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14. ABSTRACT
The nation's adversaries are out-innovating the U.S. in many sectors to include military capabilities. New and pervasive capabilities are reducing the effectiveness of current Marine Corps combat systems and TTPs. In recognition of this threat, the Marine Corps is transforming its capabilities to respond to emerging threats. This Pre-Mortem examined the impact of Force Design 2030 on engineer capabilities, and the engineering community is postured for future challenges.

15. SUBJECT TERMS
Combat engineer structure; Engineer in support of EABO; Naval integration; Naval Engineer Force; Force Design 2030; Engineer Regiment; Marine Littoral Regiment, MLR

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AUTHOR:

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AY 20-21

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

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Executive Summary

Title: Marine Corps Engineering Pre-Mortem.

Author: Ademola D. Fabayo, Major, United States Marine Corps

Thesis: Marine Corps Engineering is not postured to provide support or solutions to future engineering challenges the service component or naval expeditionary forces are expected to face.

Discussion: Innovation is quickly becoming the new buzzword in Marine Corps. Rightfully so, because if the organization does not start innovating rapidly, it is bound to become ineffective. The nation's adversaries are out-innovating the United States in many sectors to include military capabilities. Adversaries' new and pervasive capabilities are reducing the effectiveness of current Marine Corps combat systems and Tactics Techniques and Procedures (TTP). In recognition of this threat, the Marine Corps is transforming its capabilities to respond to emerging threats. The engineering community is currently examining the impact of Force Design 2030 on engineer capabilities and forecasting future core capabilities. A premortem of how changes to Marine Corps engineer's organizational structure will best support future force design; procurement of specialized equipment that supports new capabilities; Naval integration with Naval Construction Force and how the training pipeline delivers capabilities required by the future force concepts.

Conclusion: The engineering community's challenges are not insurmountable, but there is no one-size-fits-all solution. The Marine Corps needs to posture itself to succeed in the Great Power Competition between 2023 to 2027, or it will become exponentially challenging to achieve anticipated effects on adversaries. Marine Corps Engineering needs to start developing solutions right now. It will require reorganizing without taking a cookie-cutter approach; Naval integration is integral to increasing engineering capacity and capabilities; deliberate analysis of specialized equipment and refinement of individual skills matched with capabilities will allow engineers to enable mobility, counter-mobility, increase survivability, and general engineering in contested environments.

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Many people have been instrumental in helping me achieve this career and educational goal. First, the completion of this thesis would not have been possible without my thesis committee's support. Dr. Sinan Ciddi, and LtCol Patrick Manson, devoted their time and effort to shape my writing and research to reach my goal. Their advice and guidance were critical to my success.

The encouragement of my classmates MAJ Daryl Barnett in Conference Group 15, my Military Faculty Advisor LtCol Kenneth Goedecke, and the Deputy Director COL Matthew Neumeyer all played a large part in getting me through many of my complex challenges of research and writing. Their help and motivation made this entire process possible.

Finally, and most importantly, I thank my wife, Bola, for holding down the fort and encouraging me, reminding me to keep my persevering spirit. Having just completed an arduous six-year tour in the Fleet Marine Force, I know she wanted me at home as much as possible, but she accepted the challenge of having me leave as a geographic bachelor. Her sacrifice, and that of my daughters, Athena, and Amelia, surpass the sacrifice on my part to complete this endeavor. I could not have done it without their support and love.

INTRODUCTION

"The greatest danger in times of turbulence is not the turbulence; it is to act with yesterday's logic."

– Peter Drucker, Management consultant, educator, and author.

"When the rate of change inside an institution becomes slower than the rate of change outside, the end is in sight. The only question is when."

– Jack Welch, Business executive, chemical engineer, and writer.

The current and rapidly evolving combat operating environment has compelled the Marine Corps to begin a detailed audit of its capabilities and relevance in the future operating environment. The 37th Commandant of the Marine Corps, General Robert Neller, stated in his assessment of the Corps during his tenure, "The Marine Corps is not organized, trained, equipped, or postured to meet the demands of the rapidly evolving future operating environment."[1] The current Commandant, General David Berger, also emphasized similar concerns in his Commandant's Planning Guidance (CPG) published in 2018. He provided the Total Force a unified direction in his strategic guidance. He codified his five priority focus areas in the order listed: force design, warfighting, education and training, core values, and command and leadership.[2] The first three priorities will guide this research analysis of the Marine Corps' combat engineering capacity to provide effective support in the future operating environment.

This research focuses primarily on Marine engineers' ability to adequately provide support or solutions to numerous current and future engineering challenges the naval expeditionary forces are expected to face. The challenges were examined across the

[1] General David H. Berger. "Commandant's Planning Guidance."
[2] Ibid

DOTMLPF[3] spectrum, but not all elements of DOTMLPF will be discussed. General Robert B. Neller, 37th Commandant, concisely laid out how critical engineers are to the Marine Air-Ground Task Force (MAGTF)[4] and why this assessment is crucial when he stated, "Whether breaching complex obstacles, enhancing fires with integrated obstacles, hardening our positions, providing the tactical electrical power necessary to operate critical command and control systems, making water or building a road or an LZ, the future MAGTF must possess engineering capabilities and capacity that will enable the force to fight and win."[5] As a combat support element, Combat Engineers enable mobility, counter-mobility, increase survivability in contested environments, and provide general engineering to enhance commanders' ability to generate combat power and facilitate sustainment. These capabilities are critical to all MAGTF elements and the Joint Force mission success, making engineers a high-demand resource. Engineering capabilities are especially critical as the Marine Corps is posturing to maintain a persistent presence in adversaries Weapon Engagement Zones (WEZ)[6] as a conflict deterrent or prevent adversaries from expanding their objectives beyond the competition stage. The requirement of providing scalable, agile, and adaptable engineer support to the MAGTF with limited personnel and equipment resources is a constant challenge for the engineering community, and that situation is not changing in the future operating environment.

[3] DOTMLPF is Doctrine, Organization, Training, Materiel, Leadership, Personnel, and Facilities

[4] MAGTF is the Marine Corps' principal organization for all missions across the range of military operations, composed of forces task organized under a single commander capable of responding rapidly to a contingency anywhere in the world. The types of forces in the MAGTF are functionally grouped into four core elements: a command element, an aviation combat element, a ground combat element, and a logistics combat element. The four core elements are categories of forces, not formal commands. (MCRP 1-10.2)

[5] General Robert B. Neller, 37th Commandant, USMC 30 March 2018

[6] WEZ is the maximum effective firing range adversary forces can effectively employ missile, torpedo, guns and other weapons.

Background

Multiple issues have generated internal and external debates regarding where engineers fit within the total force in reference to the Force Design.[7] Questions like determining the optimal size, organizational structure, mission, and priority of Program of Record (POR) equipment still require analysis and answers. These are not new issues facing the community, and the debate has been ongoing for the last two decades of conflict in the Middle East and Afghanistan. Even though the organization was able to calibrate itself and provided phenomenal solutions to emerged challenges in those conflicts, the solutions were generally reactive and were usually written in blood. The Marine Corps' failure to identify, prepare, or quickly appreciate how enemies' systematic employment of Improvised Explosive Devices (IEDs) would impact friendly forces mobility and survivability in Iraq between 2003 to 2005 is an example of what to avoid in future conflicts. The MAGTF was at the time facing an inferior military force, a compelling force but non the less militarily inferior. Therefore, reactive solutions like that of the last two decades in a near-peer conflict will be unacceptable because it carries undesirable consequences; it will pose a significant risk to force and, more importantly, a risk to the Joint mission.

The first question is - why Marine engineers were unable to make organizational changes that would have postured the community to meet the future challenges? Implementing changes for Marine engineers has always been challenging due to various factors like a multifaceted advocacy system that kept the community from speaking with one voice. Engineers in the Ground Combat Elements (GCE), Logistics Combat Elements (LCE), or the Air Combat Element (ACE) of the MAGTF all have different priorities, and they sometimes compete for

[7] David H. Berger General, U. S. Marine Corps Commandant of the Marine Corps. "Force Design 2030."

funding. The organizational structure of engineers in the Marine Corps has also created different operational experiences depending on which part of the MAGTF engineers spent most of their careers. The differences were further highlighted because of gaps in GCE engineer capabilities in the last twenty years of war that required correction; that focus sometimes overshadowed the engineering requirements in the other MAGTF elements. The organizational structure also resulted in slow arbitration of competing ideas or proposals, awareness of problems and possible solutions, decisions to adopt innovative ideas, implementation of solutions that include modifying organizational structures to accommodate change, and institutionalizing innovation as part of Marine engineering's ongoing model.

Some might ask why don't Marine engineers follow the U.S. Army engineers' model? U.S. Army engineers provide four lines of engineer support: Assure mobility, Enhance protection, Enable expeditionary logistics, and Build capacity. These lines of efforts are not fundamentally different from Marine engineer functions of Mobility, Counter-mobility, Survivability, and General engineering. Army engineer forces are a significantly larger force consisting of more than 90,000 Engineer Soldiers in the Active Army, Reserves, National Guard, and 32,000 civilians.[8] The Marine Corps engineer/EOD active and reserve forces consist of approximately 12,000 Marines.[9] The U.S. Army engineers have more extensive responsibility to the Joint Force, and they are staffed adequately to support their mission. U.S. Army engineers are led by a Lieutenant General, who serves as the principal advisor to the secretary of the Army and other leaders on matters related to general, combat, and geospatial engineering; construction;

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[8] Military Engineering Centre of Excellence. http://milengcoe.org/nations/Pages/United%20States.aspx

[9] Numbers calculated by pulling data from "Manpower & Reserve Affairs." https://www2.manpower.usmc.mil/mosDistri. Marine Corps Engineer consist the following military occupation specialties (MOS) 1302, 1310, 1316, 1341-45, 1349, 1361, 1371, 1372, 1390, 1391, 2305, 2336, 1120, 1141, 1142, 1169, 1169, 1171

real property; and natural resources science and management.[10] The Army chain of command and advocacy structure is streamlined, and the service does not have to contend with the Navy and Marine Corps multi-service structure's complexity. Naval engineering capabilities are split between two services with limited coordination with operational, manpower, funding, and capabilities requirements. Though the Army and Marine engineers' missions have similarities, Marine engineers tend to operate at the tactical level of war and in an expeditionary and austere environment with limited resources. Thus, making the Army engineers' structure and advocacy model designed for the operational level of war an unusable template for Marines to shape its future engineering force. However, the Marine Corps enables operations which has operational and strategic impacts.

Following the 2019 Commandant's Planning Guidance, the Marine Corps Functional Concept for Fleet Marine Force Engineering was published to inform and guide the Marine Corps Capabilities Based Assessment (CBA) process; it challenges engineers to "rethink how engineers prepare for future battles"[11] by re-evaluating engineer roles, responsibilities, doctrine and processes. The document assessed that the "current engineer force organization, capabilities, and capacities impede the ability of the FMF to achieve combat-credibility."[12] It also asserts that Marine engineers will maintain the full range and depth of capabilities with flexible, task-organized formations that can consolidate in support of massed Fleet Marine Force (FMF) conducting large-scale operations and reorganize to support sea denial operations.

[10] Military Engineering Centre of Excellence. http://milengcoe.org/nations/Pages/United%20States.aspx
[11] Marine Corps Functional Concept for Fleet Marine Force Engineering (Washington, DC: HQMC, January 2020)
[12] Ibid

THE CHALLENGES

Distributed Operation (*Doctrine implications)*

Multiple adversaries have developed effective sea denial capabilities due to the proliferation of Anti-access/area denial (A2AD) missile technology and their effective use of proxy forces. The possibility for conflicts is not only growing, but it has morphed into a great power competition that spans from the Pacific Ocean, Indian Ocean, and the Mediterranean Sea. The current operating environment poses a significant challenge to United States Naval forces.[13] The Chief of Naval Operations and the Commandant of the Marine Corps approved the Expeditionary Advanced Base Operations (EABO)[14] concept in 2019 to address the Naval force's operational constraints and to drive new doctrine. The concept advocates "integrated yet distributable naval formations to support sea denial and sea control in the face of potential adversaries who pose increasing challenges to current naval forces."[15] The new concept will require testing and validation to update the current doctrine.

EABO can be deduced as distributed operations in an austere environment with the caveat of naval forces persisting within adversaries WEZ. The new EABO Tentative Manual published February 2021 stated that EABO missions include, Support sea control operations; Conduct sea denial operations within the littorals;[16] Contribute to maritime domain awareness; Provide forward command, control, communications, computers, combat systems, intelligence, surveillance, reconnaissance, targeting (C5ISRT), and counter-C5ISRT capability; and Provide

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[13] United States Naval Forces comprise the Navy and Marine Corps

[14] EABO is currently defined as a form of expeditionary warfare that involves the employment of mobile, low-signature, persistent, and relatively easy to maintain and sustain naval expeditionary forces from a series of austere, temporary locations ashore or inshore within a contested or potentially contested maritime area in order to conduct sea denial, support sea control, or enable fleet sustainment. (TM EABO): Pg F-3

[15] The Tentative Manual for Expeditionary Advanced Base Operations (TM EABO): Pg 1-1

[16] Littoral are segments of the operational environment, Seaward from the open ocean to the shore, which must be controlled to support operations ashore and Landward area inland from the shore that can be supported and defended directly from the sea. (JP 2-01.3)

forward sustainment.[17] All of the listed missions will require some variety of engineering support to be successful, especially sea control operations and sea denial operations within the littorals. EABO tasks like Conduct surveillance and reconnaissance;[18] Deny or control key maritime terrain;[19] Conduct antisubmarine warfare;[20] Conduct sustainment operations,[21] and Conduct forward arming and refueling point (FARP) operations[22] are some of the future challenges the engineering community must address by evaluating the required capabilities and capacity required to support such missions and enable strategic Freedom of Navigation.[23] Two such Freedom of Navigation Operations (FONOP)[24] are sea control and sea denial.

Engineer Support in Sea Control Operations

The Marine engineer core functions of mobility, counter-mobility, survivability, and general engineering are still applicable and necessary in EAB operations to enable projection of power ashore in the littorals. In terms of enabling sea control, Naval engineer forces currently cannot effectively preserve the freedom of movement of friendly forces or commercial shipping seaborne movement in the littorals. U.S. Rep. Rob Wittman, R-Va., in his May 2020, Defense News commentary, '*The US Navy's modernization rush must not harm mine countermeasures'* clearly stated that U.S. adversaries have learned from the Russians who were the pioneers of mine warfare and in possession of approximately 250,000 sea mines. The Chinese are in possession of an inventory of around 100,000 world's most advanced sea mines. China also has

[17] EABO missions and tasks are listed in the newly released 'Tentative Manual for Expeditionary Advanced Base Operations' (TM EABO): Pg 1-4
[18] Ibid
[19] Ibid
[20] Ibid
[21] Ibid
[22] Ibid
[23] FON is principle of customary international law that ships flying the flag of any sovereign state shall not submit to intervention from other states.
[24] FONOPs aims to prevent excessive maritime claims over coastal seas, which could threaten freedom of navigation and U.S. access to its national areas of interests.

hundreds of mine-capable ships and aircraft capable of deploying thousands of mines a day.[25] Sea mines are relatively cheap and very effective persistent coastal defense weapons that are difficult to eliminate once employed. Unlike landmines, sea mines are governed by the 1982 United Nations Convention on the Law of the Sea (UNCLOS),[26] but it does not expressly refer to sea mine-laying or nations' right to engage in mine countermeasure (MCM) operations; giving U.S. adversaries freedom of operation without limitation from international law. However, the United States is not a signatory of UNCLOS. A further review of countermine warfare or offensive mine warfare requirements should inform future policy decisions. The United States only employs two sea mines currently, the Quickstrike family (Mk 62 (500 lb.), Mk 63 (1000 lb.), and Mk 65 (2300 lb.)), which converts different sizes of air-launched general-purpose bombs into mines by attaching a simple target-detection device, and the submarine-launched mobile mine (SLMM).[27] All the current sea mines use 20th-century technology and are only effective in shallow water directly underneath a target vessel. The United States Navy lacks robust offensive or defensive mining capabilities, which puts naval forces at a disadvantage in sea control operations. The Navy has ignored offensive mine warfare due to the Navy's domination of the maritime domain, but the naval power advantage is now greatly diminished in the littorals, especially in the Pacific.

Naval forces are currently unable to rapidly detect, locate or clear mines and obstacles in the littorals or approaches to landing zones for connectors. The U.S. Navy possesses Mine Countermeasures (MCM) capabilities and assets like the Avenger-class mine countermeasures

[25] Rep. Rob Wittman. "The US Navy's Modernization Rush Must Not Harm Mine Countermeasures." Defense News, May 8, 2020.
[26] The 1971 Seabed Treaty applies in peacetime and armed conflict.
[27] National Research Council. 2001. Naval Mine Warfare: Operational and Technical Challenges for Naval Forces. Washington, DC: The National Academies Press. https://doi.org/10.17226/10176. Pg 56-69

ships, MH-53E Sea Dragon helicopter, and Explosive Ordinance Disposal (EOD) platoons.[28] However, the Navy does not possess enough capacity of the MCM assets listed to enable persistent operations, and they are unable to perform rapid reconnaissance and assessment of mines. MCM assets across the naval force are limited, will be significantly challenged, or are ill-prepared to clear sea lanes or breach explosive obstacles in a contested environment, especially in harbors, approaches, straits, and the surf zone. Equally challenging for naval engineering forces is the ability to deny the adversaries' use of the sea.

Engineer Support in Conduct Sea Denial Operations

Sea Denial is a military capability to deny the adversary's ability to use the sea without essentially controlling the sea for its own use. The object of sea control is to use the sea for use by friendly forces, while the object of sea denial tries to deny the adversaries' use of the sea. This concept is increasingly difficult to execute when operating against peer adversaries because large bases[29] and staging areas are vulnerable to attack by long-range missiles and rockets. It will require U.S. forces to employ multi-domain operations and reduced signatures to mitigate risk to force and mission. The shift from large bases and formation to smaller tactical outposts and units will complicate engineering solutions which will require multiple engineering disciplines dispersed across the INDO-PACOM AO. Marine engineers and Seabees are not currently structured or designed to conduct this type of operation. There are gaps in technical capabilities like specialized training in construction techniques on islands, assessment teams, surveying, wells, contracting capabilities, and the lack of naval engineer force integration are some of the factors currently making sea denial a limited capability.

[28] 14 ships were constructed for the United States Navy from 1987 to 1994, only 8 are currently on active service.
[29] Base is defined as a locality from which operations are projected or supported. (JP 1-02)

Marine engineers currently lack modern tunneling and mining equipment and other specialized equipment which may be required to operate or survive in a non-permissive operating environment. There is also a requirement for a theater-level strategic operation plan for the engineer forces to follow in each geographic combatant command. For example, China seems to have an integrated sea denial plan that denies the U.S. forces access to traditional logistical hubs, inhibits freedom of the seas, and controls the use of key maritime chokepoints like the Strait of Malacca and the Strait of Hormuz. Navy Construction Forces and Marine engineers have to be strategically deployed to areas of interest or partner nations before the emergence of a crisis. These deployments should be conducted primarily through Theater Security Cooperation (TSC)[30] type missions during this competition phase. Some may argue that TSC missions are ongoing; however, most are not serving EAB strategic requirements. Naval engineering forces can collectively possess the skills and tools to be a combat multiplier by constructing survivability positions required for force protection, including screening/scouting platforms, A2AD platforms, or dual-purpose hardened structures that could be quickly occupied to support sea denial and sea control operations. These dual-purpose projects should be initiated during the competition phase.

Organization

Following the Commandant's Planning Guidance, he published the Force Design 2030 to address the first of his priorities that he laid out in the CPG. The Commandant stated that "we must transform our traditional models for organizing, training, and equipping the force to meet

[30] TSC encompasses all Department of Defense (DOD) interactions, programs, and activities with foreign security forces (FSF) and their institutions to build relationships that help promote US interests; enable partner nations (PNs) to provide the US access to territory, infrastructure, information, and resources; and/or to build and apply their capacity and capabilities consistent with US defense objectives. (JP 3-20)

new desired ends, and do so in full partnership with the Navy."[31] This places the Marine engineering community yet at another crossroad. The community must decide how to support the MAGTF conducting Littoral Operations in a Contested Environment (LOCE), performing Expeditionary Advance Base Operations (EABO), and Distributed Operations with a smaller engineer force?

Force Design directed significant divestment of legacy systems such as tanks, bridging systems, and aircraft to free up resource dollars to pay for new essential capabilities. According to the Commandant, in reference to tanks and bridging assets, "[t]his capability is primarily relevant to sustained land operations. Given my guidance to avoid such criteria in designing the force, this capability is clearly excess to our requirements."[32] The divestment of Marine Wing Support Groups (MWSG) and three bridging companies signifies a substantial loss of Marine engineer structure and capacity. These losses will adversely impact capacity and capabilities across the spectrum of engineer tasks and warfighting functions. In particular, without tank's direct fire capabilities and tube artillery's ability to provide persistent obscuration, the breaching of adversaries' minefields is severely degraded using the current Tactics Techniques and Procedure (TTP). Also, the loss of standard bridging and ferrying capability degrades engineer's ability to provide mobility support to the MAGTF in compartmentalized areas separated by gaps and water. Although these changes were deemed necessary, the engineering community must evaluate whether these are genuine deficiencies in capabilities or determine if the tasks are obsolete. An analysis of the Marine Littoral Regiment (MLR) future operating concept is required to determine if bridging requirements for gap crossings based on detailed geospatial surveys will be a requirement in the future.

[31] David H. Berger General, U. S. Marine Corps Commandant of the Marine Corps. "Force Design 2030."
[32] Ibid

The Commandant said, "I am not confident that we have identified the additional structure required to provide the tactical maneuver and logistical sustainment needed to execute DMO, LOCE, and EABO in contested littoral environments against our pacing threat."[33] The Marine engineering community requires further research on creating and validating its support model for the new concept like Marine Littoral Regiments, enabling littoral maneuver and sustainment, especially in the Indo-Pacific region. Major Daniel Jernigan described in his Marine Corps Gazette article the challenges related to providing engineer support in the littoral, "supporting mobility in distributed operations where key terrain is often the only terrain above the surf zone is incompatible with the legacy techniques, tactics, and procedures."[34] One way the Marine Corps can replace the lost structure in Force Design 2030 and gain enhanced capabilities resident in the Naval Construction Force (NCF) into the Marine Engineer community by efficiently integrating the NCF. "Marines and Sailors will have to uncover and develop solutions for the challenges of operating in new modes,"[35] as stated by the Commandant in his recent Gazette article, '*The Case for Change.'*

Marine engineers currently exist in all MAGTF elements under separate battalions and squadrons. Engineer forces in the Navy or Seabees are in the Naval Mobile Construction Battalions (NMCB). The two forces operate entirely independently of one another with minimum coordination, resulting in capabilities overlaps or gaps. There is no centralized planning or coordination element responsible for directing and integrating activities for the Naval component commander. This organizational structure of naval engineer forces is the antithesis

[33] Ibid
[34] Jernigan, Maj Daniel. "The Maritime Engineer Team Theater Level Effects through the Integrated and Dynamic Application of Navy and Marine Corps Engineer Forces Afloat." Marine Corps Gazette 104, no. 11 (2020): 71-74.
[35] Gen David H. Berger, "The Case for Change: Meeting the Principle Challenges Facing the Corps," Marine Corps Gazette 8 -12. 5 (2020).

of the Navy and Marine Corps' integration in Health Services Support structure and operations; the two services are inseparable. Navy Corpsmen are organic to Marine chains of commands, including Medical and Dental Battalions, which predominantly consist of Navy medical personnel integrated under Marine Corps structures.

In his May 2020 Marine Corps Gazette Article titled *The Marine Combat Engineer Regiment,* LtCol Walt Carr addressed the scarcity of engineers in the Marine Corps and how to manage it better. With the significant manpower reduction directed by Force Design 2030, Marine Corps will have fewer engineer forces to support the MAGTF. LtCol Carr stated that "When faced with any scarce resource, the wisest thing to do is to manage it carefully with centralized command and decentralized execution."[36] He recommended that "the best way to manage scarce engineer resources is through consolidation and centralized command, enabling efficiencies in organizing, manning, training, and equipping, leading to combat engineer formations that are prepared to properly support the needs of the future FMF."[37] Combining all engineers under one command at each Marine Expeditionary Force (MEF) has the stated advantages, but it might not be the universal solution. There are also potential disadvantages that must be addressed because consolidation can have an adverse effect on speed, tempo, and unit cohesion. Having an organic engineer unit within the MLR has the advantages of generating speed and tempo by being readily available.

[36] Carr, Walt. "The Marine Combat Engineer Regiment." Marine Corps Gazette 104, no. 5 (2020): 33-38
[37] Ibid

Littoral Logistics Battalion

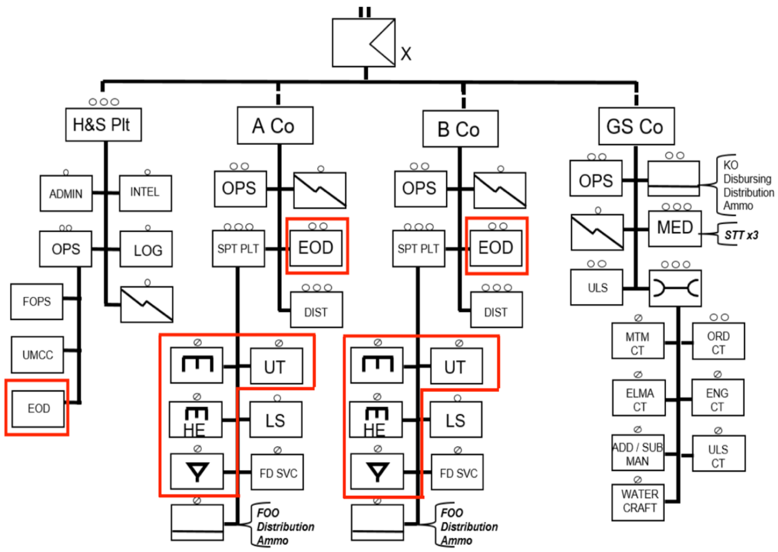

Figure 1

The proposed 2030 Littoral Logistics Battalion (LLB) illustrated in (*Figure 1)* is designed to provide the MLR tactical logistic support beyond organic capabilities by supporting EABs, managing cache sites, and connecting to operational-level logistics.[38] Engineer integration in the LLB as an organic element will support this mission. It also has the added advantage of unit cohesion, improving coordination and responsiveness. The proposed engineer structure in the LLB is scattered across the battalion in a manner that LtCol Carr referred to as the "soccer mom method."[39] Varieties of engineer Military Occupation Specialties (MOS) are distributed across two companies with undefined requirements or unclear engineer leadership. Engineer capabilities are not linear based on the numbers of troops; the capabilities can be exponential based on various variables such as mission, equipment, training, environment, or experience.

[38] EABO units' missions and tasks are listed in the newly released 'Tentative Manual for Expeditionary Advanced Base Operations' (TM EABO): Pg A-3

[39] Carr, Walt. "The Marine Combat Engineer Regiment." Marine Corps Gazette 104, no. 5 (2020): 33-38

Littoral Combat Team (LCT)

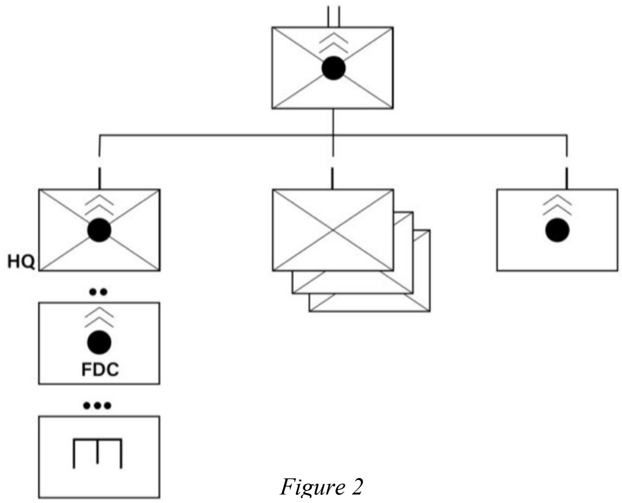

Figure 2

The proposed Littoral Combat Team (LCT) illustrated in (*Figure 2)* is designed to be employed as a task-organized maritime littoral unit, capable of commanding and controlling distributed EABs that are conducting sustained operations to enable fleet operations via sea denial.[40] The size, composition (MOS), leadership, and required capabilities are yet to be determined.

The proposed LCT and LLB structures require further examination. The current LLB structure is particularly absent of experienced leadership that will possess the training, experience, and capacity required to analyze any supported battalion's engineer requirement or mass the engineer capabilities within the LLB current structure to execute engineer tasks beyond squad level. The Marine engineer community needs to be at the forefront of getting the MLR structure right, especially given the missions related to sea denial or sea control. The LCT and LLB engineer elements should be constructed on defined requirements, which in turn develop the list of capabilities that can then be appropriately manned and equipped. These elements will

[40] EABO units' missions and tasks are listed in the newly released 'Tentative Manual for Expeditionary Advanced Base Operations' (TM EABO): Pg A-2

be the base of engineer support for the MLR with the reach-back capability to a potential engineer regiment with broad capabilities to support the MLR when required.

Equipment and Training

Equipment. The loss of organic bridging capability needs to be addressed since the requirement to cross wet and dry gaps still exists. Before divestment, the Marine Corps employed the medium girder bridge (MGB) for dry gap crossings and improved ribbon bridge (IRB) for wet gap crossings as a bridge or raft.[41] These bridges required a large logistical footprint, and they are slow to install, making them and the engineers an easy target for the adversaries during construction. A typical bridging operation required more than 20 vehicles to move MGB or IRB assets and additional vehicles for transportation of supporting heavy equipment. IRB operations in the littorals are also limited in tidal rivers and swamps because extreme tide changes can lead to the beaching of a bridge. A beached IRB can only support foot traffic, making it ineffective and potentially impossible to recover for follow-on missions. The logistical support required to transport, construct, and littoral limitations made the MGB and IRB obsolete for the Marine Corps.

The Marine Corps only has two choices to deal with the lack of organic gap crossing capability. Either entirely rely on the U.S. Army for support or invest in developing new bridging technologies that better support the Navy and Marine Corps requirements. Relying on the Army does not resolve the limitations associated with utilizing the MGB and IRB. There are currently no directives or agreements between the two branches to provide bridging support unless it is a joint operation. The second choice is for the Marine Corps to develop new bridging

[41] Department of the Army, FM 5-34 Engineer Field Data, 2003 (Washington, D.C.), Chapter 10

technologies that reduce logistical requirements while increasing load capacity above the current systems.

Focusing on a system that could be employed by a squad or platoon size elements to support an MLR will be optimal. Systems that are modular in nature, lightweight, and easily transportable by air or naval connectors, can carry most wheeled or tracked vehicles within the MLR. There is various research on using composite materials for bridging in the civilian sector, especially for disaster response that have military applications. Composites can be used to improve or reinforce existing bridges to increase the Military Load Classification (MLC)[42], allowing them to carry heavier loads. There are technologies like fiber-reinforced polymer (FRP) bridge; they have a high strength to weight ratio and lighter than aluminum or other alloys. Another system is the Lightweight Expeditionary Bridge[43] by a company called HDT Global,[44] shown in (*Image 1)*, which is designed for dismounted troops and it can be deployed within 30 minutes by a squad of engineers. The system uses Rugged AirBeam® strut technology; it is less than 1,000 pounds and capable of carrying 2,400 pounds. The weight and modularity of a system like this greatly transform the engineer's ability to enhance mobility in support of EABO.

[42] Military Load Classification (MLC) is a system of standards used by NATO to classify the safe amount of load a surface can withstand. Load-carrying capacity is shown in whole numbers for vehicles, bridges, roads, and routes. Vehicles are classified by weight, type, and effect on routes.

[43] The Lightweight Expeditionary Bridge is carried on a single Squad Multipurpose Equipment Transport (SMET) vehicle and deploys across a gap in less than 30 minutes, providing rapid passage across obstacles for dismounted infantry and their SMET vehicles. Testing at the US Army's Jungle Operations Training Center showed that after two days of training, a Combat Engineer squad can consistently deploy the Lightweight Expeditionary Bridge in less than 30 minutes. Once the bridge is deployed, it can be left in place for follow-on forces or it can be recovered on the far side to accompany infantry forward.

[44] HDT Global is a company headquartered in Solon, Ohio.

Combat Engineers deploying bridge.

Image 1.

Another problem is Marine Corps engineers' strict reliance on boutique program of record equipment with no significant technical or tactical advantages from the available civilian equivalent. Some of the assets only restricted employment and limited operational flexibility of engineer equipment in expeditionary operations. Heavy equipment inventory is an excellent example; majority of engineer heavy equipment in the Marine Corps are just "military" versions of widely available civilian construction heavy equipment. Most are not specifically designed to solve problems unique to military engineering operations. An example is the Tractor/Rubber-tired/Articulated Steering/Multi-Purpose or (TRAM), which is a multi-purpose tractor used for material handling; it is necessary for general engineering support during daily or combat operations. The TRAM program of record is an example of costly equipment without a tactical advantage. The Marine Corps paid 47,000,000 dollars for 300 TRAMS[45] at 157,000 dollars per unit. A civilian equivalent of the tractor is the DEERE 624J, which could be acquired for 50,000 dollars per unit.[46] Even with that price tag, heavy equipment is not easily transportable by

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[45] Jennifer DeWitt. "Deere Gets Military Deal." The Quad City Times, Dec 10, 2006.

[46] www.machinerytrader.com

aircraft or naval connectors and are tied to military logistics and supply chains that can be easily disrupted in a contested area of operation. These challenges will slow down engineering operations and reduce the availability of engineer support.

One of the central ideas in the Marine Corps Functional Concept for Fleet Marine Force Engineering is, "FMF engineering capabilities must capitalize on the use of locally available resources, materials, and expeditionary/non-standard designs."[47] Marine engineers currently lack organic Contract Specialist (3044) or Contracting Officers (3006) military occupational specialty (MOS) within its formation like the Navy Seabees, reducing Marine engineers ability to leverage and employ Operational Contract Support (OCS) to shape the EABO battlefield. Required supplies, services, and construction material could be acquired from commercial sources in a host nation or adjacent countries to support operations, including most heavy equipment required for EABO because they are available globally. Using locally sourced equipment reduces logistical requirement and increase flexibility and speed. It will reduce the high cost of procuring commonly available equipment and associated maintenance requirements.

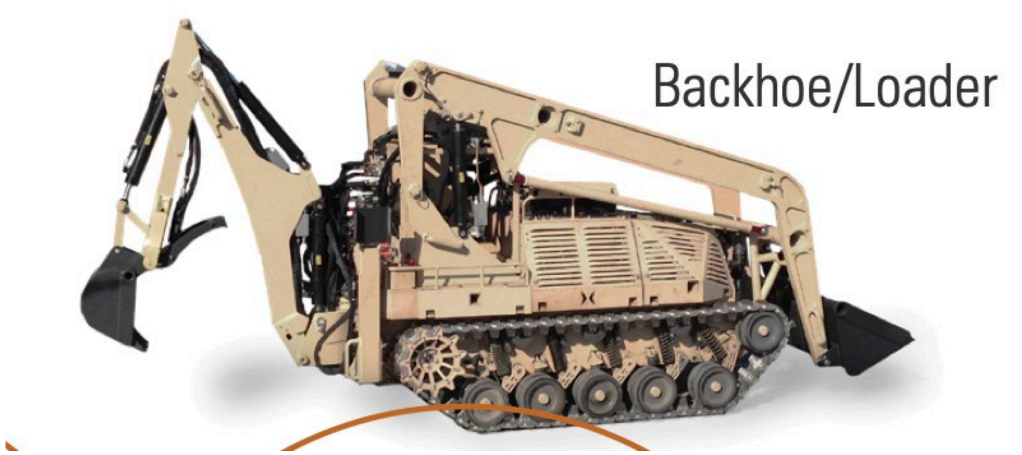

Image 2.

[47] Marine Corps Functional Concept for Fleet Marine Force Engineering (Washington, DC: HQMC, January 2020)

Acquiring multifunctional and compact assets to fit on aircraft or highspeed connectors will be vital to providing effective engineering support to units in Expeditionary Advanced Bases.[48] Marine engineers currently lack highly mobile, air-transportable heavy equipment like the Backhoe shown in (*Image 2)*. The Backhoe/loader is an example of a small, multi-purpose, lightweight equipment that can be airlifted with a squad of engineers to provide mobility, counter-mobility, and survivability support to elements of an MLR. Air mobility will be critical to personnel and equipment movement in an EABO, especially with the limited availability of high-speed naval connectors and gap crossing assets. As the Commandant divested tanks, bridges, and aviation assets, the Marine Corps engineers should divest certain legacy equipment that can be contracted globally. Just as the Commandant generated funds by divesting equipment, the funds recouped from the divestment of engineer equipment should be applied to new engineer capabilities and capacity that support new requirements.

Training. Distributed operations require officers, staff Non-Commissioned officers (SNCO), and junior Marines with more training, education, certifications, and leadership capabilities. Engineering is a broad discipline in the civilian or military environment; therefore, it is impossible to attend one school to obtain all the necessary skills to conduct engineering missions across the range of military operations. The current Marine engineer officer's training pipeline produces competent leaders capable of conducting mission analysis and advising battalion-level commands of engineering requirements, just as the SNCO education and training also produce quality engineer chiefs that are force multipliers. However, SNCO takes a longer time to educate over their career.

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[48] EAB is a working definition of a locality within a potential adversary's WEZ that provides sufficient maneuver room to accomplish assigned missions seaward while also enabling sustainment and defense of friendly forces therein. (TM EABO): Pg F-3

Marine Corps engineers lack geospatial engineer MOS or training in both officers' or enlisted engineers' education in comparison to U.S. Army engineers' structure. Marine engineer units also lack organic geospatial intelligence personnel or engineers capable of using mapping technologies like Remote sensing, Geographic Information Systems (GIS), and Global Positioning Systems (GPS) to map, aggregate, and analyze geographic data. This deficiency degrades commanders' ability to receive mission-tailored data, tactical decision aids, and visualization products that enable the commander and staff to visualize the operational environment.[49] Geospatial capability is not only required to assure mobility, counter-mobility, survivability, and general engineering; it is also essential to logistics, develop infrastructure, and build partner capacity required for EAB operations.

Training and subject matter expertise that engineers receive prior to filling critical billets in expeditionary units are crucial in the current or future operating environment. Engineers in the MLR or units conducting distributed operations should comprise of experienced and senior troops. They should be required to attend a variety of courses like Engineer Captains Career Course (ECCC),[50] or Expeditionary Warfare School (EWS)[51], Joint Engineer Officer Course (JEOC),[52] Explosive Ordnance Clearance Agent Course (EOCA),[53] Engineer Operations Chief (EOC),[54] Mountain Leaders Course (MLC) or Engineer Course,[55] or Jungle Operations Training

[49] Army Techniques Publication 3-34.80 "Geospatial Engineering" (Headquarters Department of the Army Washington, DC, February 2017) Pg V
[50] ECCC is a 21-week course for engineer Captains.
[51] EWS provides career-level, professional military education, and training to company-grade Marine officers and prepares them to lead in billets within the complex and distributed Naval expeditionary environment.
[52] JEOC focuses on joint engineer doctrine, service engineer capabilities, and how to use service engineer capabilities to support global engineering requirements.
[53] EOCA trains engineers and increase the force's ability to deal with UXO on the battlefield.
[54] EOC teaches supervisory and management level operational and planning skills in engineering related subjects pertaining to administrative, military briefing, mobility, MAGTF engineering, unit training and staff advisor functions.

Course (JOTC).[56] The schools listed above are not meant to be comprehensive, but they are some of the more complex and skill-enhancing schools available for engineers to attend. The Marine engineer community must evaluate and match required skills and qualifications to billets. A set of defined qualifications and education requirements produces a more professional force with credibility and the added ease in evaluating capabilities across the joint force. With the expectation for increased capabilities and level of experience, the Marine engineer community must consider increasing the ranks of Marines on the Table of Organization (T/O) critical billets or providing required training to Marines earlier in their careers, commonly referred to as grade shaping.

Integrating NMCB battalions into the Marine Corps engineering structure will fill some of the capabilities gap Marine Corps cannot fill in its training pipeline. NMCB Sailors are capable of a wide range of tasks, including constructing Advance Naval Bases (ANB), constructing an Expeditionary Advance Base (EAB), water well drilling, bridging operations, airfield damage repair, freshwater generation, quarry operations, general construction, pier damage repair and much more. They also have officers with Professional Engineering (PE) certification who can validate impromptu designs and bring operation-level capabilities to the Marine Corps.

[55] MLC trains students across the warfighting functions for operations in complex, compartmentalized, and mountainous terrain utilizing military mountaineering skills to enhance a unit's ability to shoot, move, communicate, sustain, and survive in mountainous regions of the world.
[56]JOTC focus on jungle mobility training, waterborne operations, combat tracking, jungle tactics, survival training, and situational training exercises at the squad level.

RECOMMENDATIONS

Naval integration is at the center of both Force Design 2030 and Marine Corps Functional Concept for Fleet Marine Force Engineering. Thus, a naval engineer structure such as the one shown in (*Figure 3* and *Figure 4)* will enable coordinated organization, training, and equipment solutions. It will also improve the interoperability of naval engineering. The structure which will work for I MEF and II MEF will be similar; however, the III MEF structure will be different. The Marine engineering structure should consolidate engineers under the MEF headquarters in a Regiment. The Regiment will comprise (1) Navy Mobile Construction Battalion (NMCB), (1) Engineer Support Battalion (ESB) with an organic Navy Mobile Construction Platoon (NMCP), and (1) Combat Engineer Battalion with an organic NMCP. The NMPC located in the CEB will consist of (3) Seabee Engineer Reconnaissance Team (SERTs) to provide engineering assessments in the field to support the battalion mission. The NMCP at ESB will only comprise (2) SERTs and robust construction staff. The intelligence section in each Battalion and Regiment should include a robust geospatial engineering cell capable of using mapping technologies like GIS and GPS to map, aggregate, and analyze geographic data within areas of operations.

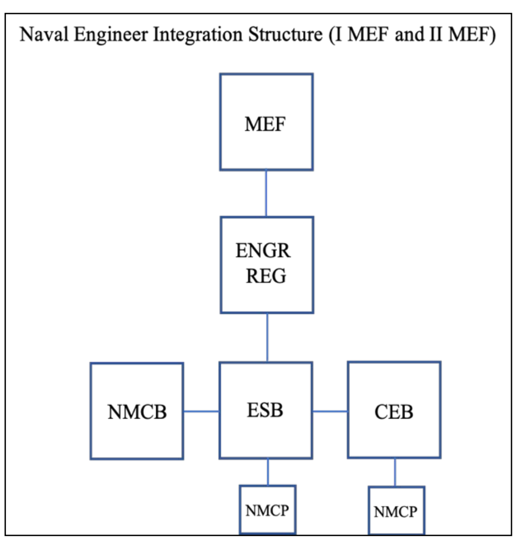

Figure 3.

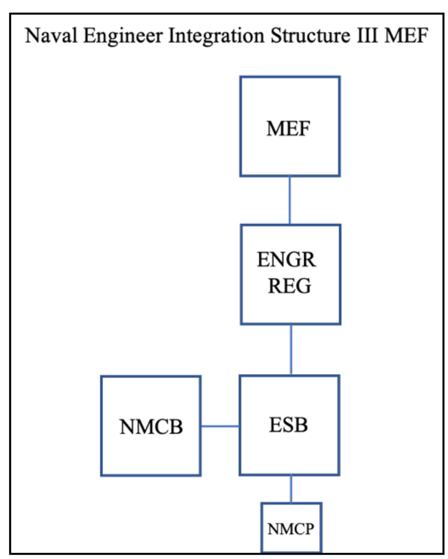

Figure 4.

Marine Corps engineer structure should include a 0-7 (Brigadier General) engineer "Superintendent" or "Director of Engineer Operations" position either at DC PP&O,[57] I&L,[58] or CD&I.[59] The General will be responsible for engineering capabilities in the Marine Corps, acting as the chief advocate for Marine engineers and arbitrate decisions within the community on behalf of the Commandant. The General will also coordinate engineering capabilities administratively or operationally across the MAGTF and the joint force. For example, the General can fill the billet of Assistant Deputy Commandant Installation and Logistics (Engineering) or as one of the directors at CD&I, specifically the Capabilities Development Directorate (CDD) position.

Development of Unmanned Underwater Vehicles (UUV) shown in (*Image 3*), either Remotely Operated Underwater Vehicles (ROUVs), which are controlled by a remote human operator, or Autonomous Underwater Vehicles (AUVs) is required to conduct rapid reconnaissance of adversary's obstacle and assessment and or reduction of mines. They are can also be equipped with sensors to accomplish geospatial intelligence tasks aiding the landing force. These systems are lightweight, low signature, easily deployable, and low cost in comparison to building new ships and crew costs. UUV's have the ability to be persistent in the littorals or loiter in areas of interest. They are also capable of detecting adversaries Sonobuoys[60] and destroying them. UUV operators can be trained across all naval engineer forces. Marine engineers and Navy Seabees can operate UUV to clear lanes for the MLR and escort other littoral vessels. UUV's will also reduce the demand on Navy and Marine EOD units because

[57] Deputy Commandant Plans, Policies & Operations
[58] Deputy Commandant Installation and Logistics
[59] Deputy Commandant Combat Development and Integration
[60] Sonobuoys are persistent sensors, sonar equip buoys capable of conducting underwater acoustic surveillance.

Marine engineers can be trained to use UUVs to interrogate and neutralize explosive obstacles or mines, supporting the Commandant's vision of enhanced capabilities while reducing cost.

Additionally, UUV's will enhance sea control capability for Naval forces. The United States should establish a clear policy regarding the use of sea mines for defensive and offensive operations. Naval mines are lawful, and the United States also should invest in advanced mining capability to allow DOD increased effectiveness and flexibility against adversaries.

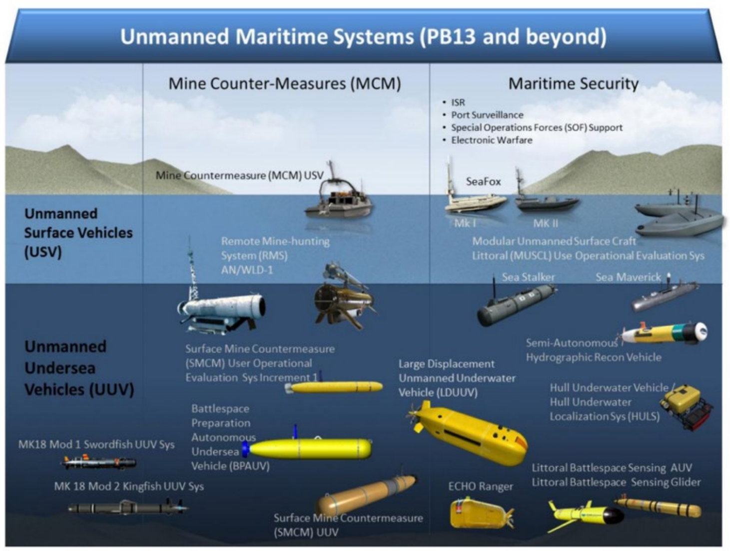

Image 3.

For total integration of Naval engineering to achieve the intended goals, the Chief of Naval Operations (CNO) and the Commandant of the Marine Corps should commission a study by the Center for Naval Analyses (CNA) to examine all Naval engineer capabilities[61] at all spectrum and echelons; laying out capabilities' distributions across the Naval forces like the example in (*Figure 5)* in order to identify duplications, gaps, and areas where new capabilities should be added.

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[61] Joint engineer capabilities should be considered.

Naval Engineer Forces Capabilties Distribution Example

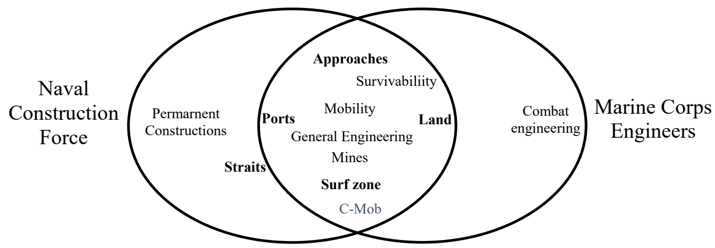

Figure 5.

CONCLUSION

This premortem of Marine engineering imagines that the engineering community has failed to provide support or solutions to engineering challenges that the service component or naval expeditionary forces will face. It is an opportunity to look forward and work backward to determine what could lead to failures if changes are not made to current ways of doing business and the effects of projected changes on the organization—the challenges.

Marine engineering disposition and its effects on the future operating environment will require detailed research of the different DOTMLPF components mentioned in this paper. This research was necessary because Marine engineer forces are crucial to extending persistent naval power into and from contested littorals, making it necessary to reinvent engineer support by moving away from the 1950s organization structure into new models that will achieve the core concepts laid out in the Force Design 2030 and the Tentative Manual for Expeditionary Advanced Base Operations. Integration of Navy and Marine engineers is one of the keys to achieving that goal. An integrated naval engineer force expands the engineering capabilities across the spectrum of engineer functions of Mobility, Counter-mobility, Survivability, and General engineering.

Implementing changes in a large organization is challenging and slow. The Commandant using Force Design 2030 as a forcing function has been effective; however, engineers cannot solidify any plans or implement changes until the operational requirements of supported MAGTF to include the newly designed MLR are defined. Despite this challenge of ill-defined requirements, the Marine engineer community is at the forefront of Force Design, more so than other MAGTF elements in implementing the vision for future naval force employment. The Marine Corps Functional Concept for Fleet Marine Force Engineering is proof of engineers leading the way as it was one of the first concepts to be signed by Deputy Commandant, Combat Development and Integration. Whatever decision the Marine Corps makes today will impact engineer effectiveness in support of EABO for the next twenty or more years once funded and implemented.

Although documents like the Marine Corps Functional Concept for Fleet Marine Force Engineering and The Tentative Manual for Expeditionary Advanced Base Operations are both nested, other MAGTF elements have yet to define their requirements. Even though the community has executed multiple working groups to address the loss of structure and support to the MLR, engineers cannot solidify any plans or implement changes until the operational requirements of supported MAGTF elements are better defined.

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