REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
15-04-2015	Research	7 July 2014 - 3 June 2015

4. TITLE AND SUBTITLE
Modernizing MAGTF Ground-Based Air Defense to Counter Emerging Threats

5a. CONTRACT NUMBER
N/A

5b. GRANT NUMBER
N/A

5c. PROGRAM ELEMENT NUMBER
N/A

6. AUTHOR(S)
Major Edward J. O'Connell, USMC

5d. PROJECT NUMBER
N/A

5e. TASK NUMBER
N/A

5f. WORK UNIT NUMBER
N/A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
USMC School of Advanced Warfighting
Marine Corps University
3070 Moreell Avenue
Quantico, VA 22134-5068

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
N/A

10. SPONSOR/MONITOR'S ACRONYM(S)
N/A

11. SPONSORING/MONITORING AGENCY REPORT NUMBER
N/A

12. DISTRIBUTION AVAILABILITY STATEMENT
Unlimited

13. SUPPLEMENTARY NOTES
N/A

14. ABSTRACT
The Marine Corps has accepted too much risk in GBAD of the MAGTF. Air Superiority in Iraq and Afghanistan meant that ground maneuver units did not have to consider a threat from the air while planning and operating. Future USMC operational concepts call for disaggregated operations over great distances, where theater-level air superiority will be difficult to gain and maintain. UASs are cheap alternatives to manned aircraft and can achieve the effects that cruise missiles can achieve - not unlike the Japanese Kamikazes of World War II. Low observable/detectable aircraft and munitions like UASs and guided rockets, artillery, missiles, and mortars (G-RAMM) have outpaced MAGTF capabilities and present a threat to the entire future range of MAGTF operations.

15. SUBJECT TERMS
Counter G-RAMM, Ground Based Air Defense (GBAD), Low Altitude Air Defense (LAAD), Defense of Air Bases, Defense Battalion

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE	UU	18	Marine Corps University / School of Advanced Warfighting
Unclassified	Unclassified	Unclassified			19b. TELEPONE NUMBER *(Include area code)* (703) 432-5318 (Admin Office)

United States Marine Corps
School of Advanced Warfighting
Marine Corps University
3070 Moreell Avenue
Marine Corps Combat Development Command
Quantico VA 22134

FUTURE WAR PAPER

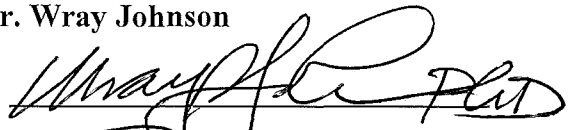
Modernizing MAGTF Ground-Based Air Defense to Counter Emerging Threats

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

Major Edward J. O'Connell, USMC

AY 2014-15

Mentor: Dr. Wray Johnson

Approved: 

Date: 15 Apr 2015

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

On 14 September 2012, approximately 20 Taliban fighters infiltrated the airfield of Camp Bastion in Helmand Province, Afghanistan. Over the course of four hours, they destroyed six United States Marine Corps (USMC) A/V-8B "Harrier" jet aircraft, various aircraft support facilities, and killed two Marines. They carefully planned this attack for over a year and attacked using small arms, grenades, and rocket propelled grenades (RPG). This successful assault ultimately led to the forced retirement of two Marine Generals for failure to properly balance force protection with force projection and the failure to employ a layered defense in depth of Camp Bastion.[1] Now, imagine a scenario sometime in the future with coalition forces deployed in a similar fashion aboard a major air base. Instead of Harriers, Joint Strike Fighters (JSF) line the airfield, at a cost of close to $150 million per aircraft. USMC forces have deployed a layered defense in depth of the base to repel ground attack because the events of 14 September 2012 have not been forgotten. However, the enemy has adapted and weapons technology has evolved. Instead of 20 individuals using small arms and RPGs, the enemy employs a swarm of 20 low-cost Unmanned Aerial Systems (UAS), each equipped with an explosive payload and used in the same manner as precision-guided munitions (PGM). Perhaps the enemy uses one UAS equipped with a basic communications package and a laser that guides rockets, missiles, or mortars onto the airfield. Twenty JSFs, over $2 billion worth of aircraft, lay either destroyed or in a state of major disrepair. UASs complimented by guided rockets, artillery, missiles, and mortars (G-RAMM) present a major threat to Marine Air Ground Task Force (MAGTF) operations. In order to meet the demands of our nation's Defense strategy and face the increasingly complex character of wars of the future, the MAGTF must improve its capability and capacity to counter G-RAMM and UAS threats in the myriad of operating environs in which the MAGTF will fight.

During the last two decades, Marine Corps leadership elected to accept major risk in manning, training, and equipping its GBAD forces. In the late 1990s, the Marine Corps eliminated the MIM-23 Homing All The Way (HAWK) missile from service with the intent to replace it with the Surfaced Launched Advanced Medium Range Air to Air Missile (SLAMRAAM) as part of the Complementary Low Altitude Weapon System (CLAWS). CLAWS was tested, but never fully fielded. In the end, HAWK gave way to the Avenger weapon system, equipped with "Stinger" missiles, and the Light Armored Vehicle Air Defense (LAV-AD) system. During the Force Structure Review Group (FSRG) process, the Marine Corps air defense community lost an entire Battery in 2007 – the only USMC air defense unit in the 3d Marine Expeditionary Force (MEF) area of operations (AO) as well as its reserve unit, 4th Low Altitude Air Defense (LAAD) Battalion (Bn), in 2005. The Avenger weapon system and the LAV-AD no longer exist. Maintenance costs and other priorities spelled doom for these two "unnecessary" weapons systems. Thus, in 2015, the MAGTF's organic air defense capability is limited to two undermanned LAAD Bns equipped with shoulder-fired Stinger missiles and "stock" crew-served weapons. Both Bns served as provisional security forces during Operations Iraqi Freedom (OIF) and Enduring Freedom (OEF).

At the time, the decision was not necessarily unfounded or unjustified; however, this may not be the case in future war. The absence of a sophisticated air threat in OIF and OEF and the historical ability for US forces to achieve air superiority has shifted priorities away from air defense. While the MAGTF will always seek to establish air superiority in its operations, the enemy knows this and is developing a counter to how the MAGTF prefers to fight. Indeed, the future operating environment will be characterized by "the proliferation of modern conventional

and cyberspace weapons to a broader range of state and non-state entities, along with the erosion of U.S. technological advantages in areas where we have long enjoyed relative superiority."[2]

The Marine Corps has accepted too much risk in GBAD of the MAGTF. Air Superiority in Iraq and Afghanistan meant that ground maneuver units did not have to consider a threat from the air while planning and operating. Future USMC operational concepts call for disaggregated operations over great distances, where theater-level air superiority will be difficult to gain and maintain. UASs are cheap alternatives to manned aircraft and can achieve the effects that cruise missiles can achieve – not unlike the Japanese Kamikazes of World War II. The sophistication of emerging enemy armed UASs is irrelevant. Low observable/detectable aircraft and munitions have outpaced MAGTF capabilities and present a threat to the entire future range of military operations (ROMO) in which the MAGTF is likely to operate.

Background

As is often the case in military history, the attack on Camp Bastion was not without historical precedent. Italian air power theorist Giulio Douhet posited, "it is easier and more effective to destroy the enemy's aerial power by destroying his nests and eggs on the ground than to hunt his flying birds in the air."[3] Admittedly, Douhet was advocating for the offensive use of air power and its best use in striking the enemy's aircraft with your own before he can leave the ground. Taken at face value, however, it offers an insight into how future adversaries may try to limit the asymmetric advantage that American air power provides in military operations. In a thoroughly researched and expansive report conducted for the RAND Corporation in 1995, Alan Vick studied all of the major attacks on air bases in conflicts from 1940 to 1992. Vick found that, in the 52-year period covered, 645 attacks were conducted against air bases and the attacks came in the form of infiltration, penetration, or via standoff weapons.[4]

> Most large- unit attacks on airfields succeeded because defending ground forces were outnumbered, outgunned, or outclassed. On Crete, maldeployment (sic) of forces and bad leadership prevented effective use of well-trained and motivated forces. Many times, attacker air superiority also played an important role. For both standoff and penetrating attacks intended to destroy aircraft, shortages in high quality rear-area security forces and a lack of surveillance assets were the most common weaknesses.[5]

Keeping Camp Bastion in mind, enemy forces still clearly view attacks on airfields as a worthwhile objective in trying to limit MAGTF capabilities. Therefore, Vick's study is as relevant today as it was in 1995, and will be relevant for the distant future. He found that the basic tactics behind air base attack and air base defense had changed little since World War II and predicted that "a variety of new information and sensor weapon technologies offers opportunities for attacker and defender alike."[6] He also found that, in Vietnam, US forces demonstrated a great deal of creativity in countering the sapper threat and, thus, the Vietnamese communists turned to standoff weapons in their efforts to destroy US aircraft.[7] Unfortunately, as Vick points out, Military Assistance Command, Vietnam (MACV), did not take air base security seriously enough to effectively counter the standoff threat to air bases: "Without ground forces and airborne surveillance assets dedicated to controlling the standoff footprint, USAF bases remained vulnerable to the end of the war."[8]

> More troublesome is the possibility that precision-guided munitions (PGMs) for existing standoff weapons, as well as for some new weapons, may give small standoff attacks a lethality that they lacked in the past. For example, recall that in Vietnam almost 300 of the standoff attacks fired fewer than 10 rounds. If the attackers had been armed with PGMs for their mortars, USAF losses from these small attacks could have been very high.[9]

Of the 194 pages of the report, it is the above quote that is of most relevance to this paper and should be of the greatest concern to MAGTF commanders and planners. We are moving into an uncertain future characterized by our adversaries both limiting our access to parts of the globe previously open and closing the technology gap that the US has

enjoyed for decades. This should be of paramount concern when allocating resources to counter such threats as standoff attacks: "The G-RAMM threat is both real and growing. If the threat from increasingly accurate and available standoff indirect fires is not addressed, it will severely limit the MAGTF's ability to project power during a period when our role in creating access is increasing in importance."[10]

The Strategic Environment

The current strategic environment can be characterized as one where the Marine Corps must prepare to counter the full range of possible emerging threats; however, it must do so in an environment where there is uncertainty about whether the Corps will have the money and manpower needed to do so. Fiscal austerity[11] and troop reductions are ongoing and in play for the near future. However, new technology and new centers of power in the world has caused US strategic focus to emphasize the full ROMO.[12] Resources will certainly drive strategy, but so too must evolving threats.

> Future conflicts could range from hybrid contingencies against proxy groups using asymmetric approaches, to a high-end conflict against a state power armed with weapons of mass destruction (WMD) or technologically advanced anti-access and area-denial (A2/AD) capabilities. Reflecting this diverse range of challenges, the U.S. military will shift focus in terms of what kinds of conflicts it prepares for in the future, moving toward greater emphasis on the full spectrum of possible operations.[13]

The above, from the 2014 Department of Defense (DoD) Quadrennial Defense Review (QDR), accurately captures the scope of the challenges posed by future conflict and reinforces the assumption that future threats are far too complex for the US military to concentrate on one particular form of warfare. History provides planners with a template:

> It would be a gross error to discount technologically propelled change in the character of some cases of irregular warfare. But it would be a still greater mistake to exaggerate the importance of the undoubted novelty at the expense of

> recognizing the extensive continuity in strategic history. Regular and irregular warfare have always coexisted.[14]

The 2012 Defense Strategic Guidance (DSG) outlined the primary missions of the U.S. Armed Forces,[15] which encompass the full ROMO, and further that although "we cannot predict how the strategic environment will evolve with absolute certainty, we will maintain a broad portfolio of military capabilities that, in the aggregate, offer versatility across the range of missions described above."[16] Moreover, the DSG introduces the idea of "reversibility," that programs may be modified to respond to "evolutions in the strategic, operational, economic, and technological spheres."[17] The 2014 QDR built upon the 21st century priorities of the 2012 DSG, chief among them "rebalancing" to the Asia-Pacific region and sustaining a global approach to countering violent extremists and terrorist threats. Regardless of the characteristics of future war, the Marine Corps must possess the ability to counter emerging threats in order to carry out the missions assigned and be the "right force in the right place at the right time."[18]

The Threat

In order to counter the full spectrum of threats and gain access in A2/AD environs, the MAGTF must be prepared to counter emerging threats and, potentially, alter the manner in which it fights. Two major emerging threats that the Marine Corps must be prepared to counter are UAS proliferation and G-RAMM, especially in areas of the world where active A2/AD systems are in place. "Anti-access strategies aim to deny the United States the ability to mass forces near a target area, disrupt basing and logistics, and asymmetrically counter high-end U.S. military capabilities that it has been able to use previously with impunity."[19] China and Iran, for example, possess anti-ship cruise missiles, mines, integrated air defenses, and G-RAMM capabilities.[20] Other potential adversaries are also acquiring weapons designed to neutralize the asymmetric advantages of the Joint Force. "As a result, access will be increasingly contested at

theater levels in multiple domains, to include sea, undersea, air, space, and cyberspace."[21]

Gaining access in A2/AD environments will require a joint effort to suppress and neutralize enemy G-RAMM capability in the amphibious objective area (AOA); thus, the MAGTF must have the ability to defend itself from the UAS and G-RAMM threat. "The initial phase of any joint theater entry operation will require achieving air, sea, undersea, and overall battle network superiority in the amphibious objective area. Air Force bombers, naval strike assets, and Marine reconnaissance and special operations forces will work to degrade and destroy enemy anti-Navy capabilities and to reduce the G-RAMM threat ashore."[22] But what happens once the lodgment is established and the enemy conducts a counterattack with well-concealed G-RAMM assets or interferes with operations with small UASs out of range of the defense umbrella that the Navy provides? The Navy will continue to concentrate on the longer G-RAMM threat,[23] but the MAGTF must possess the ability to defend itself once a lodgment is established or when a breakout from that lodgment occurs. "G-RAAM weapons will have the strategic impact on forces in the littorals and ashore that improvised explosive devices had in the Iraq War, and will be as emblematic as the machine gun in World War I."[24]

If the Joint Force is willing to go to great lengths to gain access in A2/AD environs, then it is highly likely that that the Joint Force (and the MAGTF in particular) will participate in sustained operations ashore which will necessitate basing (on sea or land), and the ability to defend that basing. "If the world again erupts in total war, bases essential to the effective employment of air and sea power must be seized regardless of the opposition encountered, and beachheads on large land masses will probably have to be wrested from hostile powers."[25]

At a time when U.S. forces are focused on operating in the Pacific Command (PACOM) area of responsibility (AOR), basing for air, sea, and land forces will be necessary to execute the

full ROMO for the MAGTF and Joint Forces. With deference to the amount of thought, writing, and investment made into sea-basing in the last several years,[26] current resource constraints mean that the US Navy will not likely possess the requisite platforms needed to conduct operations and generate sorties solely from the sea. Uncertainty and complexity will also reign in political relationships with foreign countries; therefore, the Joint Force may not be able to count on friendly for basing purposes. This was the case for both Iraq and Afghanistan, where the US was not allowed to conduct operations from Turkey and Pakistan, respectively. This means that future sustained operations against potential adversaries will require lodgments and land bases.

> At the same time, the sensors, observers, information technology, and other crucial elements of the battle network will benefit from simultaneous evolutionary improvements. As our enemies begin to employ armed unmanned air systems, these might also become a separate G-RAMM subcategory, as well as representing a significant interruption of the air superiority that we have enjoyed for decades.[27]

As noted earlier, UAS proliferation and G-RAMM munitions will likely threaten these lodgments and bases. The scenarios briefly discussed at the outset of this essay represent only a small example of how enemy UAS proliferation will change future battlefields.[28] MAGTF ground forces are at present accustomed to operating in environments where the US has obtained air superiority, which is "that degree of dominance in the air battle by one force that permits the conduct of its operations at a given time and place without prohibitive interference from air and missile threats."[29]

Rapid advances in technology and the ease by which anyone can obtain a UAS likely means the MAGTF will rarely enjoy the level of air superiority it has become accustomed to.[30] UASs in the US military arsenal are a contributing factor to this air superiority. "The US military inventory now includes over 7,000 unmanned drones in the air and another roughly 12,000 on the ground. Illustrating the rapid growth of this field, at the start of the Iraq war in

2003, these numbers were near zero."[31] Our adversaries, state and non-state actors alike, have seen what the US can do with its unmanned systems and there is no doubt they will try to close the gap. Indeed, on December 27 2014, Iran reported it had successfully tested a "suicide drone" designed for ground and sea-based targets.[32] This suicide drone is actually a copy of a captured American ScanEagle drone.[33] Admittedly, these types of UAS do not possess a huge payload, but they do have a long loiter time and they are much cheaper and more cost effective than a cruise missile. The bottom line is that UASs of any size that possess a precision capability can adversely affect Joint Force operations.[34] Equally worrisome, we know that China possesses the "Harpy" suicide UAS, which has a range of 300 miles and can carry a 70lb payload.[35]

In addition to the above, there remains the G-RAMM threat. Standoff attacks are significantly more lethal to MAGTF forces with the advent of G-RAMM. Much like other weapons systems, G-RAMM is likely to see an evolution of sorts in the coming years. The near-term will include laser-guided munitions; the mid-term (within the next 6 years) will see a greater use of GPS and sensor-fused indirect fire munitions; and in the long-term we will see truly "smart munitions" with reduced reliance on lasers.[36] For example, the U.S. 155mm M898 artillery projectile has two search and destroy submunitions that can maneuver to engage individual targets with precision.[37] The Russian-made, laser-guided "Krasnopol" artillery shell has been sold to China, India, and Belarus.[38] "Guided mortars include the Swedish 120mm 'Strix' with an infrared seeker, the Israeli GPS-aided Israeli-Raytheon Dagger GPS-120mm round and the Russian Gran…Google Earth can provide targeting support, while command and control can be handled with cell phones, Twitter and other online communication tools, high-level encryption and fiber-optic networks."[39] The MAGTF must anticipate future adversaries

using these types of munitions in order to efficiently and effectively neutralize any asymmetric advantage the MAGTF may possess.

Current Efforts

The MAGTF and the Joint Force as a whole have recognized that low radar cross section targets like UASs and G-RAMM are a significant threat to future operations, and there are prototype material solutions in research development that are beginning to address the threat. The first item coming on line for the MAGTF, and possibly the most crucial given the threat, is the AN/TPS-80 Ground/Air Task Oriented Radar (G/ATOR). Locating UASs and G-RAMM is currently a major "choke-point" in the kill chain to defeat the threat. The G/ATOR can detect light mortar and artillery shells at 11nm, medium caliber rockets and artillery between 22-27nm, and various types of aircraft (manned and unmanned) between 40-135nm.[40] This asset will greatly enhance current MAGTF early warning and cueing (EW/C) capabilities and improve the ability of GBAD forces to engage airborne targets accurately and in a timely manner.

Another major technological development in air defense is directed energy (DE) Laser Weapon Systems (LaWS). The prototype of this weapon system, recently unveiled aboard the USS *Ponce* (AFSB(I)-15), is a $40 million 30 kw-class solid-state laser (SSL). The system is undergoing testing and is listed as operational. The Ponce's commander is authorized to use the SSL in self-defense if necessary.[41] At $0.59 per laser shot,[42] the SSL provides a cost effective method for engaging low radar cross section targets.

Because the cruise missile and UAS threat have outpaced current MAGTF GBAD capabilities, the USMC intends to incorporate the detection and EW/C of the G/ATOR with a HMMWV-sized variant of the SSL currently aboard the *Ponce* to "provide continuous, low altitude, air defense of high value assets (HVA) aircraft, Combat Operations Centers, and

Tactical Assembly Areas."[43] Ideally, these two systems along with an integrated command and control system will lead to Integrated Fire Control (IFC). "IFC is an advanced capability that teams sensors and shooters together to address challenging anti-air warfare (AAW) and Air Defense problem sets. Under the IFC concept, sensors from air, land, or sea providing high fidelity target data enable weapons to be fired from any domain agnostic of the platform."[44] The desired end goal of IFC is to decrease reaction time, enhance target identification, and improve defense in depth.[45] Indeed, one of the main reasons that the DE/SSL weapon is aboard Navy shipping is in response to the very threats discussed in this paper as well as their size and the energy required to employ them. The challenge is to fit these systems to a tactical vehicle. Once that advance in science and technology takes place, the organization, training, and manning of the individual LAAD Bns will undoubtedly require a complete overhaul. Directed energy weapons are the "way of the future," but it remains uncertain when these weapons will be feasible for MAGTF expeditionary operations in defense of air bases and maneuver units.[46]

MAGTF GBAD

As of September 2014, the USMC Deputy Commandant for Aviation (DC/A) approved the following as the LAAD Bn mission statement: "Provide close-in, low altitude, surface-to-air weapons fires, and when task-organized, provide command and control, and force for ground security in defense of the MAGTF Commander's designated vital areas."[47] With this in mind, the 2015 Marine Aviation plan states: "Recent history has shown the need for the Aviation Combat Element (ACE) to protect HVAs. This mission falls clearly within the purview of the LAAD Bn."[48] HVAs in this sense refer to JSFs, radar facilities, and bases in general. "The LAAD Bns are the only dedicated Marine Corps asset that is able to provide three dimensional security forces (SECFOR) to defeat an adversary's threat to destroy MAGTF HVAs."[49]

It is critical for commanders and planners to appreciate just how much goes into base defense, "as the Marine Corps operates from expeditionary forward operating bases (FOBs) with vulnerable, critical, non-recoupable, high-dollar aviation platforms and highly trained Marines."[50] As previously mentioned, Alan Vick found that the Vietnamese turned to standoff attacks against airfields when the US employed adequate countermeasures against sapper attacks. He also found that "the most effective means to deter and prevent standoff attacks was to control the standoff footprint around the base."[51] To defeat the threat "required controlling territory extending this distance from the base perimeter, typically with a total area of over 200 square miles."[52] Figure 1 below is the "proposed roles and responsibilities for Airbase Ground Defense" for future MAGTF operations.[53]

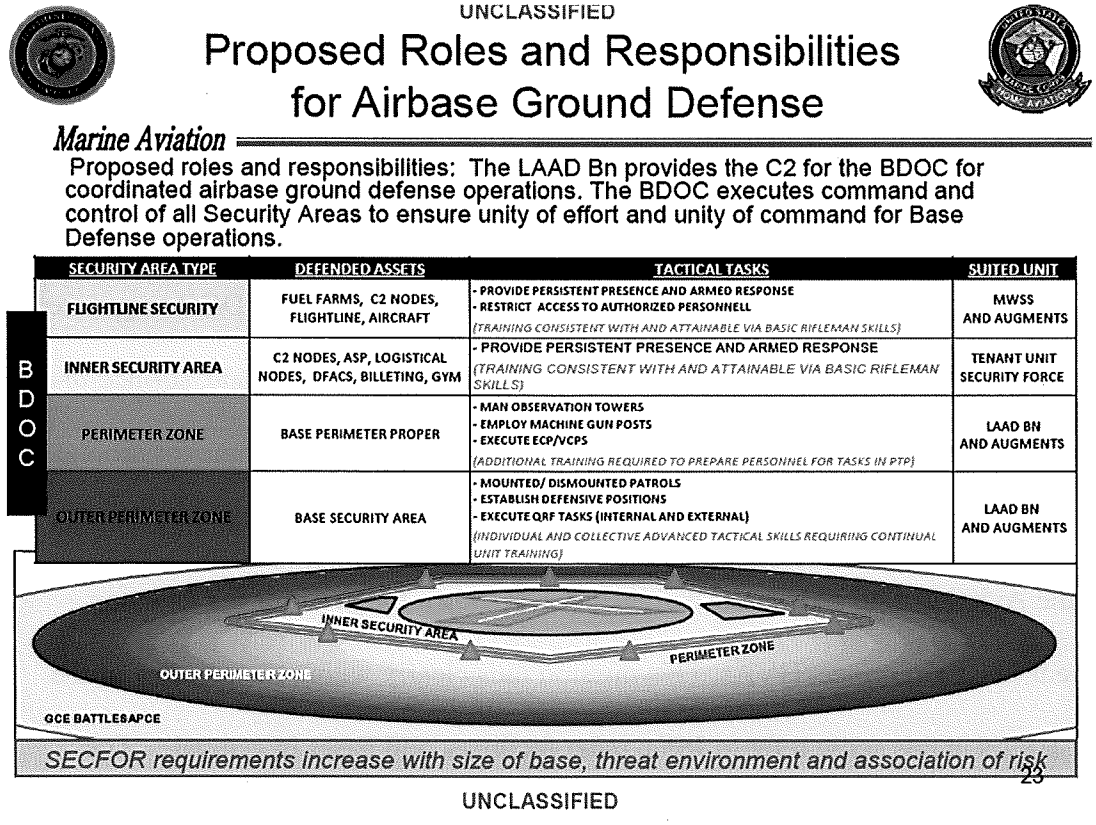


Figure 1

Depicted is a typical airbase security set-up with the LAAD Bn providing the Command

and Control (C2) for the Base Defense Operations Center (BDOC). The SECFOR posture and manning requirements will certainly adjust with the size of the base, the threat, and the commander's risk acceptance, but the security footprint as proposed is significant and could require MAGTF Commanders to accept significant risk in either offensive or defensive operations to protect HVAs in places where adversaries possess UASs and G-RAMM. If the airfield in Figure 1 is 3km, its circumference is roughly 20km. A guard tower every 200m equals 100 towers. If two Marines man each guard tower for three shifts per day, the guard towers alone require a force of 600 Marines, which is 15 Platoons of 40 Marines each. Add in the requisite supervision – corporals and sergeants of the guard, as well as platoon sergeants and commanders – and that guard force increases to 690. If the "outer perimeter zone" in Figure 1 is a 5km "buffer" to keep HVAs out of 82mm mortar range, the security increased from roughly 30 square km to 200 sq km. Two forces of similar strength are necessary to maintain security in the "outer perimeter zone" and conduct patrolling, quick reaction force, and other training. Including C2 and "commodities enablers," the SECFOR for a small (3km) airfield is approximately 1,500 Marines.[54] Bear in mind, these 1,500 Marines are executing ground defense of an air base. Absent a threat from the air via UAS or G-RAMM, the above presents an accurate planning factor for force structure.

The use of "augments" to bolster SECFOR requirements was a common practice during OIF and OEF and augments from all specialties in the Marine Corps were used in security roles. This necessitated an extensive pre-deployment training program (PTP) for several months prior to executing a security mission. As the nation's expeditionary force in readiness, the Marine Corps cannot comfortably rely on PTP for forces executing non-doctrinal mission sets across the globe. Therefore, planning to augment LAAD Bns with the forces required to defend airfields

from ground attack will prove difficult if not impractical in the future. Further, as an aside, history shows that relying on help from other services is problematic: "Reliance on other services for the defense of air bases was a problem for the RAF on Crete, the *Luftwaffe* in North Africa, and the US Air Force (USAF) in Vietnam. In each case, air base defense had to compete with other missions on which ground commanders placed higher priority."[55] Arguably, this is what happened at Camp Bastion. Competing priorities and a lack of specialized training from augments means that commanders will likely have to accept significant risk in the defense of HVAs. If the UAS and G-RAMM threat is as real and persistent as many think it will be, then even when the MAGTF has established air bases, the threat from the air to HVAs remains. Therefore the LAAD SECFOR discussed earlier, which is task organized to perform ground defense, will also have to defend against air and G-RAMM targets using "fused information and sensor data across multiple agencies to facilitate real time coordination, collaboration, and decision making."[56] This additional task will stretch already thin GBAD assets.

Modernizing GBAD

Gaining and maintaining air superiority in future operations will be prove difficult in the face of UAS proliferation and G-RAMM. Therefore, the MAGTF must be able to counter this threat with an organic weapon capability by modernizing its GBAD forces to close the gap created by over a decade of neglect. Any modernization effort that does not include an overhaul in how the LAAD community is trained, manned, and equipped is doomed to fail. An improved mix of weapons is necessary to counter emerging threats. Recall that the weapon systems of the LAAD Bn consist of Stinger missiles and stock crew-served machine guns. A very limited data link capability is the extent of the "modern" technology that exists in each of the battalions. If

the counter-G-RAMM mantle is to be taken on by the LAAD Bns, there will be a significant plus-up in weapons and other technology resident to the LAAD Bns. This will require significant additional training and, possibly, a restructuring of battalions themselves. The challenge for the Marine Corps will be to figure out the proper balance of force structure and weapons capability. Whatever capability and organization ultimately takes up the counter G-RAMM mission, it must fit in with the Marine Corps' desire to be the "middleweight" fighting force. The counter-G-RAMM capability must therefore be expeditionary and flexible enough to integrate with joint capabilities.

For all of the talk of DE/HEL weapons, the LAAD Bns must first be outfitted with a capable shoulder-fired missile and an anti-aircraft gun that is operable day and night, in good and bad weather, and absent any radar, major electric power source, or data link.[57] If the Joint Force seeks to dominate the electromagnetic spectrum, the MAGTF should anticipate its enemies doing the same. Therefore, MAGTF GBAD must maintain the ability to operate without any technological "tether" that comes with a system of the DE/HEL genre. Dismounted operations in defense of maneuver units in an environment with UAS parity and a G-RAMM threat are likely, so we must be ready for these contingencies. An upgraded Stinger missile with improved optics for visual aircraft identification (VACR) and a night sight allows for 24-hour operations, something the LAAD Bns are not currently capable of providing. An anti-aircraft gun with an anti-aircraft optic for both day and night operations, would greatly enhance the ability of the gunner in that he no longer will have to "free gun" a stock crew-served weapon in an effort to engage a target. Both of these types of weapons can be used in the offense and the defense of both maneuver units and of air bases in defense of HVAs. The Navy's Close in Weapon System (CIWS) is an example of just such an anti-aircraft gun and that type of weapon's use on the

ground is not without precedent. In 2004, Multi-National Corps Iraq produced an operational needs statement to counter rocket attacks. In response, the Army effectively deployed a trailer-mounted "Phalanx". However, at 53k pounds, this is not a viable material solution for MAGTF GBAD. [58]

While a material solution is necessary for modernizing MAGTF GBAD forces, the modernization effort will be incomplete without developing the proper organization and training. Several years ago, then Major Wayne Phelps proposed a complete restructuring of the LAAD Bns to meet the demands of conducting both air defense and ground defense of air base missions.[59] He proposed to adopt the World War II revision of "Defense Battalion."

> Overall, Defense Battalions provided a flexible, combined arms team that proved to be an effective fighting force capable of supporting offensive operations, defending bases from air and ground attack, and conducting secondary infantry missions...Defense Battalions' success during World War II can be attributed to its multi-use weapons, cross trained personnel, and flexibility to execute multi-missions.[60]

This is exactly what the 2015 Marine Aviation Plan calls for out of its LAAD Bns:

> The LAAD Bn's capability to provide air and ground defense of airbases and MAGTF HVAs through the three dimensional continuum will become a critical tool for the ACE commander to meet their force protection and AAW responsibilities. LAAD Bns have successfully conducted ground defense of FOBs and security force (SECFOR) tasks during OEF/OIF for over a ten year period. The SECFOR tasks included internal and external security along with tactical recovery of aircraft and personnel (TRAP), and training of Indigenous and coalition forces in counterinsurgency operations. The LAAD Bns are the only dedicated Marine Corps asset that is able to provide three-dimensional SECFOR to defeat an adversary's threat to destroy MAGTF HVAs.[61]

Indeed, the LAAD Bns as they are currently structured cannot provide the level of SECFOR called for while also providing GBAD of air bases and maneuver forces. The table of organization (T/O) end strength of one LAAD Bn of Stinger gunners is 60 teams of two Marines per team.[62] Given current fiscal constraints and the other needs of the Marine Corps, the LAAD

Bns will never be fully manned at the levels required. However, an effective balance, along the lines of the Defense Battalions, must be struck between fiscal constraint and risk acceptance that outfits the LAAD Bns to an adequate level. Furthermore, habitual relationships between LAAD Bns and Ground Combat Element (GCE) forces should be forged in peacetime with clearly delineated roles and responsibilities for effective defense of air bases.

Effective defense of air bases includes the defeat of small cross section air targets like UAS and G-RAMM. The most difficult part of defeating this threat is finding it. The G/ATOR will significantly enhance the MAGTF's ability to find these targets, but there is still an extensive kill chain between detection and firing. Any future weapon solution the MAGTF adopts should include serious consideration of the acquisition of radar assets and personnel. Then, the Battalion headquarters could act in a fire control capacity instead of having to rely on EW/C in the Marine Air Command and Control System (MACCS). EW/C and fire control at the Battalion level would significantly shorten the time from detection to engagement and would increase the likelihood of acquiring and destroying a target.[63]

Finally, when the solid-state laser that now exists aboard the USS *Ponce* is sized to fit on a Joint Light Tactical Vehicle (JLTV) or a HMMWV, the enhanced capability of the LAAD Bn would be truly significant, if not revolutionary. Cross training with GCE elements, especially artillery for fires integration, will be imperative for LAAD officers in planning and executing operations. LAAD Marines, or a cadre thereof, should also possess the qualifications necessary to control close air support (CAS) while executing defense of an air base to destroy ground targets outside the range of their organic weapon systems. In fact, the Marines of the modern LAAD Bns must be well-versed in all aspects of the MACCS so that they understand air space

planning, Anti-Air Warfare and the command and control of aircraft and missiles in MAGTF operations.

Conclusion

The attack on Camp Bastion demonstrates that the need to defend bases has not gone away and can be neglected. Future adversaries understand the asymmetric advantage of overwhelming American air power and will seek to negate that advantage. As Alan Vick noted, history is replete with examples that air base attacks are a relatively frequent phenomena since 1940 and over 75% of the attacks came via stand off weapons. Thus, the proliferation of UASs and G-RAMM presents a significant challenge to MAGTF operations. In that regard, the MAGTF must have the capability to counter UASs and G-RAMM, one that integrates the MAGTF into the larger Joint Force construct of integrated air and missile defense. DE/HEL weapon systems are likely the way of the future to counter emerging threats. Although some steps have been taken to counter these threats it will be some time before the promise of SSL technology will reduce the size of the weapon to fit the Marine Corps' desire for a lightweight and expeditionary force. For now, the foundation of any future GBAD force should be a shoulder-fired missile, not unlike the stinger, with optics and sights that allow for 24-hour, all weather operations. Furthermore, an anti-aircraft gun is necessary for the dual role of offense and defense of maneuver units and bases, in both ground defense and air defense missions. Finally, updating the organization and training of the LAAD Bns is necessary to effectively employ future weapon systems in a wide range of operations against emerging enemy threats.

---

[1] James F. Amos, "Read Camp Bastion Attack Investigation Documents" (*The Official Website of the US Marine Corps.* September 30, 2013). http://www.hqmc.marines.mil/Portals/142/Docs/CMC%20Memo%20for%20the%20Record%20in%20Bastion%20Investigation.PDF (accessed October 28, 2014).

[2] Headquarters Marine Corps, *Expeditionary Force 21* (Washington, D.C.: Department of the Navy, 2014).
[3] Giulio Douhet, *The Command of the Air* (Washington, D.C.: Office of Air Force History, 1983), 53-54.
[4] Alan Vick, *Snakes in the Eagle's Nest: A History of Ground Attacks on Air Bases,* (Santa Monica, Ca: RAND, 1995), xiv.
[5] Ibid, xviii.
[6] Ibid, xx.
[7] Ibid, 108.
[8] Ibid, 108.
[9] Ibid, 107.
[10] LtCol James W. Hammond III and LtCol Mike Cancellier, "Precision Munitions: Defeating the Challenge." *Marine Corps Gazette*, (January 2013), 49.
[11] U.S. Department of Defense, *2014 Quadrennial Defense Review* (Washington, DC: Office of the Secretary of Defense, 2014), IV. "The Department of Defense is also facing a changing and equally uncertain fiscal environment. Beginning with the Fiscal Year (FY) 2012 appropriations, the Department began absorbing significant impacts from the $487 billion, ten-year cut in spending due to caps instituted by the Budget Control Act (BCA) of 2011. The BCA also instituted a sequestration mechanism requiring cuts of about $50 billion annually. The Bipartisan Budget Act of 2013 provided modest immediate relief from sequestration, but unless Congress acts, annual sequestration cuts are set to resume in FY2016. To protect the security interests of the United States most effectively while recognizing the fiscal imperative of deficit reduction, the President's FY2015 Budget reduces projected defense budgets by about $113 billion over five years compared to levels requested in the FY2014 Budget. The President's Budget provides a balanced and responsible path forward given continuing fiscal uncertainty. It reflects the strict constraints on discretionary funding required by the Bipartisan Budget Act in FY2015, but it does not accept sequestration levels thereafter, funding the Department at about $115 billion more than projected sequestration levels through 2019."
[12] Ibid, III.
[13] Ibid, VII.
[14] Colin S. Gray, *Another Bloody Century: Future Warfare* (London: Phoenix, 2005), 222.
[15] As stated in the 2012 DSG, these priorities are: counter terrorism and irregular warfare, deter and defeat aggression, project power despite anti-access/area denial challenges, counter weapons of mass destruction, operate effectively in cyberspace and space, maintain a safe secure and effective nuclear deterrent, defend the homeland and provide support to civil authorities, provide a stabilizing presence, conduct stability and counterinsurgency operations, conduct HA/DR.
[16] U.S. Department of Defense, *Sustaining U.S. Global Leadership: Priorities for 21st Century Defense (Defense Strategic Guidance)* (Washington, DC Office of the Secretary of Defense 2012), 6.
[17] Ibid, 7.
[18]James F. Amos, *Expeditionary Force 21* (Washington, D.C.: Department of the Navy, 2014), 3.
[19] Brian M. Burton, "Looking Beyond the EFV," *Proceedings,* United States Naval Institute, 137, no. 1 (Jan 2011): 58-62.
[20] Ibid, 58-62.

[21] Honorable Robert O. Work, "Post-Afghanistan Marine Corps," *Marine Corps Gazette* 94, no. 11 (Nov 2010): 106-111.
[22] Ibid, 106-111.
[23] Ibid, 106-111.
[24] Hammond III and Cancellier, "Precision Munitions: Defeating the Challenge." 45.
[25] Jeter A. Isley and Phillip A Crowl, *The US Marines and Amphibious War* (Princeton: Princeton University Press, 1951), 590.
[26] As a small example, the January 2015 issue of *The Marine Corps Gazette* contained three articles discussing small, company sized, distributed MEU operations from a sea-base.
[27] Hammond III and Cancellier, "Precision Munitions: Defeating the challenge," 46.
[28] Chairman of the U.S. Joint Chiefs of Staff, "DOD Dictionary of Military and Associated Terms." *Joint Publication (JP) 1-02, as amended through 15 Nov 2014,* (Washington, DC: CJCS, November 8, 2010), 262. UAS is defined as "that system whose components include the necessary equipment, network, and personnel to control an unmanned aircraft.")
[29] Ibid, 10. Arguably, during operations in Afghanistan the US enjoyed air supremacy, which JP 1-02 defines as: "That degree of air superiority wherin the opposing force is incapable of effective interference within the operational area using air and missile threats.")
[30] Hand held drones are available on Amazon.com for as little $50. Diydrones.com offers complete "one-stop shopping" on the basics of UAS building.
[31] Peter W. Singer, *A Revolution Once More: Unmanned Systems and the Middle East,* November 2009. http://www.brookings.edu/research/articles/2009/10/11-robotic-revolution-singer (accessed December 29, 2014).
[32] Associated Press, "Iran Deploys Suicide Drone for First Time," *CBS News.* December 27, 2014. http://www.cbsnews.com/news/iran-deploys-suicide-drone/ (accessed December 27, 2014).
[33] Kelsey D. Atherton, *Iran's Drone Bombs will be Pretty Lousy Cruise Missiles* (December 30, 2014), http://www.popsci.com/irans-drone-bombs-will-be-terrible-cruise-missiles (accessed December 30, 2014).
[34] Naval Research Advisory Committee, "Marine Corps Capabilities for Countering Precision Weapon Threats," *2011 Study Sponsored by CG, MCCDC,* (Quantico, 2011), slide 11.
[35] Ibid, slide 11.
[36] LtCol Michael Cancellier, "United States Marine Corps Initial Capabilities Document for Counter Guided Rockets, Artillery, Mortars, and Missiles (G-RAMM), (March 2012), 6-7.
[37] Hammond III and Cancellier, "Precision Munitions: Defeating the challenge," 46.
[38] Naval Research Advisory Committee, "Marine Corps Capabilities for Countering Precision Weapon Threats."
[39] Christopher J. Castelli, "Key Changes Urged in Amphibious Ops to Counter Precision Weapons," *Inside the Pentagon* 28, no. 19 (May 2012).
[40] Jane's Radar and Electronic Warfare Systems, *AN/TPS-80 Ground/Air Task Oriented Radar (G/ATOR).* Nov 24, 2014. https://janes-ihs-com.lomc.idm.oclc.org/CustomPages/Janes/DisplayPage.aspx?DocType=Reference&ItemId=++++1381438&Pubabbrev=JREW (accessed Dec 28, 2014).
[41] Luis Martinez, "See the Navy's New Futuristic Laser Weapon in Action," *ABC News.* Dec 10, 2014. http://abcnews.go.com/Politics/navys-futuristic-laser-weapon-action/story?id=27507405 (accessed Dec 28, 2014).

[42] Ibid.
[43] Headquarters Marine Corps, Aviation Department, *2015 Marine Aviation Plan* 2015, 4.1.30. https://vcepub.tecom.usmc.mil/sites/directorates/mtesd/asb/ATS/Secondary%20Web%20part%20pages/LAAD.aspx (accessed December 28, 2014).
[44] Ibid.
[45] Ibid.
[46] Ibid. The GBAD HEL concept is not a program of record as of the writing of this paper. Current research and development projections call for a 30kw HEL mounted on a HMMWV to be tested sometime in Fiscal Year 2017 with the possibiliy of becoming a program of record in 2018.
[47] Major Mike Kutsor, "APX SHORAD WC Brief," (Sep 2014), slide 18. Obtained via email by the author.
[48] *2015 Marine Aviation Plan*, 2.2.3.
[49] Ibid, 2.2.4.
[50] Ibid, 2.2.7.
[51] Vick, *Snakes in the Eagle's Nest,* 87.
[52] Ibid, 87.
[53] Kutsor, "APX SHORAD WC Brief,"
[54] These numbers are a product of the work of Colonel Michael Morris, Director, School of Advanced Warfighting (SAW) for his Ground Combat Element (GCE) Offensive and Defensive Operations seminar at SAW, AY 2014-2015.
[55] Vick, *Snakes in the Eagle's Nest*, 108.
[56] *2015 Marine Aviation Plan*, 2.2.7.
[57] Jane's Land-Based Air Defense, *Common Air Defense Launcher (CADL).* Dec 03, 2013. https://janes-ihs-com.lomc.idm.oclc.org/CustomPages/Janes/DisplayPage.aspx?DocType=Reference&ItemId=+++1363599&Pubabbrev=JLAD (accessed Dec 28, 2014).
Raytheon and General dynamics have created a Common Air Defense Launcher (CADL). This HMMWV mounted system includes an AMRAAM, AIM-9X, 4 Stinger missiles, and a GAU-19 12.7 mm Gatling gun. I include this note here because I think having the Stingers and a system not unlike the GAU-19 should provide the foundational weapons makeup of the LAAD Bn. There is a mounted and dismounted, offensive and defensive capability to both weapons. With future technological systems, a possibility exists for radar guidance of both weapons. For example, the GAU could end up operating like the Navy's Close in Weapons System (CIWS).
[58] John E. Montemayor, "G-RAMM update paper" (August 6, 2010), 2. This is a document provided to Marine Corps Command Development Command on the status of programs and progress in USMC counter G-RAMM. This document was obtained via email by the author.
[59] Major Kenneth W. Phelps, "A New Defense Battalion for the MAGTF?" Master of Military Studies Paper (Quantico: Marine Corps Command and Staff College, 2009).
[60] Ibid, 3-4.
[61] *2015 Marine Aviation Plan*, 2.2.4.
[62] Commandant of the Marine Corps, *Low Altitude Air Defense Battalion Training and Readiness Manual*, NAVMC 3500.57A, November 22, 2011, 1-3, http://www.marines.mil/Portals/59/Publications/NAVMC_3500.57A_1.pdf

[63] While having a G/ATOR organic to the LAAD Bn would be highly beneficial, it is also highly unlikely that will ever happen. However, other systems are available. For example, SRC is developing a counter-UAS HMMWV mounted radar that is the same size of the counter-IED systems with which HMMWVs were equipped beginning with the latter stages of OIF. More information on this system is available at: http://www.srcinc.com/what-we-do/ew/counter-UAS.aspx

Bibliography

Amos, James F. "Read Camp Bastion Attack Investigation Documents." *The Official Website of the US Marine Corps.* September 30, 2013. http://www.hqmc.marines.mil/Portals/142/Docs/CMC%20Memo%20for%20the%20Record%20in%20Bastion%20Investigation.PDF (accessed October 28, 2014).

Anonymous. "Changes coming in Ground-Based Air Defense." *Marine Corps Gazette* 78, no. 8 (August 1994): 6.

Associated Press. *CBS News.* December 27, 2014. http://www.cbsnews.com/news/iran-deploys-suicide-drone/ (accessed December 27, 2014).

Atherton, Kelsey D. *Iran's Drone Bombs will be Pretty Lousy Cruise Missiles.* December 30, 2014. http://www.popsci.com/irans-drone-bombs-will-be-terrible-cruise-missiles (accessed December 30, 2014).

Burton, Brian M. "Looking Beyond the EFV." *Proceedings* (United States Naval Institute) 137, no. 1 (Jan 2011): 58-62.

Cancellier, LtCol Michael. "United States Marine Corps Initial Capabilities Document for Counter Guided Rockets, Artillery, Mortars, and Missiles (G-RAMM)." (March 2012).

Castelli, Christopher J. "DOD Aims to Boost Investment in Capabilities for Major Power War." *Inside the Pentagon's Inside Missile Defense* 17, no. 20 (Oct 2011).

Castelli, Christopher J. "Key Changes Urged in Amphibious Ops to Counter Precision Weapons." *Inside the Pentagon* 28, no. 19 (May 2012).

Castelli, Christopher J. "Pentagon Poised to Announce New Multiservice AirSea Battle Office." *Inside the Pentagon's Inside the Navy* 24, no. 44 (Nov 2011).

Chairman, U.S. Joint Chiefs of Staff. "Countering Air and Missile Threats." *Joint Publication (JP) 3-01.* Washington, DC: CJCS, March 23, 2012.

—. "DOD Dictionary of Military and Associated Terms." *Joint Publication (JP) 1-02, as amended through 15 Nov 2014.* Washington, DC: CJCS, November 8, 2010.

Clark, Colin. "New Weapons Spell Death for Drones." *Breaking Defense.* Oct 13, 2014. http://breakingdefense.com/2014/10/new-weapons-spell-death-for-drones-the-countermeasure-dance/ (accessed Dec 28, 2014).

Commandant of the Marine Corps. *Low Altitude Air Defense Battalion Training and Readiness Manual.* NAVMC 3500.57A, November 22, 2011. http://www.marines.mil/Portals/59/Publications/NAVMC_3500.57A_1.pdf

Costello, Major Patrick. "Capability Gaps Caused by Army Modularity: A Need for Air Defense at the Tactical Level." *Master of Military Studies Paper.* Quantico, VA: US Marine Corps Command and Staff College, 2009.

Doubleday, Justin. "Officials Unveil Surveillance Blimp Ahead of Three-Year Operational Test." *Inside the Pentagon's Inside Missile Defense* (http://search.proquest.com.lomc.idm.oclc.org/docview/1639927803?accountid=14746) 20, no. 26 (December 2014).

Douhet, Giulio. *The Command of the Air.* Washington, D.C.: Office of Air Force History, 1983.

Headquarters Marine Corps. *Expeditionary Force 21.* Washington, D.C.: Department of the Navy, 2014.

Gormley, Dennis M. "Globalization and WMD Proliferation Networks: The Case of Unmanned Air Vehicles as Terrorist Weapons." *Strategic Insights* (Center for Contemporary Conflict) V, no. 6 (July 2006).

Gray, Colin S. *Another Bloody Century: Future Warfare.* London: Phoenix, 2005.

Hammond III, LtCol James W, and LtCol Mike Cancellier. "Precision Munitions: Defeating the challenge." *Marine Corps Gazette*, January 2013: 45-49.

Headquarters Marine Corps, Aviation Department. *2015 Marine Aviation Plan.* 2015. https://vcepub.tecom.usmc.mil/sites/directorates/mtesd/asb/ATS/Secondary%20Web%20part%20pages/LAAD.aspx (accessed December 28, 2014).

Isley, Jeter A. and Phillip A Crowl. "The US Marines and Amphibious War." Princeton: Princeton University Press, 1951.

Janay, Jesse. "Cloak Blade UAS." *Marine Corps Gazette* 97, no. 11 (November 2013): 50-53.

Jane's International Defence Review. *US Navy pushes resurgence in DEW interest.* 07 24, 2012. https://janes-ihs-com.lomc.idm.oclc.org/CustomPages/Janes/DisplayPage.aspx?DocType=News&ItemId=+++1515573&Pubabbrev=IDR (accessed Dec 28, 2014).

Jane's Land-Based Air Defense. *Common Air Defense Launcher (CADL).* Dec 03, 2013. https://janes-ihs-com.lomc.idm.oclc.org/CustomPages/Janes/DisplayPage.aspx?DocType=Reference&ItemId=+++1363599&Pubabbrev=JLAD (accessed Dec 28, 2014).

Jane's Radar and Electronic Warfare Systems. *AN/TPS-80 Ground/Air Task Oriented Radar (G/ATOR).* Nov 24, 2014. https://janes-ihs-com.lomc.idm.oclc.org/CustomPages/Janes/DisplayPage.aspx?DocType=Reference&ItemId=+++1381438&Pubabbrev=JREW (accessed Dec 28, 2014).

Jean, Grace V. "Fighting at the Speed of Light." *National Defense* (http://search.proquest.com.lomc.idm.oclc.org/docview/213373045?accountid=14746) 94, no. 669 (August 2009): 34-36.

Kutsor, Major Mike. "APX SHORAD WC Brief." Sep 2014.

Martinez, Luis. "See the Navy's New Futuristic Laser Weapon in Action," *ABC News.* Dec 10, 2014. http://abcnews.go.com/Politics/navys-futuristic-laser-weapon-action/story?id=27507405 (accessed Dec 28, 2014).

Mintz, Major John Paul F. "Asymmetric Air Warfare: A Paradigm Shift for US Air Superiority." *Naval War College Paper.* Newport, RI, May 2013.

Naval Research Advisory Committee. "Marine Corps Capabilities for Countering Precision Weapon Threats." *2011 Study Sponsored by CG, MCCDC.* Quantico, 2011.

Phelps, Major Kenneth W. "A New Defense Battalion for the MAGTF?" *Master of Military Studies Paper.* Quantico: Marine Corps Command and Staff College, 2009.

Political Transcript Wire. "Sen. Joseph I. Liberman holds a Hearing on the Current and Future Roles, Missions, and Capabilities of U.S. Military Land Power." March 30, 2009.

Singer, Peter W. *A Revolution Once More: Unmanned Systems and the Middle East.* November 2009. http://www.brookings.edu/research/articles/2009/10/11-robotic-revolution-singer (accessed December 29, 2014).

SRC Incorporated. *Counter UAS Systems.* http://www.srcinc.com/what-we-do/ew/counter-uas.aspx (accessed Dec 28, 2014).

Thomas, Jim. "House Armed Services Subcommittee on Emerging Threats and Capabilities Hearing." *Congressional Documents and Publications.* Lanham: Federal Information and News Dispatch, Inc, 2011.

U.S. Department of Defense. *Quadrennial Defense Review 2014.* Washington D.C.: Secretary of Defense, 2014.

U.S. Department of Defense. *Sustaining U.S. Global Leadership: Priorities for 21st Century Defense (Defense Strategic Guidance).* Washington D.C.: Secretary of Defense, 2012.

Vick, Alan. *Snakes in the Eagle's Nest: A History of Ground Attacks on Air Bases.* Santa Monica, Ca: RAND, 1995.

Von Clausewitz, Carl. *On War.* Edited by Michael Howard and Peter Paret. Princeton, NJ: Princeton University Press, 1976.

Work, Honorable Robert O. "Post-Afghanistan Marine Corps." *Marine Corps Gazette* 94, no. 11 (Nov 2010): 106-111.