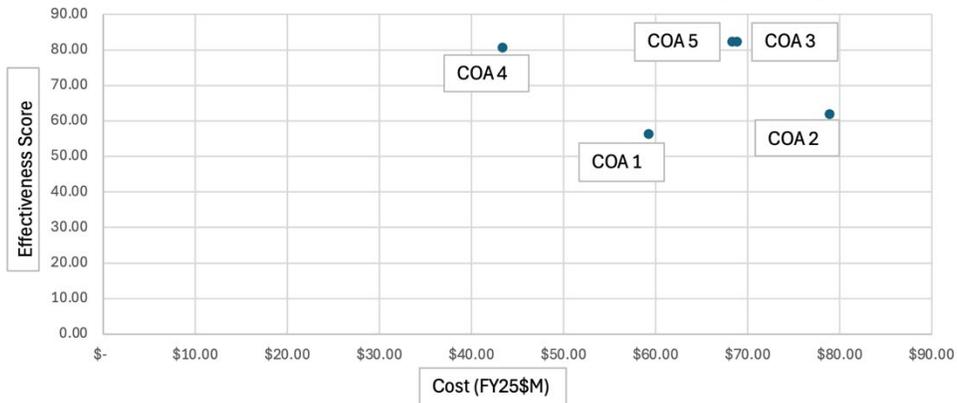
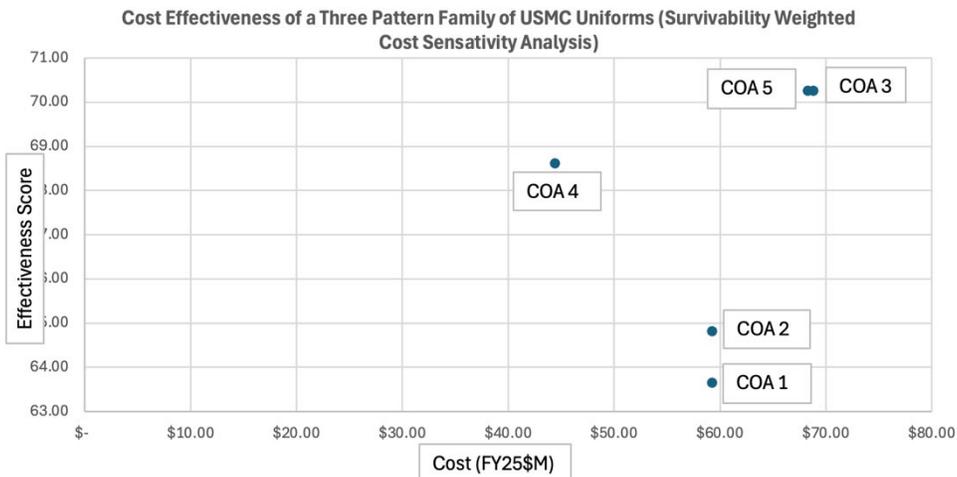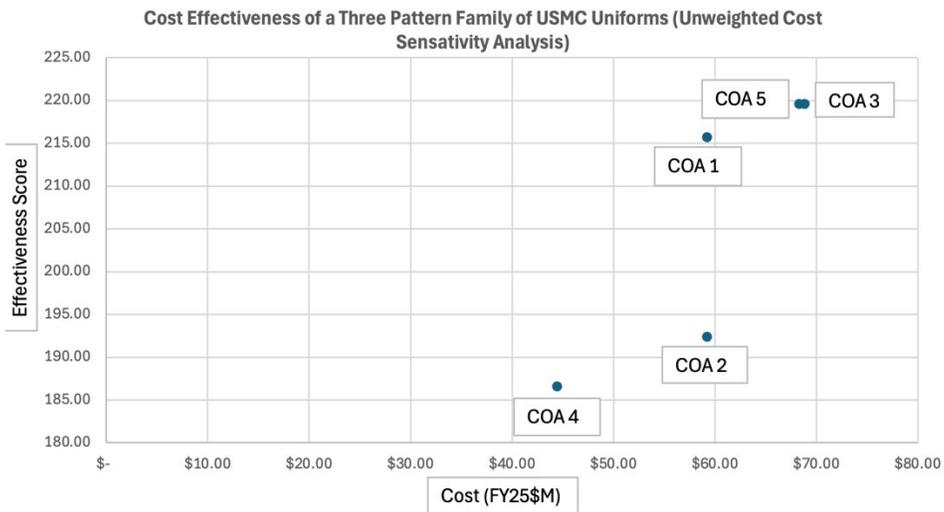**Cost Effectiveness of a Three Pattern Family of USMC Uniforms (Unweighted)**
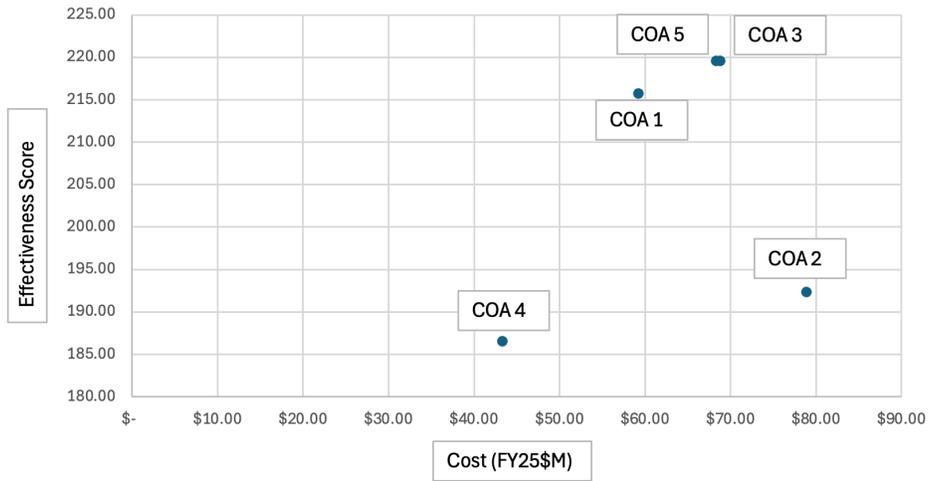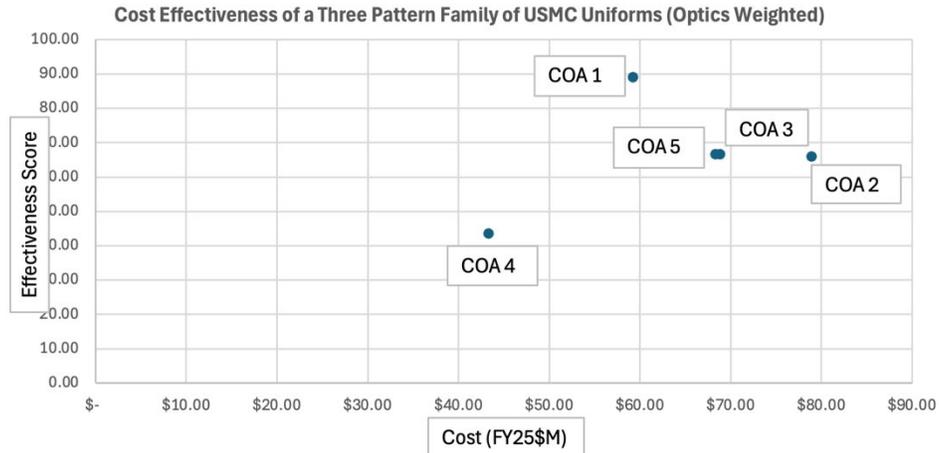

Cost Effectiveness of a Three Pattern Family of USMC Uniforms (Survivability Weighted)
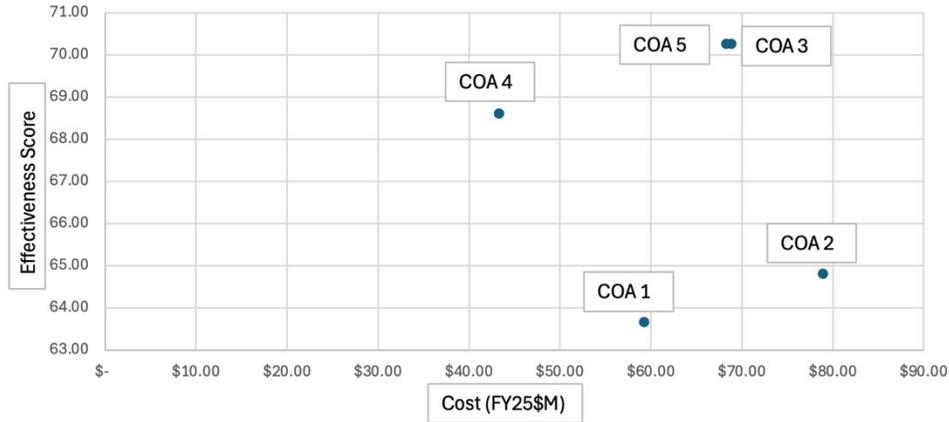
Cost Effectiveness of a Three Pattern Family of USMC Uniforms (Suitability Weighted)

Cost Effectiveness of a Three Pattern Family of USMC Uniforms (Optics Weighted)

Effectiveness Score

COA 1

COA 3
COA 5

COA 2

COA 4

Cost (FY25$M)

Cost Effectiveness of a Three Pattern Family of USMC Uniforms (Unweighted Cost Sensativity Analysis)

Effectiveness Score

COA 5   COA 3

COA 1

COA 2

COA 4

Cost (FY25$M)

Cost Effectiveness of a Three Pattern Family of USMC Uniforms (Survivability Weighted Cost Sensativity Analysis)

Effectiveness Score

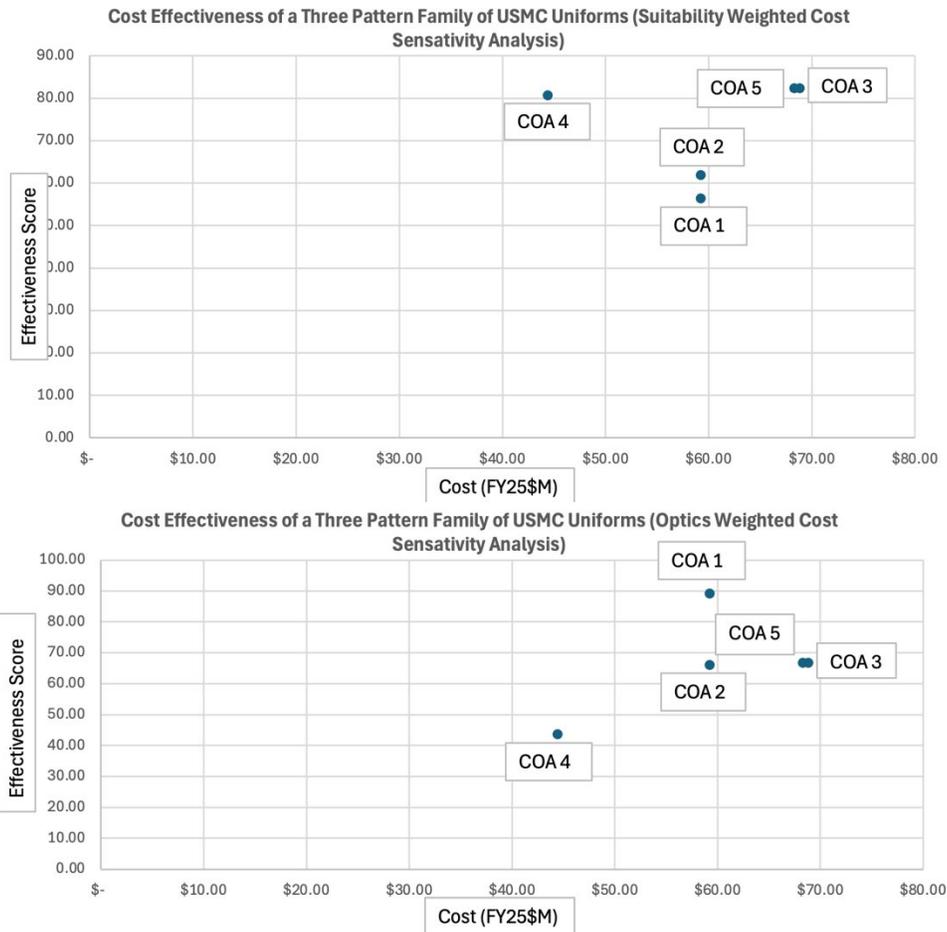COA 5   COA 3

COA 4

COA 2

COA 1

Cost (FY25$M)

Figure 13. Graphic cost effectiveness representation of each weighting and cost scenario. (Dollars are in millions)

It is appropriate to restate the research questions in order to recenter the research paper and ensure all questions have been answered. The following questions are:

1. How effective are the current patterns of camouflage in use by the Marine Corps today?

2. What options are available to address the challenges raised by current camouflage capabilities?

3. How can the U.S. Marine Corps invest in a three-family pattern of camouflage for the Marine pattern (MARPAT) MCCUU and Flame Retardant Operational Gear (FROG) variants?

4. What is the best and most cost-effective method to invest in effective camouflage uniforms for the future?

When considering the results of the effectiveness analysis, the outcomes inform decision makers of several important items. The first is that the weight of each tier one

objective shapes the outcome of the effectiveness analysis. This does not render the analysis as a bad mechanism but rather emphasizes how important it is that a leader knows what they value in a utility uniform. Survivability and suitability are assumed to outweigh the importance of optics when discussing serious military operations. Therefore, if a decision maker is pressing against the results of an analysis that weights survivability or suitability heavily, their actual preference is that of optics. The real criteria that is unmeasurable in this situation is the will to lead change. That criteria is not measurable for an effectiveness analysis but is required to enact something new like a transitional pattern of uniform. A transitional uniform that increases survivability and suitability for warfighters may be met with some opposition by people who prefer the status quo, but that effect on optics should not outweigh the priority of increasing effectiveness of front-line warfighters.

With the weighted results showing that a deployer bunder or an AOR specific bundle result in the most effective outcome for suitability, survivability, and optics, there is a way forward that ensures Marines are ready to fight in anywhere and anytime. This is a continuous effort as the character of war changes. The choice between these two COAs offers different but useful options to commanders and decision makers alike. Either COA would serve to enable more lethal Marines in a peer conflict or across the range of military operations.

Looking at the costs of the different COAs compared to their respective effectiveness, COAs 3 and 5 stand out the most. Their median cost combined with their high effectiveness score make them very palatable options for decision makers looking to achieve the most efficient outcome. The status quo option is less effective than other COAs in most scenarios studied.

In conclusion, this research answered the research questions it set out to inform. It describes how effective Marine Corps current camouflage capabilities are in current conditions and facing our current adversaries. It offered several options to increase camouflage capability within the Marine Corps to various degrees. This study provides ways of applying research to future MCCUUs and FROGs in the force. Lastly, it provides a clear analysis of the cost effective means to achieve these ends.

B.   APPLICATION

This research can be useful to decision-makers seeking to make an informed, logical decision about adding a transitional pattern to the Marine Corps uniform inventory. The real value of this research is not in the numerical outcomes but in the model that can produce results for decision makers. Any hypothetical costs or other camouflage parameters can be entered into this model and inform a decision maker. Thus, a decision maker can buy themselves trade space to negotiate the right equipment into the hands of the right warfighter. The three-pattern family of camouflage, issued in any of the manners given in these COAs, provides an increase in warfighter effectiveness. Equipped with desert and woodland bookends complimented by a transitional pattern in-between, warfighters stand to gain substantially during future operations. With an increase in capability, there will often be an increase in costs as well. However, decision-makers must be prepared to gather support for the costs required to keep the sons and daughters of this nation as effective on the battlefield as possible. This research can be applied to support those ends in pursuit of the common mission to increase lethality across the Marine Corps and, therefore, across the entire DoD.

C.   RECOMMENDATIONS FOR FUTURE RESEARCH

Future research for this topic may include extending the application of a transitional pattern onto field gear used by Marines, such as the rucksacks, helmets, gloves, and boots employed in operational environments. Additionally, future researchers should seek to pursue means of making the uniform average unit cost decrease by reducing the labor required per uniform or exploring certain methods of creating uniforms that maintain the same quality but take less time and waste less material. Lastly, future researchers in this field should consider methods to centralize efforts within the DoD to better share uniform technology and developments so that warfighters across the force can implement technology to their advantage in a joint environment rather than siloing success in specific Service branches.

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