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The future security environment and the Marine Corps' shift in mission focus to competition against a peer adversary create significant challenges for the Marine air command and control system (MACCS). To remain relevant in the future security environment, the Marine Corps needs to develop a new MACCS concept of operations consistent with naval expeditionary operations. The Navy and Marine Corps need to develop new aviation operations and aviation command and control doctrine to define how naval expeditionary force aviation will support CFMCC operations. The MACCS should be capable of distributed operations by employing task-organized nodes and teams. Lastly, it can be more survivable with disciplined signature management and diverse sensor employment.

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MASTER OF MILITARY STUDIES

RECONCEPTUALIZING THE MARINE AIR COMMAND AND CONTROL SYSTEM

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

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EXECUTIVE SUMMARY

Title: Reconceptualizing the Marine Air Command and Control System

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Thesis: The Marine Corps needs to develop a new MACCS concept of operations, close doctrinal gaps in naval expeditionary force aviation operations, and make the MACCS agile and survivable.

Discussion: The future security environment and the Marine Corps' shift in mission focus to competition against a peer adversary create significant challenges for the Marine air command and control system (MACCS). To remain relevant in the future security environment, the Marine Corps needs to develop a new MACCS concept of operations consistent with naval expeditionary operations. The Navy and Marine Corps need to develop new aviation operations and aviation command and control doctrine to define how naval expeditionary force aviation will support CFMCC operations. The MACCS should be capable of distributed operations by employing task-organized nodes and teams. Lastly, it can be more survivable with disciplined signature management and diverse sensor employment.

Conclusion: The Marine Corps needs to develop a new MACCS concept of operations, close doctrinal gaps in naval expeditionary force aviation operations, and make the MACCS agile and survivable. First, by pursuing new concepts of operations, the Marine Corps can explore opportunities for the MACCS to expand its role into other domains. It has the potential to enable all-domain fires by employing or integrating a wide range of sensors to disseminate situational awareness across all domains. It also has the potential to reorganize around new concepts like Joint All-Domain Command and Control (JADC2) that will enable distributed C2 nodes and allow the MACCS to divest its consolidated C2 centers (e.g., TACC, DASC, TAOC). Second, a consolidated Navy and Marine Corps publication on naval expeditionary force aviation operations will clarify command relationships and Marine aviation's role in naval operations. Third, the MACCS should be capable of distributed operations using task-organized nodes or teams depending on the mission. To be more survivable, the Marine Corps will need to combine technological solutions with new employment concepts, signature management TTPs, and diverse sensor employment options.

DISCLAIMER

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List of Acronyms and Abbreviations

AC2	aviation command and control
ACE	aviation combat element
AI/ML	artificial intelligence / machine learning
AOC	Air Operations Center
CAC2S	common aviation command and control system
CAS	close air support
CFACC	Combined Force Air Component Commander
CFMCC	Combined Force Maritime Component Commander
CWC	Composite Warfare Commander
DASC	Direct Air Support Center
EABO	expeditionary advanced base operations
EMS	electromagnetic spectrum
F2T2EA	find, fix, track, target, engage, assess
GCI	ground-controlled intercept
JADC2	Joint All-Domain Command and Control
JDN	Joint Doctrine Note
JP	Joint Publication
LAAB	Littoral Anti-Air Battalion
MACCS	Marine Air Command and Control System
MACS	Marine Air Control Squadron
MACG	Marine Air Control Group
MADIS	Marine Air Defense Integrated System
MAGTF	Marine Air-Ground Task Force
MATCD	Marine Air Traffic Control Detachment
MCDP	Marine Corps Doctrinal Publication
MCTP	Marine Corps Tactical Publication
MCWP	Marine Corps Warfighting Publication
MLR	Marine Littoral Regiment
MRIC	medium-range intercept capability
NEF	Naval Expeditionary Force
NDS	National Defense Strategy
NWP	Naval Warfare Publication
OIE	operations in the information environment
OPNAV	Office of the Chief of Naval Operations
PRC	People's Republic of China
RF	radio frequency
SIGMAN	signature management
TACC	Tactical Air Command Center
TAOC	Tactical Air Operations Center
TM EABO	*Tentative Manual for Expeditionary Advanced Base Operations*
TTP	tactics, techniques, procedures
WEZ	Weapons Engagement Zone

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Introduction

Two ongoing phenomena are impacting the relevancy of the Marine Air Command and Control System (MACCS). First, the Marine Corps is shifting its focus to competition in the littorals against a peer adversary – a dramatic shift from the previous two decades of counterinsurgency operations. Second, the character of war in which the MACCS will operate is changing rapidly with the proliferation of long-range precision munitions and the U.S. military's diminishing technological advantage. To be successful in the future security environment, the Marine Corps will need to make significant changes to divest capabilities no longer needed and invest in capabilities that will make it lethal and survivable in joint maritime campaigning. The recently published *Tentative Manual for Expeditionary Advanced Base Operations* is a profound indication that the Marine Corps is undergoing significant change and will influence the Marine Corps's approach to warfighting. In this period of transition, it is imperative that the Marine Corps reconceptualize its MACCS that has been relatively stagnant since it emerged during World War II.

To remain relevant in the future security environment, the Marine Corps needs to develop a new MACCS concept of operations, close doctrinal gaps in naval expeditionary force (NEF) aviation operations, and make the MACCS agile and survivable. Its new concept of operations must align with naval expeditionary operations. It should be innovative, break from the current paradigm, and define a new operational approach for the MACCS. Additionally, the Marine Corps needs to initiate a Navy and Marine Corps effort to establish doctrine for naval expeditionary force aviation operations to close the doctrinal gap between aviation operations in support of Marine Air-Ground Task Force (MAGTF) operations and naval aviation in composite warfare. Lastly, in synchronization with doctrinal development, the Marine Corps needs to

continue to solve the MACCS' problems of agility and survivability with organization and materiel solutions.

This paper provides a brief background of the mission and organization of the MACCS, then explains the changes in the future security environment. The "Problem" and "Solution" sections discuss just three of the significant challenges for the MACCS to get from its current state to the desired future state. They are not all-inclusive. This paper's overall goals are to highlight the critical condition of the MACCS and start the conversation among senior leaders and air command and control professionals about what the Marine Corps can do to prepare the MACCS for the future fight.

Background

The purpose of the MACCS is to enable the aviation combat element (ACE) commander to command and control aviation in support of MAGTF operations.[1] The MACCS performs the sixth function of Marine aviation, control of aircraft and missiles, which integrates the other five aviation functions: antiair warfare, offensive air support, assault support, electronic warfare, and air reconnaissance. It also provides the ACE commander with an interface between adjacent and higher joint and coalition aviation command and control agencies.[2] The primary missions of the MACCS are air direction and air control.[3] Air direction includes air tasking order development and adjusting the aircraft and surface-to-air weapon assignments as the situation changes.[4] Air control is the decentralized execution arm of the MACCS that enables the control agencies to direct aircraft or surface-to-air weapon systems to engage targets, and it includes airspace management.[5]

Current Organization

The Marine Air Control Group (MACG) and its subordinate squadrons and battalions form the administrative backbone of the MACCS, as depicted in the top portion of Figure 1. The battalions and squadrons provide the tactical agencies that comprise the MACCS (shown in the lower part of Figure 1). The Tactical Air Command Center (TACC) is the senior MACCS agency, which provides the ACE commander's command post. The primary tactical control agencies subordinate to the TACC are the Direct Air Support Center (DASC), Tactical Air Operations Center (TAOC), and Marine air traffic control detachments (MATCD). The MACCS currently has low altitude surface-to-air weapon capability to defend critical assets from air threats and a communications squadron to provide the ACE's communications backbone.

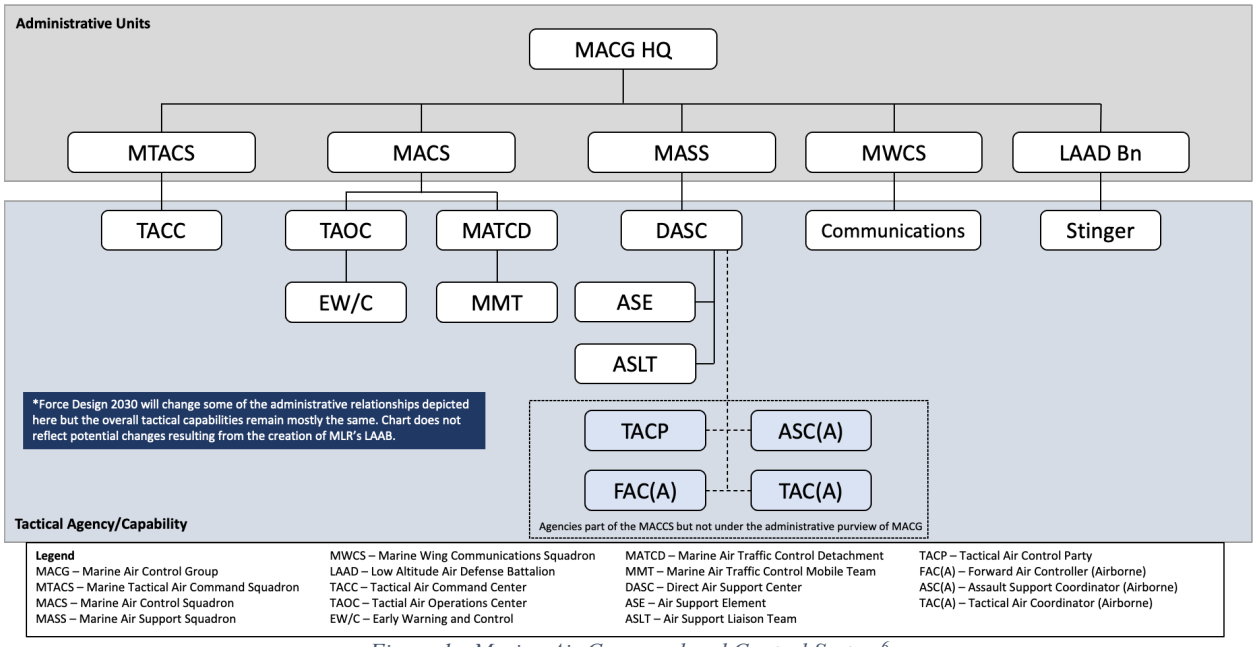

Figure 1: Marine Air Command and Control System[6]

Historical Evolution

The Marine Corps started forming the MACCS during World War II to command and control aviation operations to support the landing forces in the Pacific. To protect the landing forces from enemy air attacks, the Marines directed friendly fighter aircraft to intercept hostile air targets – a capability enabled by new radar technology and ground-controlled intercept (GCI)

tactics adopted from Britain's Royal Air Force.[7] Furthermore, the same GCI controllers deconflicted airspace users and antiaircraft artillery weapons to engage hostile air targets that friendly fighters could not prosecute.[8] To coordinate the air-to-air and surface-to-air engagements, the Marine Corps established air warning squadrons, which eventually became the modern-day Marine Air Control Squadron (MACS) and its air defense agency, the TAOC.[9] Second, the introduction of close air support (CAS) required a dedicated unit to coordinate and control air-delivered fires supporting the ground troops. Air liaison parties (now called tactical air control party) and landing force air support control units (now called DASC) processed air support requests, controlled aircraft close to friendly forces, and coordinated other supporting arms.[10]

In addition to air defense and air support, other modern-day MACCS capabilities emerging during World War II included the TACC and air traffic control. To better integrate and oversee antiair warfare and CAS missions, the Marine Corps established a command post to exercise centralized command of landing force aviation operations, which became the first version of the modern-day TACC.[11] Additionally, the technological advances in radar made possible the approach and departure of aircraft in periods of low visibility marking the beginning of Marine air traffic control.[12]

Since World War II, the MACCS has undergone several iterations of administrative consolidation and some phasing in and phasing out of surface-to-air weapons but has not changed significantly. For example, the MACG, activated in 1943, briefly became the Marine Wing Headquarters Group from 1956-1966 before returning to its MACG title.[13] Air traffic control units remained under the Marine Aircraft Group's administrative purview until becoming part of the MACG in 1967.[14] The Marine Corps' surface-to-air weapon capability began as

antiaircraft artillery before World War II, then transitioned to the HAWK short to medium-range missile employed by the Light Antiaircraft Missile Battalion from 1967-1997.[15] The Marine Corps' current surface-to-air capability is the Stinger missile used by the Low-altitude Air Defense Battalion.

Now, almost 80 years after the first remnants of the MACCS formed, it performs essentially the same missions in virtually the same functional form. According to Marine Corps Warfighting Publication (MCWP) 3-20, "[t]he ever-changing world security environment requires that Marine aviation continually anticipate and adapt to new challenges. Employing new technology with existing doctrine will not always provide the required operational capabilities."[16] However, until recently, the security environment has not changed so dramatically to force a change in Marine aviation or the MACCS. The next section of this paper unfolds some of the complexities of the future security environment, which indicate a changing paradigm for Marine aviation and establish an imperative for the Marine Corps to reconceptualize its concept of employment for the MACCS.

Future Security Environment

Strategic Context

The *Description of the National Military Strategy 2018* states the re-emergence of great power competition with China and Russia is the greatest threat facing the U.S.[17] After nearly two decades of counterinsurgency operations in Iraq and Afghanistan, the U.S. faces new challenges. Furthermore, the global security environment is likely more complex than during the last period of great power competition with the Soviet Union. If not more complex, it is certainly a different kind of complexity primarily because of the global advancements in technology. The *Summary of the 2018 National Defense Strategy* (NDS) asserts that the rapid evolution of technology

worldwide is changing the character of war.[18] It frames the problem in terms of China and Russia contesting the U.S. in all domains; air, land, sea, space, and cyberspace.[19] Interestingly, however, the 2018 NDS' qualifier of *changing* in the context of the changing character of war suggests that the security environment continues to evolve, making the future more difficult to predict. The tone in the 2018 NDS also reflects a sense of urgency for the joint force to change its force posture, processes, and mindset to remain a credible and lethal force into the future.

The U.S. military's shift in mission focus to competition, coupled with the technological changes, requires that the U.S. military rethink its offensively-biased mindset to perhaps a more defensive mindset. In the competition continuum, the simplicity of distinction between war and peace is no longer present.[20] Joint Doctrine Note (JDN) 1-19, *Competition Continuum*, states the "joint force does not win or lose but is in the process of winning or losing."[21] In other words, mission success occurs when the U.S. military can persist in the competition continuum long-term. One example that provides context to how competition impacts the commander's mindset is how doctrine defines the tactical task *defeat*. In MCDP 1-0, the definition of defeat is "disrupt or nullify the enemy commander's...will to fight..."[22] With this definition, one can assess mission accomplishment relatively quickly as the point at which the enemy stops resisting or surrenders. In *Competition Continuum*, defeat is to "create conditions to impose desired strategic objectives upon the adversary."[23] This definition of defeat is ambiguous and implies that a commander may be willing to accept short-term losses to create the conditions for long-term success. Competition also emphasizes U.S. cooperation with allies and partners.[i] The U.S. military must get better at

[i] The *Description of the National Military Strategy 2018, Summary of the 2018 National Defense Strategy, Advantage at Sea* (Tri-service maritime strategy), and the 38th *Commandant's Planning Guidance* all stress the importance of allies and partners for the U.S. to maintain a competitive advantage in competition.

sharing information and intelligence and integrating ally and partner weapons systems into the U.S. military's kill chains.[24]

Operational Context

The joint force can no longer expect presumptive sea control, air superiority, or assured communications.[25] China's expanding naval power and proliferated long-range precision fires will challenge the joint force's ability to maintain sea control and denial to protect U.S. strategic and economic interests in the Indo-Pacific region. To prevent a *fait accompli* scenario, the joint force will maintain a stand-in force close to allies, partners, and critical maritime terrain. Instead of the joint force fighting its way into an area of operations, it will persist there. As the nation's naval service, the Marine Corps, Navy, and Coast Guard will provide stand-in forces capable of disrupting adversary aggression and enabling access for the joint force.[26] The Navy's *Distributed Maritime Operations* and the Marine Corps' *Expeditionary Advanced Base Operations* concepts explain how the services need to reorganize to meet the joint force's new demands. They will guide the Navy and Marine Corps' force development through 2030 or beyond, and they will require functional capabilities, like the MACCS, to transform accordingly.

Expeditionary Advanced Base Operations

The *Tentative Manual for Expeditionary Advanced Base Operations* (TM EABO) explains how the Marine Corps will persist inside the range of adversary weapons. It introduces the term *littoral force* as stand-in, task-organized, naval units performing EABO.[27] The littoral force may operate in a MAGTF construct, as a task group under composite warfare commander construct, or under a CWC afloat.[28] The littoral force has the flexibility to respond to contingencies throughout the competition continuum. It is dispersed, mobile, maneuverable, and low-signature,

a combination of characteristics that will complicate the adversary's targeting and enable it to survive while simultaneously holding the adversary's forces at risk.

Competition with China in the Indo-Pacific

The naval service will focus its efforts on competition with the People's Republic of China (PRC) as the only rival with the potential to challenge the U.S. militarily and economically over the long-term.[29] As of 2020, China has surpassed the U.S. military in shipbuilding, ground-launched ballistic and cruise missiles, and integrated air defense systems.[30] In the air domain, the U.S. is losing its technological advantage and, as a result, will struggle to achieve air superiority at the onset of conflict against the PRC.[31] Furthermore, the technological advancements in missile capability in terms of range and precision create what Chairman of the Joint Chiefs of Staff, General Mark Milley, called a 'fundamental change in the character of war.'[32] Dr. T.X. Hammes, Distinguished Research Fellow, Center for Strategic Research, echoes General Milley's assessment suggesting that ballistic and cruise missiles may replace legacy manned aircraft in the next 20 years.[33] While the future character of war may be profoundly different, it is too early to fully understand the implications of rapid technological advancements, especially those impacting the air domain. Nevertheless, the future security environment will likely be dramatically different than it is today.

The joint force is losing uncontested access to the electromagnetic spectrum (EMS) to command and control, maintain battlespace awareness, and employ its weapons systems. The PRC is increasingly adept at using the electromagnetic operating environment to support its targeting schemes and deny or degrade joint force communications.[34] Stand-in forces conducting EABO will need to manage their signature to be survivable, maintain access to command and control (C2) systems, and preserve kill chain integrity. More than just radio frequency (RF)

signature, other detectable emissions include visible signature, infrared (heat signature), and noise. Radios, radar, cell phones, generators, or disturbances in the earth's soil, are just a few examples of what creates a signature and what the PRC can exploit to find, fix, track, and target U.S. forces.

Problems

A recently completed independent readiness review concluded that the MACCS is not organized, equipped, ready, or effectively preparing to conduct its assigned mission in the future security environment.[35] Its unpreparedness is not surprising given the relative stagnation of the MACCS since it originated after World War II. The MACCS has proven it is slow to transform, and with the dramatic shift in the security environment, the MACCS is quickly losing relevancy in the future fight.[ii] In recent years leading up to the Commandant of the Marine Corps' watershed CPG, the Marine Corps has increased its efforts to modernize the MACCS with materiel solutions (e.g., continued investment in common aviation command and control system (CAC2S), development and acquisition of marine air defense integrated system (MADIS), and experimentation with new employment options like the aviation command and control (AC2) node that is a modular, scalable form of a combined TAOC and DASC). At the same time, there was no evidence of the Marine Corps focusing on modernizing doctrine.[36] Now, the Marine Corps is turning its focus to EABO, for which the MACCS is even less prepared because it lacks the structure and equipment needed for distributed operations.[37]

[ii] Many of the same issues facing the MACCS today existed in the late 1990s. For example, in a presentation to the Operational Maneuver from the Sea (OMFTS) Working Group, the primary issues facing the MACCS were its inflexibility to operate from afloat and ashore, to integrate sensors and shooters across the joint force, and increase its mobility by fielding CAC2S, a nascent concept at the time. *Marine Air Command and Control System (MACCS) Presentation to OMFTS Working Group,* 1997-1999, Headquarters, United States Marine Corps, Studies and Reports Collection, Archives and Special Collections Branch, Library of the Marine Corps, Quantico, VA.

The Marine Corps is establishing a new MACCS capability in the Littoral Anti-Air Battalion (LAAB) as part of the Marine Littoral Regiment (MLR).[38] The first LAAB will activate in 2023, and at the time of this paper's publication, its concept of employment is largely undeveloped. In less than two years, the Marine Corps will conduct experimentation, develop doctrine, people, equipment, tactics, techniques, procedures, and complete myriad other requirements to achieve full operational capability. Although the time to build a combat-ready MLR seems extremely short, it highlights the Marine Corps' urgency to change and posture for the future security environment. However, the LAAB's existence creates an opportunity for the Marine Corps to reconceptualize its employment of the MACCS as a combination of stand-in and standoff forces.[iii]

The MACCS community is at a crossroads where it can continue to make evolutionary improvements to its legacy operating concept, or it can fundamentally redefine its purpose, mission, and function to support the MAGTF and Joint Force. Senior military leaders recognize that immediate change is necessary for the U.S. military to maintain its competitive advantage in the future. The 2018 NDS directs that "[military] leaders will adapt their organizational structures to best support the Joint Force. If current structures hinder substantial increases in lethality or performance, it is expected that Service Secretaries and Agency heads will consolidate, eliminate, or restructure as needed."[39] Furthermore, the 38th Commandant's Planning Guidance (CPG) echoes the NDS stating, "[The Marine Corps] cannot afford to retain outdated...doctrine [or] organizations..."[40] The changes in the 2030 security environment create several immediate challenges for the MACCS to remain relevant and ready for the future fight.

[iii] The term *standoff* may have multiple meanings/definitions. In this context, standoff is simply those forces positioned outside of the adversary's WEZ. See Figure 1-1 in Headquarters, United States Marine Corps, *Tentative Manual for Expeditionary Advanced Base Operations* (Washington, DC, February 2021), chap. 1, 4, https://mcwl.marines.mil/tmeabo

As the list of challenges is potentially exhaustive, this paper addresses three of the most significant.

First Challenge – Concept of Operations

The first challenge facing the MACCS is developing a concept of operations that will endure the rapid technological advancements and uncertainty of the future security environment. Headquarters Marine Corps is working through this challenge now. However, the various draft operating concepts focus too narrowly on solutions that make the MACCS more agile and survivable without giving sufficient attention to what other missions the MACCS might need to perform to best support the joint force.[iv] Other factors impacting the future relevancy of a MACCS concept of operations are the changing nature of aviation operations due to the increased range and precision of missiles, the proliferation of information-related capabilities, and the growing need for autonomy to harness massive amounts of information to support decision-making.

Second Challenge – Naval Expeditionary Force Aviation Doctrine

Navy and Marine Corps doctrine does not address NEF aviation operations sufficiently. Chapter 7 of MCWP 3-20 *Aviation Operations* recognizes that Marine aviation may participate in the execution of Navy functions as a collateral mission to its primary mission as a supporting arm of the MAGTF.[41] Specific to the MACCS, the current Marine Corps doctrine on naval operations is limited to how to phase the MACCS ashore during an amphibious operation.[42] No doctrine details the operations of Navy and Marine Corps, or naval, aviation operations. From a C2 perspective, the various potential command relationships will grow in complexity as the

[iv] Except for the draft marine air command and control future functional concept in development at Capabilities Development Directorate, Deputy Commandant for Combat Development and Integration, there is no evidence that Marine Corps is considering expanding the MACCS' missions more formatively beyond air control, air direction, and airspace management – its 70-year-old doctrinal missions.

MACCS may be tasked under the Joint/Combined Force Air Component Commander (J/CFACC) or Joint/Combined Force Maritime Component Commander (C/JFMCC) at different phases of an operation. As part of the NEF, the CFMCC may subsume Marine Corps' aviation assets for sea combat operations, or the CFMCC may delegate CWC roles to the MACCS, such as air and missile defense commander (AMDC). There likely exist numerous other command relationship challenges as part of the Marine Corps' renewed mission to focus on naval operations.

Third Challenge – Agility and Survivability

The third challenge is for the MACCS to be more agile and survivable. The Marine Corps will require the MACCS to operate in a more expeditionary manner, to command and control from afloat and ashore as part of the Naval Expeditionary Force. The Commandant of the Marine Corps has directed the Marine Corps to become more agile to operate at sea and to and from the land and sea.[43] Also, it may operate with a full suite of equipment, perhaps for the portions of the MACCS that are standoff forces or in a hybrid construct for those portions with the stand-in force. Additionally, it may operate as part of a MAGTF or as an extension of the CWC. In other words, the MACCS needs to have enough agility and flexibility to support EABO and other missions of the Fleet Marine Force, simultaneously and interchangeably.[44]

The MACCS has a significant physical and electromagnetic signature that the adversary can target easily when inside its weapons engagement zone (WEZ). Its significant physical laydown is because of technical limitations that require functional areas, like air defense and air support, to consolidate its controllers on a single piece of equipment, like CAC2S. In addition to an operational facility (usually a tent or combination of tents), there are communications trucks with truck-mounted or ground-mounted antennas, air conditioner units to keep the equipment cool,

and many generators to supply continuous, redundant power to all equipment. In other words, the current MACCS' physical attributes are easily detectable throughout the EMS. Regarding its electronic signature, air control agencies primarily use radio frequency waveforms to communicate with aircraft using voice or digital communications. The primary sensor of the MACCS is an active sensor that generates significant RF energy. Unless paired with passive sensors, it will be the only means for the MACCS to generate an air picture.

Solutions

> As good as we are today, we will need to be even better tomorrow to maintain our warfighting overmatch. We will achieve this through the strength of our innovation….
>
> -- General David H. Berger, *Commandant's Planning Guidance*

The Marine Corps should look to innovation as a means to develop the future MACCS. The Commandant of the Marine Corps referenced innovation over a dozen times throughout his planning guidance.[45] Senior leaders have emphasized innovation to address what the 2018 NDS calls an eroding U.S. military advantage against great-power competitors.[46] In 2014, then-Secretary of Defense, Chuck Hagel, made innovation the defense department's third offset strategy as the means to maintain U.S. military superiority in the 21st century.[v] Additionally, the *Description of the National Military Strategy 2018* states that innovation will "enable the Joint Force to do what it does differently to retain a competitive advantage against any adversary." [47] While innovating, however, one must also recognize that there will be opportunities for adaptation to address critical short-term gaps.

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[v] The United States' first offset strategy focused on nuclear advantage; the second offset strategy focused on maintaining the U.S. military's technological superiority. Source: Timothy A. Walton, "Securing the Third Offset Strategy: Priorities for the Next Secretary of Defense," *Joint Force Quarterly* 82 (3rd Quarter, July 2016), https://ndupress.ndu.edu/JFQ/Joint-Force-Quarterly-82/Article/793224/securing-the-third-offset-strategy-priorities-for-the-next-secretary-of-defense/.

Although there is extensive literature on innovation, it is important to clarify innovation's meaning, as this paper uses the term. First, consider what innovation is not. In Barry Posen's award-winning book, *The Sources of Military Doctrine*, he contrasts innovation with stagnation or stability.[48] Stagnation is probably an overstatement because most organizations will seek to improve processes and gain efficiencies. Stability infers an organization will continue to improve its practices but will continue doing essentially the same thing. Stability is safe only when there are no significant disruptions in the external environment. One could also use the term adaptation to describe how military organizations typically change. Adaptation infers that change is small-scale, incremental, and is one continuing to do the same thing, just better. Therefore, for a solution to be innovative, it must produce a significantly different operational approach that leads to overall greater military effectiveness.[49] This paper argues for innovation based on the following assumptions:

- The convergence of a dramatic shift in the security environment and the current unpreparedness of the MACCS warrant significant change that adaptation cannot satisfy.[vi]
- Innovation focused on doctrine will produce more effective change than technological innovation based on successful innovation during the interwar period because of doctrinal developments.[vii]

[vi] Barry Posen argues that military doctrine must be sufficiently innovative to respond to "changes in political circumstances, adversary capabilities, or available military technology...[and] for the competitive and dynamic environment of international politics." For more detail on innovation related to military doctrine, see; Barry R. Posen, *The Sources of Military Doctrine : France, Britain, and Germany Between the World Wars* (Ithaca: Cornell University Press, 1986), 16, Accessed March 20, 2021. ProQuest Ebook Central;

[vii] Two examples of interwar period innovation are in U.S. amphibious doctrine and German armored warfare doctrine. Despite the slow pace of materiel acquisition, the first major U.S. amphibious assault in World War II at Tarawa succeeded because of its 20 years of doctrinal development combined with just enough materiel to tip the scale between victory and defeat. Had the Marines failed at Tarawa, the history of amphibious warfare might read much differently. See Gunther E. Rothenburg, “From Gallipoli to Guadalcanal,” in *Assault from the Sea: Essays on*

- Innovation will be a learning process because it involves doing something new and significantly different than before. Therefore, an innovative solution will require several iterations of wargaming, experimentation, and refinement. As a result, innovative solutions will take longer to develop fully than will adaptive solutions.

Of the three challenges facing the future MACCS, the solution to the first challenge will require the Marine Corps to innovate. Adaptive, small-scale change may be sufficient for the MACCS to succeed in the future. Yet, it is unlikely because of the rapid technological shifts and growing complexity of the battlespace. The second and third challenges appear to be more straightforward and are more adaptive rather than innovative. However, any new concept of operations for the future MACCS will likely impact what the Marine Corps develops or helps the Navy develop as solutions for its naval doctrine, agility, and survivability problems.

First Challenge – Concept of Operations

The first and most urgent step is for the Marine Corps to develop a supporting concept of operations to EABO for MACCS employment. A MACCS concept of operations should define how the MACCS "wins" in EABO. The authors of the *Tentative Manual for Expeditionary Advanced Base Operations* acknowledge that their work provides a baseline for future doctrinal development to inform experimentation of *Force Design 2030* capabilities until doctrine replaces it.[50] Although it is incomplete, it enables innovation to continue through experimentation. The air command and control community needs to contribute to the ongoing innovation with a

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the History of Amphibious Warfare, edited by Merrill L. Bartlett (Annapolis: Naval Institute Press, 1983), 177; Due to Versailles Treaty restrictions, Germany tested armored warfare doctrinal concepts based on the promise of the tank using wooden mock-ups "driven" around the battlefield with bicycles or foot soldiers. As a result, when Germany finally started building tanks in 1934 in open defiance of the Versailles Treaty, it had a much clearer objective for what the tank should do. Mary Habeck, *Storm of Steel: The Development of Armor Doctrine in Germany and the Soviet Union, 1919-1939* (Ithaca, NY: Cornell University Press, 2014), 85, https://ebookcentral.proquest.com/lib/usmcu-ebooks/reader.action?docID=3138631#.

supporting baseline concept of operations. TM EABO provides considerations for MACCS employment options but refers the reader to the respective Marine Corps Warfighting Publications for more information on existing MACCS agency employment (e.g., MCWP 3-25F.2 for information on employing the TACC). While the Marine Corps could simply revise existing MCWPs to incorporate EABO concepts, doing so will miss the opportunities for the MACCS to enable joint force lethality in other domains.

The Marine Corps should seek an innovative solution to using the MACCS to disseminate common situational awareness across multiple domains.[viii] The future MACCS could manage a wide range of sensors that would generate a common tactical picture of air, ground, surface, and sub-surface tracks.[51] The implications of expansive sensor inputs make it necessary for the MACCS to become an information hub and a critical enabler for all-domain fires in Joint All-Domain Command and Control (JADC2).

New joint concepts like JADC2 will not only drive capability requirements in terms of equipment and interoperability but will change C2 constructs as well. For instance, the U.S. Air Force examines JADC2 impacts on its Air Operations Center's (AOC) centralized control construct shifting to a distributed control model – a dramatic shift in the Air Force's current tenet of centralized control, decentralized execution.[52] A few factors driving the Air Force to change its C2 are the AOC's vulnerability as a centralized C2 node, an increase in dynamic targeting missions that nullify the utility of planned targeting via the 72-hour air tasking cycle, and the increasing options to deliver coordinated effects via multiple domains.[53] Marine Corps aviation

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[viii] One of the three principal objectives of the MACCS is to disseminate common situational awareness. The other two are enhance unity of effort and integrate the elements of the command and control system. Headquarters US Marine Corps, *Control of Aircraft and Missiles*, MCTP 3-20F (Washington, DC: Headquarters US Marine Corps, May 2, 2016), chap. 2, 1-2. Additionally, a draft AC2 concept of operations from Deputy Commandant for Aviation calls the MACCS an information management organization.

and Navy CWC already exercise a decentralized control concept. Yet, the factors affecting the Air Force's change in command philosophy have implications for the naval force. For instance, the prevalence of dynamic targeting and geographic dispersion of C2 nodes could reduce the role of TACC as it delegates command authorities to subordinate nodes. Furthermore, dispersion enabled by JADC2 may also eliminate the need or utility of consolidating functions in a TAOC or DASC.

As new technologies and concepts like JADC2 come to fruition, the naval service can expect an increased role of autonomous systems, enabled by artificial intelligence and machine learning (AI/ML) to support decision-making. The automation level could range from simply using AI/ML to optimize sensor emissions based on the threat or to recommend weapons-to-target pairings. Autonomous systems will also improve decision-makers' speed and accuracy and reduce the amount of human interface required. It will also require the naval service to define tactics, techniques, and procedures (TTPs) for man-on-the-loop or man-out-of-loop engagements.[ix]

To enable concept development and refinement, the Marine Corps should improve its wargaming capabilities to better incorporate the effects of Operations in the Information Environment (OIE). As the Marine Corps continues to increase its information-related capabilities, it will also need to develop its ability to wargame effects in the OIE.[54] The ability to wargame the electromagnetic spectrum effects is crucial for the MACCS, which will need to test its signature management practices.

[ix] **Man-in-the-loop**: Human operator assigns weapons to targets manually. **Man-on-the-loop**: Human operator makes final engagement decision based on computer-generated weapon-to-target pairings.
Man-out-of-the-loop: The machine is fully autonomous and conducts engagements without human intervention. Reference: The Office of the Secretary of the Navy, *Advantage at Sea: Prevailing with Integrated All-Domain Naval Power* (Washington, DC, December 2020), 26, https://media.defense.gov/2020/Dec/16/2002553074/-1/-1/0/TRISERVICESTRATEGY.PDF.

Second Challenge – Naval Expeditionary Force Aviation Doctrine

The Navy and Marine Corps have developed or are developing many concepts that will guide future force development and force design like *TM EABO*, *Littoral Operations in a Contested Environment*, and *Stand-in Forces*.[55] As these concepts begin to form into doctrine, the Navy and Marine Corps need to develop a combined doctrine for naval aviation operations.[x] More than just the MACCS' primary function of control of aircraft and missiles, the Navy and Marine Corps should examine all Marine aviation functions in the context of the Naval Expeditionary Force. The new doctrine could supplement or potentially replace MCWP 3-20 *Aviation Operations*, MCTP 3-20 series publications, NWP 3-30 *Naval Command and Control of Air Operations (Organization and Processes)*, and JP 3-30. It should define the command relationships between the CFMCC, CFACC, CWCs, Littoral Force Commander, and the various MACCS and Navy C2 agencies.

Future NEF aviation doctrine development could model how the Army and Marine Corps co-developed the counterinsurgency manual in 2006 to replace service-specific Vietnam-era manuals.[56] Although doctrine is not for a specific operation or theater, it was beneficial for the Army and Marine Corps to operate from the same baseline fundamentals in the fight against Islamist extremists. Similarly, the Navy and Marine Corps should collaborate to provide the same baseline fundamentals for Marine Corps and Navy aviation operations in the coastal environment. To initiate this action, the Chief of Naval Operations and Commandant of the Marine Corps need to task the OPNAV staff and Headquarters Marine Corps to lead the development of this doctrine and then coordinate with the J-7 to update JP 3-30.

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[x] The Commandant of the Marine Corps directed the service conduct a comprehensive review of all doctrinal, reference, and warfighting publications to ensure that our doctrine, concepts, tactics, and procedures nest within and support composite warfare. Reference: Commandant of the Marine Corps, *Commandant's Planning Guidance*, 10.

Third Challenge – Agility and Survivability

Issues of agility are primarily due to the rigid organization of the MACCS. The MACCS needs to be capable of task organizing for various missions in a variety of operating conditions because of the operating environment's complexity and unpredictability. It is conceivable that the functions of the TAOC, for instance, would be geographically distributed as air control nodes and sensor teams that alternate control and sensing responsibilities to reduce signatures and allow the "down" node/team to move and set up in a new position. As the threat environment shifts between the contact and blunt layers, the MACCS should be able to organize for distributed operations when there is an elevated air and missile threat and then consolidate capabilities for day-to-day competition.

Survivability solutions pertain to the adversary's ability to target the MACCS. One helpful way to view potential MACCS survivability issues is through the lens of a kill chain or the dynamic targeting steps of find, fix, track, target, engage, and assess (F2T2EA).[57] The survivability of the MACCS will depend on more than its ability to *survive* an attack. It needs to prevent the adversary from completing any of the steps in its kill chain. The remainder of this section presents some of the options for the MACCS to break the adversary's kill chain, specifically in the F2T2E steps.[xi]

The MACCS agencies will need to become proficient in signature management (SIGMAN) TTPs to protect against the first targeting step, find. In addition to SIGMAN, the Marine Corps needs to leverage passive sensors to provide the common tactical picture and use active sensors,

[xi] The last targeting step, *assess*, occurs throughout the kill chain as the adversary seeks to confirm it has the right information to continue executing its kill chain. This paper does not include options for the MACCS to defeat the assess step because it is implicitly included in the F2T2E steps.

like the AN/TPS-80, to support kinetic actions.[xii] Movement and dispersion are other methods to complicate the adversary's ability to find. Like small-form-factor CAC2S, future technologies will enable the MACCS to be more mobile and disperse. In practice, however, it will be complicated for the MACCS agencies to remain undetected. For instance, the PRC's increasing use of space-based intelligence and human intelligence collection assets mixed in with the local populations will make it extremely difficult for the MACCS or any part of the joint force to move around the battlespace undetected. Therefore, the Marine Corps should incorporate additional means to increase the survivability of its units.

Decoys and signature management will complicate the adversary's ability to fix, track, and target. In the previous targeting step, find, the adversary is scanning the battlespace, likely through passive sensors to limit its systems' exposure. To fix, track and target, the adversary will begin to "turn on" more of its sensors to gain positive identification of the target. Thus, one can use decoys to present a false laydown of its critical assets. Additionally, one can manage the emissions in random or alternating emission cycles among multiple emitters to further confuse and force the adversary to use and expose its active sensors.

Active air defense measures with electronic protection will prevent the adversary from completing the kill chain's engage step. The Marine Corps will have MADIS for short-range air defense and counter-unmanned aerial systems and is pursuing a medium-range intercept capability (MRIC) to extend its engagement ranges against aircraft and cruise missiles. The Marine Corps' challenge in this step is not in defeating adversary fires but in defeating a barrage of adversary fires. The MRIC's fire support radar, once turned on to support MRIC missiles in-

[xii] For recommended technology solutions for multi-spectral/modal sensors, see: Scott Caton, "The Marine Air Command and Control System: Creating Resilient Sensors, Sharers, and Shooters," (master's thesis, Marine Corps University, 2019),.

flight, will unveil its position and be vulnerable to follow-on attacks and jamming. Therefore, in addition to the air defense weapons systems, the Marine Corps will need to develop TTPs to synchronize sensor activity, electronic protection, and kinetic or non-kinetic counterattacks.

Conclusion

The future MACCS should appear much different than it does today. The most significant challenge for the Marine Corps will be developing an innovative solution to how it needs the MACCS to operate in the future. Based on the dramatic shifts in the security environment, the changing character of war due to the proliferation and advancement in ballistic and cruise missile technology, and the current unpreparedness of the MACCS, adaptive solutions will not be enough. However, by pursuing new concepts of operations, the Marine Corps can explore opportunities for the MACCS to expand its role into other domains. It has the potential to enable all-domain fires by employing or integrating a wide range of sensors to disseminate situational awareness across all domains. It also has the potential to reorganize around new concepts like JADC2 that will enable distributed C2 nodes and allow the MACCS to divest its consolidated C2 centers (e.g., TACC, DASC, TAOC). Another solution the Marine Corps can pursue now is developing doctrine for NEF aviation to replace or supplement MCWP 3-20, MCTP 3-20 series publications, NWP 3-30, and JP 3-30. A consolidated Navy and Marine Corps publication will clarify command relationships and Marine aviation's role in naval operations. The Marine Corps also needs to continue solving the issue of agility and survivability of the MACCS. The MACCS should be capable of distributed operations using nodes or teams that are task-organized depending on the mission. To be more survivable, the Marine Corps will need to combine technological solutions with new employment concepts, signature management TTPs, and diverse sensor employment options. Lastly, the MACCS should have the flexibility to support

the joint force while operating in contested spaces and be just as ready to support a MAGTF in response to crisis elsewhere.

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