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Marine cannon artillery is not, at present, properly equipped or trained to support the force on the modern and future battlefield against a near-peer competitor. Marine artillery overcommitted to the use of digital systems without adequately committing to developing a more robust precision capability. At the same time, it de-emphasized manual methods of fire mission processing that are vital when signatures produced by robust digital capabilities must be avoided. This led to a community that lacked the overall capability to fully support the ground combat commander on the modern or future battlefield.

By fully committing to the development and implementation of alternate methods of precision, such as laser guided munitions, and recommitting to the sustainment of manual non-digital methods of fire mission processing, Marine artillery can provide the ground commander with a more capable and effective asset on the modern and future battlefield.

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Marine Corps Artillery and Essential Steps to Support the Future Force

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Executive Summary

Title: Marine Corps Artillery and Essential Steps to Support the Future Force

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Thesis: By fully committing to the development and implementation of alternate methods of precision, such as laser guided munitions, and recommitting to the sustainment of manual non-digital methods of fire mission processing, Marine artillery can provide the ground commander with a more capable and effective asset on the modern and future battlefield.

Discussion: The modern and future battlefield of the 21st century is characterized by the requirement for precision fires and is dominated by technology. It is comprised of complex urban terrain that is plagued with collateral damage concerns, and it requires modern military forces, including Marine cannon artillery, to possess a robust precision capability to remain effective. Conversely, because a near-peer enemy will have the ability to either negate digital systems or use their electronic signatures as a means of targeting, Marine artillery must have the ability to seamlessly transition to operations without the assistance of these systems to manage and reduce its overall digital signature.

In an effort to keep pace with the battlefield's modernization and ensure its ability to continue to effectively support the ground combat commander, Marine cannon artillery enhanced its current capabilities. Unfortunately, the way in which Marine cannon artillery developed, impacted by its habitual relationship with the Army, failed to result in a more lethal and effective fighting force.

The most significant Marine Corps documents designed to shape the force (the MOC and QDR) agree that precision and the ability to operate with or without current and advanced technology are emerging requirements. Currently the only true Marine cannon artillery precision capability is the GPS-guided Excalibur munition, which in a technology degraded environment, will have limited effectiveness due to its reliance on GPS. Marine artillery overcommitted to the use of digital systems without adequately committing to developing a more robust precision capability. At the same time, it de-emphasized manual methods of fire mission processing that are vital when signatures produced by robust digital capabilities must be avoided. This led to a community that lacked the overall capability to fully support the ground combat commander on the modern or future battlefield.

Conclusion: Marine cannon artillery is not, at present, properly equipped or trained to support the force on the modern and future battlefield against a near-peer competitor, but can, through the steps indicated above, emerge as a far more effective weapon system.

DISCLAIMER

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

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MOC - Marine Operating Concept

QDR - Quadrennial Defense Review

IA - Individual Augment

RAP - Rocket Assisted Projectile

DFCS - Digital Fire Control System

GPS - Global Positioning System

PRC - Portable Radio Communications

DPICM - Dual Purpose Improved Conventional Munition

AFATDS - Advanced Field Artillery Tactical Data System

PGM - Precision-guided Munitions

EPIAF - Enhanced Portable Inductive Artillery Fuze Setter

FDC - Fire Direction Center

JTAC - Joint Terminal Attack Controller

JFO - Joint Forward Observer

LTD - Laser Target Designator

MCCRE - Marine Corps Combat Readiness Evaluation

MTVR - Medium Tactical Vehicle Replacements

MTAR - Moving Target Artillery Round

SAL - Semi-Active Laser

ITX - Integrated Training Exercises

T&R - Training and Readiness

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Preface

As an artilleryman who has had the opportunity to hold every officer billet in an artillery battery and operated in both garrison and combat, my estimation of the current state of Marine artillery reflects that of a ground-level view. This view enabled me to gain a firsthand appreciation of the end results of institutional-level decisions that have had long-lasting effects within the Marine artillery community. Ultimately, I am concerned that the potential for Marine artillery to become less effective and eventually obsolete is quickly becoming a reality. However, based on research that was driven by my professional experiences, I quickly developed the view that Marine artillery has an opportunity to overcome institutional challenges and develop into a more significant and effective capability for the ground commander on the modern and future battlefield. With this body of work, I intended to provide an understanding of the elements leading to Marine cannon artillery's current ineffectiveness and provide tangible solutions that will resonate with Marine leadership who have the ability to influence changes to the status quo.

In pursuit of this Master's of Military Studies and throughout my research, I quickly gained a new passion for Marine artillery and its future potential, as both a Marine officer and a professional artilleryman. I'd like to thank my wife and three children for their patience and support throughout this process. Frustration regularly tested my commitment, and I have my family to thank for the completion of this research. I would also like to acknowledge those that have provided guidance and mentorship throughout this process, Dr. James Joyner, LtCol Rodrick McHaty, LtCol Bradley Pennella, and Dr. John Gordon. Their guidance and experience were paramount in helping me develop a product that can have a meaningful contribution to the Marine artillery community.

"The Marine Corps is not currently organized, trained and equipped to face a peer adversary in the year 2025."

General Robert B. Neller, United States Marine Corps

Commandant of the Marine Corps

"[T]o be detected is to be targeted is to be killed…[n]o matter the means of detection, unmanaged signatures will increasingly become a critical vulnerability*."*

The Marine Corps Operating Concept

I. Introduction

The modern and future battlefield of the 21st century is characterized by the requirement for precision fires and is dominated by technology. The *Quadrennial Defense Review* (QDR)[i], published in 2014, clearly states that the current "operating environment is increasingly enabled by technology," and calls for "prioritizing the ability to strike with precision ."[1] More recently, the *Marine Corps Operating Concept* (MOC)[ii] describes the modern and future battlefields as being comprised of densely populated, urban terrain constrained by collateral damage concerns, and where technology not only increases lethality but also vulnerability.[2] The MOC also states that the force must be "flexible, and versatile."[3]

[i] The QDR was a document published by the Secretary of Defense in 2014 and was meant to facilitate meaningful changes within the United States military in order to prepare it to combat future enemies. It has been superseded by a new National Security Strategy and National Defense Strategy, and Congress has replaced it in law with Defense Strategic Guidance. Although superseded, much of substance found within the QDR was replicated within the MOC and concepts found within the QDR remain relevant today.

[ii] The MOC is a document published by the Marine Corps in 2016 at the direction of its current Commandant (General Robert Neller) and is designed to act as a guiding function for the development of the 21st century Marine Corps. It specifically builds on the Marine Corps' previous guiding document, Expeditionary Force 21 and the QDR.

Flexibility requires the ability to operate in any environment regardless of the physical or technological constraints. Versatility and lethality come with the development of weapon systems with robust capabilities, specifically a precision capability, which can destroy an increasingly wide range of targets.

As a traditional tool used to deliver these capabilities, Marine artillery must have the ability to harness advanced technology while at the same time be prepared to operate effectively without it, whether because the adversary is denying GPS capabilities or because of a conscious decision to operate without technology to avoid signature targeting.

At present, Marine cannon artillery is not properly equipped or trained to support the force on the modern and future battlefield against a near-peer competitor. It lacks the necessary robust and redundant capabilities to effectively fight a near-peer enemy. Its GPS-based precision-guided munitions are fielded in limited quantities and potentially vulnerable to enemy denial efforts. Additionally, GPS-based munitions provide limited effectiveness against mobile, armored targets. Conversely, if the community over-relies on digital capabilities it will leave it unprepared for an operating environment in which the adversary denies these capabilities. By fully committing to the development and implementation of alternate methods of precision, such as laser guided munitions, and recommitting to the sustainment of manual non-digital methods of fire mission processing, Marine artillery can provide the ground commander with a more capable and effective asset on the modern and future battlefield.

An argument can be made that Marine cannon artillery de-emphasized its traditional ability of operating using manual methods of fire mission processing in favor of digital, technologically advanced capabilities. But this came at a price, by overemphasizing technology traditional manual methods atrophied. This left the community training to a capability it needs to

possess, while simultaneously becoming less proficient in a traditional capability it must own. Marine cannon artillery community has to find a balance between the two juxtaposed capabilities in order to support the ground commander regardless of the environment. This demands Marine cannon artillery to be capable of quickly reverting to its roots and support maneuver on a technologically degraded battlefield while continuing to embrace new technology. In order to further develop advanced technology, Marine artillery must continue to leverage its beneficial relationship with the Army in terms of research and development, and yet, advance to new levels on its own. [iii] However, due to the Marine Corps's unique expeditionary role, this may mean conducting independent research and development when the two service requirements diverge.

An understanding of Marine cannon artillery's current situation and the viable solutions requires a discussion of an evolving battlefield and essential actions for Marine artillery to take to remain effective. There are two seemingly contradictive requirements at play: First, to develop cannon artillery that takes full advantage of its technological capabilities perusing additional precision munitions; and second, to simultaneously remain proficient in manual, non-digital procedures of the "traditional" sort. The following is a brief analysis of key Marine artillery developments that were heavily impacted by Marine artillery's historic and beneficial relationship with the Army. Additionally, the essay provides a way ahead through the development and regular implementation of precision guided munitions (specifically laser guided capable ammunition), and a recommitment to proficiency with non-digital fire mission processing methods as a means to increasing Marine artillery's effectiveness and lethality. Finally, a strategic approach to implement these necessary changes is provided.

[iii] For a detailed history of Marine Corps artillery's relationship with the Army, see Carson, Michael T. "Marine and Army Artillery: Forging a Lasting Relationship." *Field Artillery* no. 4 (Jul, 1999): 18-23. https://search-proquest-com.lomc.idm.oclc.org/docview/231240038?accountid=14746.

II. The Current State

A point of challenge has been the period of restructuring during times of fiscal constraint following the wars in Iraq and Afghanistan.[4] This period came on the heels, as some would argue, of a "lack of focused core artillery training"[5] as a result of the artillery community assuming the majority of *Individual Augment* (IA) and *In Lieu of* missions in Iraq and Afghanistan.[iv] The current situation demands that Marine artillery must effectively support the force on modern and future battlefields by developing a robust and redundant precision capability, while yet, as indicated previously, simultaneously maintaining proficiency in manual, non-digital methods of fire mission processing. This begs the question, why commit to developing precision, which is enabled by technology, while simultaneously focusing on maintaining proficiency in unsophisticated, non-digital processes? It would seem that one capability would effectively replace the other. The answer lies in the evolution of the battlefield.

a. Evolving Battlefield

Historically, the military force capable of bringing to bear a greater combination of lethal fires more rapidly than its enemy could with a reasonable amount of certainty expect to be victorious. During the Napoleonic Wars for instance, artillery "transformed from a specialized profession overseen by 'mechanics,' into a major service branch capable of dominating battlefields."[6] Major General Robert H. Scales, Jr., USA, the 44th Commandant of the U.S.

[iv] In Major Slinger's thesis, he argues that because Marine artillery had to focus on preparing for IA and In Lieu Of missions, it lost its ability to adequately train to core artillery Mission Essential Tasks. This resulted in an atrophy of a perishable skill losing touch with the current needs of the ground commander. Recent (post major combat operations in Iraq and Afghanistan) fiscal constraints may also be a contribution factor. Of the Navy's approximately $171 billion budget for fiscal year 2018, the Marine Corps will receive $26 billion of that. This is compared to the Army and Air Forces fiscal year 2018 budgets of approximately $137 billion and $165 billion respectively. See Department of Defense, *Highlights of the Department of the Navy FY 2018 Budget* (Washington, DC: Office of Assistant Secretary of the Navy; Financial Management and Comptroller, 2017), 1-7.

Army War College, recognized superior firepower in World War II as a key factor in "a series of quick and decisive victories" for the United States and a focal point for the Japanese defense of Okinawa when they "recognized that they could not match American firepower."[7] Likewise, during the Korean War, "the Spring 1951 offensive mounted by the Chinese sputtered to a halt" due to superior American artillery.[8]

As the battlefield evolved, the weaponry required to secure success was also forced to evolve. Modern enemies began utilizing the battlefield's growing urban composition to their advantage as a way of negating superior firepower. According to the MOC, one of the key aspects of the modern battlefield is "Complex Terrain," which is defined by "crowded" areas where "collateral damage in highly urbanized areas will be difficult to avoid."[9] This leads to the requirement to fully commit to a robust precision capability supported by technological advancements, including but not limited to digital systems.

On the evolving battlefield, technology can also become a vulnerability. As a future near peer enemy may have the ability to target through electronic signature, the MOC states that "units will need to adapt how they fight, emphasizing emissions control and other means of signature management to increase their survivability."[10] This potential reality points directly to the requirement to maintain Marine artillery's core competency of being able to execute fire missions using non-digital methods, thereby preventing a large, detectable electronic signature. The QDR accurately sums up these two seemingly contradictory requirements when it states "we need to begin to move away from traditional platforms and methods, without sacrificing the benefits of our current posture and capability set."[11]

III. Managing Marine Artillery Developments & Requirements

Marine cannon artillery has been enhancing its capabilities in an attempt to remain effective on this evolving battlefield. This initially included improving its primary weapon system from the M101 to the M198 to increase overall range, lethality, and mobility, and was followed by incorporating advanced technology in the M777 ultimately enabling the development of a precision capability.

Many of Marine artillery's largest developments were either procured after the Army fully developed and fielded the equipment or developed in conjunction with the Army - usually as the junior partner. "As the nation's expeditionary force-in-readiness, the Marine Corps must maintain itself for immediate employment in 'any clime and place' and in any type of conflict."[12] Capabilities that may work within the Army's construct may prove less suitable for the Marine Corps. The Army is heavier, larger, and is designed to execute sustained operations. Therefore, the capabilities it develops are inherently just as heavy and large. Conversely, expeditionary in terms of the Marine Corps equates to a "Force in Readiness… forward-deployed and forward-engaged… responding to all manner of crisis and contingences… alert and ready… responsive and scalable," and most importantly, "light enough to get there quickly, but heavy enough to carry the day upon arrival."[13] The Commandant of the Marine Corps, General Robert Neller, succinctly defines the Marine Corps's expeditionary mindset in his Marine Corps 101 presentation by identifying the Marine Institutional Ethos as "Warfighting Philosophy over Warfighting Methodology."[14] Marine artillery's relationship with the Army certainly contributes to it achieving the United States military's overall Warfighting Methodology. However, the Marine Corps's expeditionary warfighting philosophy requires capabilities be developed to directly support this unique role.

Instead of developing capabilities driven by the emerging characteristics of the modern and future battlefield to support this expeditionary role, the relationship provided Marine artillery with the ability to continue to rely on the Army. In turn, the Marine Corps optimized Army designs to support a Marine Corps mission. The procurement of the M198 is an example of this. The M777, conversely, provides an example of a weapon system that the Marine Corps played a more active role in developing.

a. <u>M198 & M777 155 Howitzers</u>

A considerable development within Marine Corps cannon artillery in the modern era was the procurement of the M198 155mm howitzer in fiscal year 1981 (see figure 1).[15] The M198 howitzer provided the Marine Corps with a medium weight, large caliber, towed howitzer with extended range and greater destructive power. It increased the max range of support out to 22.5km when firing conventional HE 155 mm shells, almost doubled the range of the M101A1[v] with a max range of 30km when firing the newly developed Rocket Assisted Projectile (RAP), and was more accurate due to its modernized sites and laying procedures.[16] However, the Army developed the M198 with its mission, capabilities, and strengths in mind, none of which truly complemented the Marine Corps's lighter, more agile identity; the Marine Corps simply made it fit within its mission. The M198 was too large and heavy - the M198 weighed in at nearly 16,000lbs[17] - and never suited the Marine Corps's primarily expeditionary role. MajGen Leslie M. Palm, USMC (Ret) reaffirms this point with his statement that this development was "when Marine artillery gave up its expeditionary capability."[18]

[v] The M198 155mm howitzer eventually replaced the World War II era M114A2 155mm towed howitzer as well as the M101A1 105mm towed howitzer, however, Marine general support battalions maintained these older weapon systems, along with 8 inch self-propelled howitzers and 175mm self-propelled guns, in the beginning of Desert Shield/Desert Storm.

Figure 1 (M198 155mm howitzer) [vi]

Figure 2 (M777 155mm howitzer) [vii]

Even prior to Operations DESERT STORM and ENDURING FREEDOM, available technology was quickly rendering the M198 obsolete for both the Army and the Marine Corps. The M198's non-digital systems limited artillery's ability to develop a robust precision capability, which was becoming more of a requirement as the modern battlefield emerged. The ability to fully incorporate digital systems on towed artillery pieces became mainstream with the M198's replacement, the M777 (see figure 2), which the Marine Corps took a leading role in developing. Unique to the M777's development, it was "a joint program between the Marine Corps and the Army."[19] Both the service and Department of Defense recognized the need for the Marine Corps to play an active role in developing a weapon system specific to its intended mission set. Evidence of this is the Joint Program Manager's comments in 1995: "the Marine Corps has a valid, approved, high priority requirement for an advanced towed lightweight 155mm howitzer that meets increased operational thresholds."[20] The M777 was lighter (the M777 weighed in at just under 9,000lbs), more maneuverable, and had a smaller footprint.[21] Subsequent models of the M777 would contain a Digital Fire Control System (DFCS), a Global

[vi] Aaron Skinner, "Trumpeter 1/35 scale M198 155mm Towed Howitzer (Early Version)," FineScale Modeler, http://www.finescale.com/product-info/kit-reviews/2009/08/trumpeter-1-35-scale-m198-155mm-towed-howitzer-early-version.
[vii] "M777 Howitzer | Things You Should Know About It," GoSSB, http://www.gossb.com/m777-howitzer-things-know/.

Positioning System (GPS), and a PRC119 Harris radio - which facilitates digital communications. The Marine Corps now had in the M777 an expeditious, state-of-the-art, indirect fire platform capable of supporting the development of a robust precision-guided capability. However, more is needed to ultimately ensure this improved weapon system, its advanced technology, and its precision capabilities are fully leveraged.

The M777 was outfitted with an improved DFCS, which tied in to the Advanced Field Artillery Tactical Data System (AFATDS). The AFATDS is a computer and software program that enables automated fire mission processing and data transmission. The AFATDS digitally connected the weapon system to the modern battlefield, enabled faster fire mission processing, and ultimately would support future advanced precision weapons, such as the XM982 Excalibur.[22] The AFATDS also had the ability to remove human error from fire mission processing. A potentially significant causal factor behind Marine artillery *firing incidents* is the inaccurate transmission of firing data from the Fire Direction Center (FDC) to the gunline. Without a capability like the AFATDS, firing data is transmitted from the FDC to the gunline via voice over a radio. Unfortunately, this leads to the potential for Marines to either transmit and/or receive incorrect firing data by simply misunderstanding each other. With the AFATDS, data is digitally sent from the FDC directly to the howitzer. Assuming the FDC enters the correct data into the AFATDS, human error is removed from the equation. Additionally, the AFATDS can transmit the appropriate data to multiple howitzers simultaneously, thus decreasing the time it takes to process fire missions.

Currently, Marine artillery focuses less on the manual, non-digital methods of executing fire missions in lieu of the M777's digital and technologically advanced systems. In the current Artillery Training and Readiness (T&R) manual, for example, none of the *collective* 4000 level

evaluated events that the Fire Direction Center is required to execute dictate the use of manual methods.[23] While the T&R manual does require degraded operations, it is only at the individual level, as opposed to the collective level.[24] The T&R manual gives the firing unit the option to execute missions utilizing manual or automated methods. Additionally, there are no *E-coded events*[viii] that require the use the degraded methods.[25] Arguably, this focus on available digital systems - such as the AFATDS - was because they had the *potential* to mitigate human error and to speed up mission processing, not to support a robust suite of advanced munitions. Unfortunately, with the focus being on digital fire processing methods there is the clear potential for firing units to quickly atrophy skills in degraded methods.

b. <u>The Precision Requirement</u>

Marine artillery leadership needs to take this state-of-the-art weapon system and develop more munitions to support its precision potential. It needs to face the emerging precision requirement head on and fully commit required funding and personnel to its solution. Marine artillery fielded its first precision munition, the laser guided M712 Copperhead, in 1981,[ix] but discontinued its use after Desert Storm.[26] As a replacement for the Copperhead, it adopted only a single true precision capability, the XM982 Excalibur, since the M777 came online over thirteen years ago. The Excalibur is capable of striking a target within two meters at ranges of up to forty kilometers.[27] Unfortunately, due to its reliance on GPS satellites and a fully digitally capable M777, the Excalibur is not ideal in a near-peer fight - this is specifically centered around

[viii] "An 'E-Coded' event is a collective T&R event that is a noted indicator of capability or, a noted Collective skill that contributes to the unit's ability to perform the supported MET. As such, only 'E-Coded' events are assigned a CRP value and used to calculate a unit's CRP." See Headquarters US Marine Corps, *Artillery Training and Readiness Manual*, NAVMC 3500.7B (Washington, DC: Headquarters US Marine Corps, June 18, 2015), B-3.

[ix] The M712 Copperhead was only in production from 1981 to 1984; the Army and Marine Corps only purchased 7,695 rounds. See Patrick Cooley, "Area Fire Weapons in a Precision Environment: Field Artillery in the MOUT Fight," (unpublished essay, last modified January, 2005), PDF file, Marine Corps Center for Lessons Learned, 3, https://www2.mccll.usmc.mil/index.cfm?disp=IDOL/myIdolSearch_XML.cfm.

the enemy's ability to target digital signatures. Outside Excalibur, Marine cannon artillery has only invested in *near precision*[x] munitions, such as the GPS assisted, M1156 Precision Guidance Kit[xi] (PGK); however, its reliance on GPS limits its effectiveness on a future battlefield similar to Excalibur.[28]

The M777's fielding took place during combat operations in Iraq and Afghanistan, and both theaters validated the requirements for precision fires. The first 155mm true precision munition, which had the added benefit of anti-armor capability, the laser guided Copperhead, proved to be a highly effective weapon throughout its sporadic use in Operation DESERT STORM.[29] With the collateral damage concerns that the MOC currently addresses becoming more and more of a reality in early Iraq and simultaneous to the M777's fielding, Marine artillery would have been well suited to commit to further developing weapons such as the proven Copperhead. Unfortunately, it was complicated to employ and had a relatively high cost. [30] Additionally, due to a firing report issued by the Commander of U.S. Army Joint Modernization Command in 2004 requiring remaining Copperhead munitions be fired in ballistic mode, thus negating the precision capabilities of the munition, both the Army and Marine Corps discontinued it use.[31]

While Copperhead provided the Marine Corps with a precision, anti-armor capability, the Marine Corps adopted the Dual Purpose Improved Conventional Munition (DPICM) munition because of its lower cost ease of use. Unfortunately though, the DPICM proved to be a dud

[x] The M1156 PGK is designed to be accurate within 50 meters versus the 10 meter requirement for true precision. See J.R. Wilson, "Steel on Target: JM&L LCMC Delivers Precision Munitions for the Warfighter," *Defense Media Network*, last modified January 6, 2011, https://www.defensemedianetwork.com/stories/steel-on-target-jml-lcmc-delivers-precision-munitions-for-the-warfighter/.

[xi] The M1156 PGK is designed to increase the accuracy of a standard high explosive ballistically guided munition with the addition of a specialized fuse that replaces the standard fuse. This fuse has the ability to acquire a GPS grid coordinate and track to a target with the assistance of canards that extend from the fuse.

producing munition creating obstacles for maneuver and a danger to civilian populations following hostilities. In terms of a true precision replacement for the Copperhead, Marine artillery settled for a single solution in the GPS guided Excalibur munition and near precision fuses such as the PGK.[32] All of these munitions were again developed by the Army and adopted by the Marine Corps and utilized GPS as its source of guidance.

Ultimately, the Marine Corps developed the M777 as much for its lighter weight, smaller footprint, and resulting increased agility as for its ability to support future technologies such as precision munitions. Marine artillery correctly recognized that the technologically advanced M777 had the ability to increase its effectiveness on the modern and future battlefield, as it not only met its unique mission requirements, but it also supported the expansion of alternate true precision capabilities. Unfortunately, based on the evolving modern battlefield, having a sole GPS based precision capability creates a critical vulnerability for Marine artillery. To achieve this, however, decision-makers need to commit to developing alternate methods of attaining precision capabilities in order to counter the growing enemy threats.

IV. Solutions to Support the Force

To this point, this essay has identified why Marine artillery is unable to support the force on the modern and future battlefield. This included a brief explanation of how Marine artillery failed to manage two seemingly competing interests (developing a robust precision capability while simultaneously maintaining proficiency in manual, non-digital methods of fire mission processing) as the modern and future battlefield developed, and an understanding of several key developments undertaken by Marine artillery. The essay also explained how Marine artillery's relationship with the Army impacted developments. Now, how does Marine artillery become a

more effective and complete capability for the ground commander on the modern and future battlefield?

The development and implementation of a robust precision capability, beyond GPS, must become a priority. Additionally, the Marine artillery community must embrace operating in a technology denied environment by training to manual methods of fire mission processing. Reinforcing manual methods of fire mission processing ensures Marine artillery remains capable of supporting the ground combat commander in a technologically degraded and/or denied environment. Ultimately, by fully committing to the development and implementation of alternate methods of precision, such as laser guided munitions, and recommitting to the sustainment of manual non-digital methods, Marine artillery provides a more capable and responsive asset to the ground combat commander in the modern maneuver and precision centric battlefield as well as in a digitally and technologically degraded environment.

a. <u>Commitment to Precision Guided Munitions</u>

The precision requirement is more prevalent on the modern battlefield than it ever has been. A cursory search of any modern military operation, Operation ENDURING FREEDOM for instance, will certainly confirm this.[33] While the enemy the United States encountered in Afghanistan was far from near peer, the environment it operated in was certainly complicated by collateral damage concerns and required precision munitions. Mark F. Cancian, a retired Marine Reserve colonel and a senior adviser with the CSIS International Security Program, contends:

> Future joint operations will be increasingly discriminate to minimize unintended consequences. The increased transparency of the future security environment, where digital devices will be everywhere, heightens the need for force to be used precisely when possible … In the saturated information environment of tomorrow, even minor lapses in conduct or the application of fires could seriously damage the international reputation of the United States…With precision, munitions become more important than the platform.[34]

According to retired Army Major General David C. Ralston, previously the Chief of Field Artillery, "force commanders require, and have asked for, precision indirect-fire capabilities, and the field artillery is committed to providing these capabilities tactical precision-guided munitions (PGMs)."[35] Marine artillery needs to commit to providing this capability, just as the General states.

That's not to say that the artillery community does not need to have the ability to mass large amounts of conventional fires when required. Unguided munitions still have a place on the modern and future battlefield, but as stated within the "*Joint Capstone Concept,"* that role is subordinate to precision and a fall back when precision is unachievable.[36] Marine artillery should reduce the amount of unguided munitions purchased in support of combat operations and replace that allocation with a more developed precision guided capability, in addition to the current GPS capability. J.R. Wilson, previously an editor with Janes Information Group, confirms that "with greater accuracy enabling first-round target engagement without the need for adjusting onto the target, initial expectations were that the increased use of precision and near-precision artillery also would mean fewer rounds needed overall".[37] As this essay has detailed the driving factors behind the requirement to develop a more robust precision guided capability, driven entirely by the need to better support the force on the modern and future battlefield, a discussion specifically about laser guided munitions is appropriate at this time. First and foremost, the capabilities of any developed laser-guided munition should match that of the Excalibur in terms of range, lethality, and accuracy. Arguably, this can effectively result in a net gain in regards to effectiveness on the modern and future battlefield for Marine cannon artillery.

As discussed, an opportunity exists for Marine artillery to increase its effectiveness on the modern battlefield by increasing its precision capability, specifically a laser guided variant. It is

important to note that the Marine Corps must look at this capability as an addition to the current GPS capability versus a replacement for it. A laser guided munition can deliver the same results as the current GPS guided munition but with added benefit. Laser guided munitions do not require complicated digital systems to employ and provides additional anti-armor and moving target capabilities.

Excalibur, one of the most sought after and effective 155mm munitions employed on the current battlefield due to its precision,[38] requires a robust technologically advanced suite to employ. Requiring firing data for a mensurated[xii] ten-digit grid prior to firing, the howitzer Section Chief must set the fuse of an Excalibur with an Enhanced Portable Inductive Artillery Fuze Setter (EPIAF)[xiii] that must receive the targeting data via an electronical signal sent from the AFATDS in the Fire Direction Center (FDC). Unfortunately, this process means that the howitzer and associated FDC must be fully digitally capable and increases the amount of time to fire a round.

A laser guided round on the other hand, has limited electronic and digital constraints compared to the Excalibur. A howitzer section can potentially fire a laser guided round in the same fashion as a standard round, with the round subsequently acquiring the laser energy along its flight path. Because a laser guided munition would not require complex digital systems for its employment, there is a potentially significant advantage: a unit can employ the munition even if they are in a technologically degraded environment where digital signatures must be avoided.

[xii] Grid mensuration is a process of refinement that increases overall accuracy of a given grid location. For a detailed discussion of grid mensuration, see Matthew J. Day, "Application of Mensuration Technology to Improve the Accuracy of Field Artillery Firing Unit Location," (master's thesis, U.S. Army Command and General Staff College, 2013), 35-38, Defense Technical Information Center, http://www.dtic.mil/dtic/.

[xiii] For detailed understanding of the EPIAF, see Tom Walker, *Enhanced Portable Inductive Artillery Fuze Setter (EPIAFS),* (Armament Research Develop Engineer Center, Picatinny, NJ, May 10, 2006), PowerPoint presentation. https://ndiastorage.blob.core.usgovcloudapi.net/ndia/2006/fuze/walker.pdf.

In terms of lethality and destruction, the majority of current laser guided munitions are designed to be used against enemy armor or to penetrate hardened surfaces and can engage both stationary and moving targets. While Excalibur has a limited ability to penetrate hardened surfaces by configuring its fuse to operate in *delay* mode, it is restricted to stationary targets. The Excalibur does not have the ability to update target location after being fired. Conversely, a laser guided munition has the ability to correct its flight path if the laser energy it is seeking begins to move, while tracking a moving vehicle for instance. The United States' ability to effectively "engage moving armored targets like tanks and personnel carriers" during the war in Iraq is equated to the use of laser guided munitions.[39]

An advantage to acquiring laser guided munitions at this point is that the other half of the equation already exists. As one of the most widely utilized munitions on the modern battlefield, the battlefield is currently flooded with ground and aviation-based laser targeting capabilities. Whether it is a Joint Terminal Attack Controller (JTAC) or Joint Forward Observer (JFO) with a handheld laser designator, or an aircraft with a Laser Target Designator (LTD), the technology required to effectively designate the target exists and is widespread. Developing a realistic 155mm artillery laser guided capability will only increase Marine artillery's overall effectiveness on the modern and future battlefield. It will provide Marine artillery with an additional precision capable munition that gives it the versatility to engage both hardened structures and armor, whether stationary or moving, in either a technologically permissive or degraded environment.

In addition to accuracy and lethality that come with laser guided munitions, there is also the desire to decrease the logistical tail.[40] Laser guided munitions, and precision guided munitions as a whole, decrease the overall logistical requirement, footprint, and burden on a firing unit when compared to that of standard munitions. This is paramount when engaging a

near peer enemy that will actively seek to target extensive supply lines on the battlefield. Because one precision guided munition can deliver similar results to as many as ten standard munitions due to its accuracy, the amount of ammunition a firing unit must maintain and the rate at which it must be resupplied significantly decreases.[41] This can reduce a firing unit's footprint and make target acquisition for the enemy more challenging.

Currently, a Marine artillery battery requires seventeen Medium Tactical Vehicle Replacements (MTVRs) just to move the howitzers and required amount of ammunition for a battery to be effective. [xiv][42] By decreasing the amount of ammunition required to remain effective, a Marine firing battery can operate with fewer MTVRs. Due to operating fewer trucks, this leads to decreased fuel consumption and maintenance requirements, and less frequent resupply operations. Simply increasing the efficiency of each round fired through increased precision capabilities, would reduce the potential impact on logistics, one of the largest planning considerations for any military operation.

Along with the price of the individual round, a majority of the cost associated with the execution of artillery operations is centered around logistical requirements: fuel and maintenance. As just discussed, the implementation of laser guided munitions will have an overall positive impact in terms of logistical costs. Cost per unit is the most lopsided aspect of gaining a laser guided capability at this point. However, in fiscal year 2019, the Marine Corps will spend approximately $218,363,037 more on standard munitions than on Excalibur to fulfill the projected requirement to support both training and combat operations.[43] The argument is that the Marine Corps can reinvest a portion of that $218,363,037 into the development and procurement of additional precision capabilities, therefore exponentially increasing its

[xiv] A Marine artillery battery doctrinally fields six howitzers. Each howitzer rates two MTVR's: one prime mover and one ammunition truck.

effectiveness. The Marine Corps can further reinvest the additional money saved from decreased logistical requirements, purchase similar quantities to Excalibur of a potential laser guided munition, and exponentially increase their effectiveness. There already exists a limited effort within the Marine Corps to develop new forms of laser guided munitions, as well as an attempt to increase Excalibur's capabilities to include laser target designation. The Marine Corps simply needs to accelerate the effort of both fronts and lead if feasible.

There are currently two forms of laser guided technology in terms of artillery munitions that the Marine Corps is pursuing: the Moving Target Artillery Round (MTAR), and Semi-Active Laser (SAL) technology.[xv][44] Both experimental capabilities enable precision fires and moving target capabilities. Additionally, Raytheon has developed a *dual mode* Excalibur round that is initially GPS guided, and then terminally guided by a laser designator.[45] It is incumbent on the Marine Corps to fully commit to the future development of existing capabilities such as these to limit redundant costs and manpower. Having discussed the need for redundant precision capabilities, specifically laser-guided, this essay now turns to a discussion on the sustainment of manual non-digital methods of fire mission processing.

b. <u>Regaining the Confidence in Manual Methods of Fire Mission Processing</u>

The second part to the answer of how to increase Marine artillery's effectiveness is a recommitment to the manual methods of processing fire missions, or what artillerymen refer to as "glass and iron" techniques and "manual gunnery."[xvi] In the process of evolving into a

[xv] For a more in-depth explanation of these two capabilities, see Luke Steelman, *Enhanced Expeditionary Engagement Capability (E2C)* (National Defense Industrial Association, Arlington, VA, April 25-28, 2016), PowerPoint presentation, https://ndiastorage.blob.core.usgovcloudapi.net/ndia/2016/armament/18280_ Steelman.pdf; and, "Semi-Active Laser (SAL) Precision Guidance System," *Defense Update*, January 2005, http://defense-update.com/products/l/laser-guidance.htm.

[xvi] Manual gunnery consists of utilizing all manual methods to process fire missions. This involves the use of maps and hand created charts to calculate distance and direction (quadrant and deflection), and manually calculating for all external factors that can impact the flight path of an artillery shell by utilizing Tabular Firing Tables (TFT). Glass and Iron refers to the process of laying an artillery battery utilizing Aiming Circles and pre-surveyed points

technologically advanced and increasingly digitally driven precision capability, Marine artillery lost touch with it roots and this manual capability. As such, its ability to support the force in a technologically degraded environment has decreased.

The formal artillery school house for all artillerymen, officer and enlisted, at Fort Sill, Oklahoma, teaches manual methods of executing fire missions. This includes everything from laying the howitzer with aiming circles to conducting manual calculations to attain firing data. The intent behind teaching this process to all young artillerymen is to ensure there exists resident knowledge of what goes into processing fire missions. A true understanding of manual methods of fire mission processing also facilitates troubleshooting when things go wrong. But more importantly, the school house teaches this method of manually processing fire missions so artillery has the capability to function with the loss of digital capabilities. The requirement to be proficient in manual methods is still recognized in today's Marine Artillery regiments and battalions. Every artillerymen, regardless of ranks, is required to take and pass with a perfect score an annual *safety test.* This test requires the Marine to both compute firing data and ensure the safety of fire mission data without the assistance of digital systems. Prior to participating in any live fire artillery training exercise, a Marine has to pass this test. Other than passing the safety test, the only other formal process of testing an individual or unit's ability to operate using manual methods is the Marine Corps Combat Readiness Evaluation (MCCRE).[46] Simply taking an annual safety test and executing a MCCRE does not adequately result in a well-balanced force, especially when the MCCRE does not evaluate a units ability to operate using manual methods of fire mission processing.

within a firing position. Modern survey teams utilize GPS devices, but can also utilize meteorological data such as the stars or sun if GPS is unavailable.

As discussed, the most significant documents regarding the future force envision a high likelihood the Marine Corps will face an adversary with the ability to use digital signatures as a method of targeting and will have the ability to jam or corrupt GPS signals. This will leave no alternative aside from manual methods of fire mission processing. Artillery is one of the only all-weather highly destructive capabilities available to the ground commander that can operate in this degraded communications environment. Maine artillery can ensure this remains the case by increasing the overall formal requirement to operate utilizing manual, non-digital methods of fire mission processing. Ideally, a unit should be able to revert to manual methods in stride if a situation calls for it. However, this capability only exists if units train to it on a regular basis and under a formal, regular process of evaluation.

Much of this hesitation stems from risk aversion in training environments, as digital methods improve accuracy and decrease the likelihood of human error. However, this hesitation also exists because the modern battlefield requires such a high degree of precision. This is undeniable and certainly valid. But this precision, whether in the form of laser or GPS guided munitions must not come at the expense of abandoning artillery's manual capability. For instance, laser guided munitions provide an outstanding option for conducting precision fires without digital systems, but it still requires competence in manual methods to fire the round within specific parameters to facilitate locating the necessary laser energy. Marine artillery has the requisite knowledge internal to the organization and the established formal methods of educating its operators; it simply needs to recommit itself to training and operating in this particular fashion as the rule, not the exception. This departure from the current mindset requires involvement from the maneuver commander as well. Throughout large-scale exercises such as Integrated Training Exercises (ITX), artillery and maneuver units must designate training

objectives driving this form of support. This will ensure there is a common understanding among artillery and maneuver units involving available weapon to target matches, timeliness of fires, and expectation management in regards to the accuracy and overall level of support available. Ultimately, if artillery units retain the ability to effectively transition from delivering precision guided munitions with the assistance of all available technology to conducting missions using none of it, and proper training is conducted with maneuver units under both scenarios, it will ensure artillery's ability to effectively deliver effective fires on the future battlefield.

A contributing factor to Marine artillery spending less time exercising manual methods, and presumably a big part of the leadership's rationale for focusing on digital systems, is because the digital systems are so complicated. One of the advantages to utilizing a system such as the AFATDS was to decrease fire mission processing time and the potential for human errors, certainly worthy of the training commitment. Unfortunately, because the current system requires continual software updates to remain effective in the Marine Corps's growing communications architecture, Marines are spending valuable training time relearning the system versus furthering their ability to effectively employ it. All total, since September, 2017, the AFATDS has undergone "13 separate upgrades."[47] To allow Marines to spend more time training to the manual methods that are vital on the future battlefield, the Marine artillery must look to replace the AFATDS with a more user-friendly system. The specific capabilities and parameters of this future system must be the topic of additional research. The need for laser guided missions and manual methods of fire mission processing having been addressed, this essay transitions to the way forward.

c. <u>A Plan to Implement Change</u>

Developing combat systems that specifically support the Marine Corps's unique expeditionary core mission is vital to the Corps's longevity. A robust precision capability ensures Marine cannon artillery remains a lethal and effective asset for the ground commander. Sustaining proficiency in manual methods of fire mission processing ensures Marine cannon artillery's ability to operate in a technologically degraded environment where digital systems are unavailable. That being said, how does the Marine Corps drive combat systems development that ultimately supports their expeditionary roots; and, what is the institutional driving function that guarantees Marine cannon artillery can consistently employ precision guided munitions across the spectrum or warfare, and remain capable of seamlessly reverting to manual methods?

While development of the M777 was a joint venture between the Army and the Marine Corps, it was and remains a program led by the Marine Corps.[48] As the program lead, the Marine Corps had the ability to influence the howitzer's functions, capabilities, and specifications to ensure it adequately addressed the needs of the Marine Corps. For instance, the variant of the M777 that the Marine Corps is outfitted with does not have run-flat tires, thus decreasing the overall weight of the howitzer and keeping it below the desired 10,000lbs threshold.[49] The expeditionary benchmark for the Marine Corps is whether the MV-22 Osprey has the ability to carry the weapon or not, and the M777 is great example of a weapon system that delivers the lethality of a weapon traditionally developed by the Army, but specifically designed to meet the Marine Corps's specific expeditionary requirements. Ensuring future Marine cannon systems continue to meet these requirements, the Marine Corps must continue to lead, or at the very least have a heavy hand during the design phase, exactly as they did with the M777's development. Post system development, updates to the T&R manual will ensure the

Marine Corps effectively trains to the weapon's full range of capabilities and employs it in a way that supports the Marine Corps's expeditionary role.

The T&R manual drives training for all units in the Marine Corps. As previously identified, the current Marine Artillery T&R manual does not contain any evaluated events that require units at the platoon level and higher, or their Fire Direction Centers, to execute fire missions in a degraded capacity using only manual methods.[50] While there are certainly T&R events that require degraded operations, they are neither evaluated nor collective events, meaning they are only expected to be completed in preparation for the evaluated events. This is called a *chained T&R* code.[xvii] The same is true for precision fires. There are currently no T&R evaluated events centered around the execution of a fire mission that employs a precision munition. Given that the T&R manual generates all evaluation criteria for all formal training events, the T&R manual must be updated to include precisely these two scenarios. Through coordination with Training and Education Command, Marine artillery can recommend changes to the current T&R manual. Once these events are added to the T&R manual, Marine artillery cannon units will be required to show proficiency in each of them.

The T&R manual drives more than training and proficiency standards, it also validates additional resource and training requirements by way of Mission Essential Tasks (MET) and the Defense Readiness Reporting System (DRRS).[xviii] With the addition of these two evaluated events in the T&R manual, artillery units now have the formal forcing function in place to drive

[xvii] All evaluated T&R events are supported by *chained*, lower-level T&R, non-evaluated, events. Chained events are designed to help unit leaders identify T&R events that support upper-level, evaluated events. Chained events by definition are not evaluated on an individual basis.

[xviii] Applicable units report their overall readiness by indicating proficiency, or not, in each of their METs via DRRS. DRRS is intended to give the Chairman of the Joint Chiefs of Staff an assessment of the readiness of individual U.S. military capabilities or the force as a whole. An argument can be made that an indication of a deficiency in training, equipment, or personnel within DRRS translates to a potential validation for additional resources. See US Department of Defense, *Department of Defense Readiness Reporting System (DRRS)*, Directive 7730.65, May 11, 2015.

an increase in the allotment of annual precision munitions and unitary funds to support the additional training requirements for degraded operations.

There are two events where Marine cannon units display proficiency in evaluated T&R standards: one is the Marine Corps Combat Readiness Evaluation (MCCRE), and the second is during an Integrated Training Exercise (ITX). One training evolution executed during ITX is the Fire Support Coordination Exercise (FSCEX), which is the ideal scenario to evaluate an artillery unit. A unit must execute a MCCRE once every twenty-four months or prior to a deployment. Units attend ITX, and therefore execute a FSCEX, on a rotational basis depending on their individual deployment cycles. As T&R standards are updated, the Marine Corps has an opportunity to further increase Marine cannon units' exposure to formal evaluations of these vital T&R standards by increasing the frequency of ITXs and/or MCCREs. Units should execute either a MCCRE or an ITX at least once a year regardless of their deployment cycle. Additionally, throughout the conduct of a FSCEX, firing battery's must be required to execute a portion of the exercise solely utilizing manual methods. This will require substantial prior planning with the supported maneuver unit, as additional safety measures and coordination will be required when digital systems are removed. Ultimately, this is a positive for both the firing and the maneuver unit; it will provide a baseline for real world operations when firing methods shift between digital and degraded.

In addition to implementation requirements for manual mission processing, Marine artillery should concurrently address the requirement to exercise its precision capabilities. In regards to the increased requirement to employ precision fires during these training evolutions, as early as 2011 the Artillery Operations Advisory Group (AOAG) has been formalizing this requirement. In 2011 the AOAG updated the Artillery Campaign Plan that was first published in

2009. It recommended the allocation of an additional 24 Excalibur rounds for employment during ITX's predecessor, Exercise Mojave Viper.[51] The updated T&R standards will progress this initiative to include precision munitions beyond Excalibur and further increase their overall allocation.

Conclusion

The modern and future battlefield of the 21st century is characterized by the requirement for precision fires and is dominated by technology. Directives such as the QDR and MOC agree that precision and the ability to operate with or without current and advanced technology are emerging requirements. The modern battlefield is comprised of urban terrain that is plagued with collateral damage concerns requiring a robust precision capability to remain effective. Currently, the only Marine cannon artillery precision capability is the GPS guided Excalibur munition. On the future battlefield, Marine artillery must have the ability to operate without the assistance of digital systems as the enemy will have the ability to either negate them or use them as a means of targeting. Unfortunately, Marine artillery is not currently trained or equipped to support the force on the modern or future battlefield. By fully committing to the development and implementation of alternate methods of precision, such as laser guided munitions, and recommitting to the sustainment of manual non-digital methods, Marine artillery can provide a more capable and effective asset to the ground combat commander on the modern and future battlefield.

As the battlefield modernized and the variables that shaped it evolved, modern militaries took advantage of technological advancements and developed capabilities to remain effective. Where superior firepower in both caliber and quantity, delivered by a larger more disciplined and

experienced force, were once the keys to success, precision and technology emerged as the prerequisites for victory. Advances in technology enabled improvements of current weapons and allowed for the development of newer more lethal capabilities to meet these new requirements for victory. In an effort to keep pace with this modernization and ensure its ability to continue to effectively support the ground combat commander, Marine artillery undertook a number of significant developments in an attempt to evolve its artillery capability. Marine artillery relied on its proven and beneficial relationship with the Army when it came to combat systems development. Unfortunately, this resulted in the Marine Corps compromising.

Marine artillery leadership fully recognizes the characteristics of the modern and future battlefield (urban, complex terrain complicated by collateral damage concerns dominated by technology) and what is required to remain a lethal capability to the ground commander (a robust precision guided capability in conjunction with the ability to seamlessly transition to manual, non-digital methods of fire mission processing). If Marine artillery can more effectively influence the development of future Marine cannon systems, it will remain a viable option to the ground commander and remain an effective weapon on future battlefields that also meets the Marine Corps's expeditionary role.

Lastly, the forcing function behind the implementation of both precision fires and the requirement to remain proficient in degraded methods of fire mission processing is updates to the Marine Artillery T&R Manual. With the inclusion of evaluated T&R events that specifically require the employment of precision fires as well as degraded operations, units will be required to display proficiency in both in greater frequency. Additional financial resources will be allocated to support the subsequent increase in the annual allotment of precision munitions and the increased training requirements. And finally, with an increase in the frequency of MCCREs

and ITXs, units will inevitably have to adjust their training plans to incorporate both of these capabilities on a more consistent basis. Increased T&R requirements drive an increase in training, which ultimately results in increased proficiency. The end result is a community that is more proficient, lethal, and prepared to support the future force against a near-peer enemy and in the complex terrain of the modern battlefield.

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