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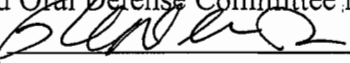
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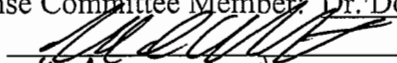
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Executive Summary

Title: A MAG for the Twenty First Century: Lethal, Lighter, Energy Efficient, and Cheaper

Author: Major Matthew A. Brown, United States Marine Corps

Thesis: The Marine Corps should acquire the OV-10X, a fixed wing light attack aircraft, and group that newly formed squadron with future Unmanned Aircraft System (UAS) squadrons and the newly armed KC-130 squadrons into a common Marine Aircraft Group (MAG) in order to achieve several significant goals.

First, this proposal addresses the MV-22 Osprey escort gap and the training and personnel limitations of the UAS and KC-130 communities by establishing a primary career path for UAS officer aircrew and integrated aircrew training across all three squadrons.

Second, it provides a model to supply additional U.S. Marine Corps airframes, in support of an identified U.S. Air Force and U.S. Navy strike-fighter shortfall, while simultaneously reducing Marine aviation and logistical fuel requirements for the Marine Air Ground Task Force (MAGTF) in the most likely conflicts requiring a persistent forward presence.

Third, the proposed organization facilitates the most effective combat employment of all Marine Tactical Air (TACAIR) assets and UASs, resulting in several positive effects across the spectrum of the Marine Air Ground Task Force (MAGTF) through the efficient use of assets, training, time, and money.

The proposed twenty-first century MAG yields an Aviation Combat Element (ACE) that provides strategic, operational, and tactical flexibility to the MAGTF commander, while continuing to provide the Ground Combat Element (GCE) with increased time on station coverage and the highest level of Close Air Support (CAS) execution. Furthermore, the organization of the ACE helps to preserve the service life of the Joint Strike Fighter (JSF) or F-35B; and allows time for UAS technology to continue to mature as the Marine Corps defines its aviation assets for the future beyond 2030.

Discussion: Marine aviation is in a period of transformation and acquisition with continually emerging technology and weapon systems. The combination of the MV-22 Osprey, RQ-7B Shadow, CH-53K, JSF, and the armed KC-130J Harvest Hawk will bring amazing capability to the MAGTF. Yet, potential changes to organization, command relationships, personnel, aviation training, and cost have received insufficient focus. Close analysis on these necessary changes will influence the employment of these new capabilities and expose gaps in Marine aviation's ability to support the MAGTF or the joint force commander.

The employment gaps identified within this study are minor when considered individually, but when taken together they result in significant inefficiencies and a net loss of capability for the MAGTF. The current Marine aviation vision for TACAIR and UASs does address all mission and skills; however, it is grossly inefficient within two main areas, assault support escort and fixed wing persistent presence in permissive threat environments.

First, as the MV-22 Osprey becomes the main combat assault support transport asset in the Aviation Combat Element (ACE); it still lacks a true escort capability. While the UH-1Y and

AH-1Z rotary wing aircraft provide phenomenal escort capability, they cannot fly fast enough or far enough for the Osprey. The JSF is a capable escort for the Osprey based on speed and distance, yet without aerial refueling, it lacks the time on station required for most assault support missions. Additionally, it lacks the ability to rapidly suppress and neutralize targets in the objective area the way a helicopter can with high off boresight cannons or door guns.

Second, while the JSF is a fifth generation aircraft, in that it is a stealth fighter capable of supersonic flight equipped with advanced sensors, fire control, and data-link systems unavailable today, it has the severe limitation common to today's legacy strike fighters. It is unable to provide an un-refueled persistent presence overhead an area within a permissive environment better than an FA-18 or AV-8B. In many mission areas, it is true that four JSFs equal the combat power of at least six FA-18s, 2 EA-6Bs and four AV-8Bs combined. However, in many core missions such as Close Air Support (CAS), Armed Reconnaissance (AR), Strike Coordination and Armed Reconnaissance (SCAR), and Forward Air Controller (Airborne) (FAC(A)), where time on station is a critical capability, the JSF does very little to improve on Marine aviation's current capability.

Recommendation: The proposed re-organization of the MAG and the acquisition of the OV-10X aircraft provide the MAGTF commander an efficient complementary mix of aircraft, ideally employing every airframe. UAS, OV-10X, and KC-130 aircrew could serve as permissive mission environment air to ground experts and fill other limited roles in major conventional combat operations, while the JSF community would focus on advanced missions requiring its capabilities such as destruction of strategic air defenses.

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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Preface

The genesis of my concept and significant portions of my research occurred while I was an instructor at the Marine Aviation center-of-excellence, Marine Aviation Weapons and Tactics Squadron-1 (MAWTS-1). Several significant events combined to shape the emerging concept. First, as an aviation fires expert and the FA-18 Forward Air Controller Airborne (FAC(A)) program manager, I was directed to further UAS integration in major theater combat scenarios, which revealed the strengths and weaknesses of the Marine UAS community. Second, within MAWTS-1, I was assigned as the lead FA-18 representative for initial KC-130 Harvest Hawk, the new armed variant of the KC-130, tactics, techniques, and procedures development, which exposed the challenges the KC-130 community will face specific to training and personnel. Lastly, over four years at MAWTS-1, I was involved on a limited basis in JSF integration into the MAGTF. I am well aware of the tremendous capabilities the JSF will add to the MAGTF and of its limitations. Marine TACAIR will continue to accomplish all of its missions, but I am convinced that those missions can be accomplished more efficiently and effectively. My desired end state is to propose a realistic and achievable vision that maximizes and fully integrates all of the Marine aviation transformation programs while addressing gaps in capability. It is my belief that this is a proposal that can be rapidly executed without sacrificing any of Marine aviation's current initiatives.

It is important to note that each aspect of this project is of sufficient magnitude to merit individual study; however, I have studied the proposal as a whole to uncover the combined gains of the entire concept for the MAGTF, and how it may be rapidly implemented. With that in mind, this study analyzes the creation of the Marine Fixed Wing Light Attack squadron (VMLA) and the re-organization of the current fixed wing MAGs. Further, it studies the possible

requirements towards implementation using the Department of Defense (DoD) accepted decision-making tool, Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, Facilities, and Cost (DOTMLPF-C). For clarity, the study is organized accordingly: aviation-training, organization and command relationships, doctrine, personnel, materiel acquisition, logistics instead of leadership and education, facilities, and cost.

Dedication

I would be thoughtless not to acknowledge the wealth of assistance I have received. Midway through the year, I lost my mother to cancer; I would like to thank Dr. Paul Gelpi for his mentorship and understanding throughout this endeavor. My gratitude and respect is also owed to Marine Majors Nick “Tard” Neimer and Scott “Shoe” Schoeman for their input into my concept and pointing out the copious challenges for implementation. Additionally, I must acknowledge the tremendous research support of the world’s greatest research librarian, Miss Rachel Kingcade. Finally, I must acknowledge the support and patience of my loving wife, who endured much this year at the expense of my research efforts. Without all of them, this concept would still be on a bar napkin in the Marine Corps Air Station Yuma Officer’s Club.

Table of Contents

	Page
EXECUTIVE SUMMARY.....	i
DISCLAIMER	iii
PREFACE	iv
DEDICATION	v
DEFINING THE PROBLEM	1
ISSUES ONE THROUGH FIVE.....	2
PROPOSED SOLUTION	5
PART I: AVIATION TRAINING	6
PART II: ORGANIZATION / COMMAND RELATIONSHIPS	11
PART III: DOCTRINE	13
PART IV: PERSONNEL	16
PART V: MATERIEL, LOGISTICS, FACILITIES.....	19
PART VI: COST	24
CONCLUSIONS / RECOMMENDATIONS	28
APPENDIX A: ILLUSTRATIONS	31
APPENDIX B: TABLES	33
APPENDIX C: U.S. MARINE CORPS OA-X REQUIREMENTS.....	39
GLOSSARY.....	45
END NOTES.....	52
BIBLIOGRAPHY	59

Defining the Problem

We need to be thinking about how we accomplish the missions of the future – from strike to surveillance – in the most affordable and sensible way...For those missions that still require manned missions, we need to think hard about whether we have the right platforms. Whether, for example, low-cost, low-tech alternatives exist to do basic reconnaissance and close air support in an environment where we have total command of the skies – aircraft that our partners can also afford and use.

-Secretary of Defense Robert M. Gates¹

In an effort to maintain a balanced and relevant force for conventional operations against peer competitors, as well as persistent operations in permissive environments, the Secretary of Defense (SECDEF) gave the U.S. Air Force its marching orders to explore, define and acquire light attack aircraft capability in addition to its fifth generation advanced strike-fighters. Taking its cues from the SECDEF's guidance to the U.S. Air Force, the U.S. Navy initiated its own study of the light attack concept, known as Imminent Fury, and will conduct a combat deployment test of concept in 2010.² Recently, 3D Marine Aircraft Wing (MAW) assigned officers to study the light attack concept, but the Marine Corps as an institution has yet to evaluate or act upon this guidance relative to its Marine Aviation transformation vision.³

A Marine Solution for a Marine Problem

As a military organization with a significant aviation component, the U.S. Marine Corps should evaluate and integrate as appropriate the SECDEF's guidance to the U.S. Air Force; however, the result should be a uniquely Marine answer by balancing the ideal mix of aircraft, technology, personnel, training, and cost. Advanced technology strike fighters are not the only or the complete answer to twenty-first century warfare.

Issue 1: MV-22 Escort Capability

The MV-22 Osprey is rapidly becoming the primary asset providing combat assault support transport. This study has revealed a gap; the Osprey has no optimal escort. During Aero scout missions in Operation Iraqi Freedom (OIF) 2007, the ideal attached escort in the landing zone, the AH-1W and UH-1N helicopters, limited the MV-22s mobility over the large Al Anbar province because of their increased logistical requirements for fuel.⁴ Although the FA-18 and AV-8B are capable escorts, they lack the ability to provide similar perspective to the assault support aircraft, and most notably, high off boresight instantaneous cannon fires of the Cobra and Huey variants (see Appendix C, 39.e). These limitations will not change with the Joint Strike Fighter (JSF) / F-35B.⁵

Issue 2: Development of Offensive Air Support (OAS) Expertise within Marine Unmanned Aerial Vehicle Squadrons (VMU) and Marine Aerial Refueler Transport Squadron (VMGR)

With the introduction of weaponized unmanned aircraft systems (UAS) and the armed KC-130J, or Harvest Hawk, both communities will be unable to maximize the employment of their platforms, weapon systems, and capabilities due to current aircrew training and personnel limitations.⁶

Issue 3: Strike Fighter Shortfall / Joint Asset Reality

As both the U.S. Air Force and Navy have identified significant future shortfalls in strike-fighter inventories within the next ten to fifteen years, the Marine Corps must realize that its JSF force could easily become tasked as a national asset in the same manner that the EA-6B has been tasked for years since the retirement of the EF-111.⁷ The incorporation of a fixed wing light

attack aircraft into the Marine Air Ground Task Force (MAGTF) would provide fixed wing OAS that likely would not be taken from the operational control of the MAGTF commander.

Issue 4: Efficient Energy Use and Aircraft Time on Station

The 2010 Quadrennial Defense Review requires the Department of Defense (DoD) to become more energy efficient where feasible while not sacrificing war fighting capability.⁸ The reality that augmentation of the F-35B force by a light attack aircraft that uses approximately 15% of the fuel to provide the same amount of on station time in permissive environments cannot be ignored. A Marine Expeditionary Brigade (MEB), composed of about 15,000 troops, uses about 500,000 gallons of fuel a day. Approximately 73 % of the fuel goes to aviation, 17 % to logistics and 11 % to ground combat vehicles. Of that 73 % of fuel going to aviation, about 75 % is for fixed wing aviation operations.⁹ The addition of a light attack aircraft not only reduces fuel required, but also reduces aerial refueling sorties required, further providing for the service lifetime extension of both KC-130Js and F-35Bs.

Issue 5: Rising Costs of Advanced Technology

As acquisition and operating costs of complex technology increase exponentially, it is incumbent upon Marine aviation to provide a force that balances capability, efficiency, and effectiveness while maintaining an organization and culture able to remain flexible, agile and adaptive to future warfare.¹⁰ The concept of light attack aircraft is not a low technology solution; it is a right technology solution. Forget the vision of ancient propeller aircraft that lacked precision munitions and Aircraft Survivability Equipment (ASE). Instead, envision a modern glass cockpit completely inter-operable into any data-link architecture including digitally aided close air support (CAS) systems, and command and control (C2) architecture with modern

defensive systems, thus making it as survivable or more so than the rotary wing assets and the MV-22 Osprey it will integrate with on the battlefield.¹¹ Take the rugged, austere capability of those venerable predecessors and add the precision, accuracy and survivability systems of the most modern strike fighter systems and you have today's light attack aircraft, specifically the AT-6B Texan, the A-29 Super Tucano, and the OV-10X Bronco.

Proposed Solution:

Today's approach of loitering multi-million dollar aircraft...is not the most effective use of aviation fires in this irregular fight. A Light Attack Armed Reconnaissance (LAAR) aircraft capability has the potential to shift air support from a reactive threat response, to a more proactive approach...

-General James N. Mattis, USMC, Commander, USJFCOM¹²

The Marine Corps should acquire the OV-10X, a fixed wing light attack aircraft, and group that newly formed squadron with future Unmanned Aircraft System (UAS) squadrons and the newly armed KC-130 squadrons into a common Marine Aircraft Group (MAG) in order to achieve several significant effects. First, this proposal addresses the MV-22 Osprey escort gap by recommending the acquisition of a fixed wing light attack aircraft. Second, the training and personnel limitations of the UAS and KC-130 communities is addressed by establishing a primary officer career path for UAS aircrew and integrated aircrew training across all three squadrons. Third, the proposal provides a model to supply additional U.S. Marine Corps airframes, in support of an identified U.S. Air Force and U.S. Navy strike-fighter shortfall, while simultaneously reducing Marine aviation and logistical fuel requirements for the Marine Air Ground Task Force (MAGTF) in the most likely conflicts requiring a persistent forward presence. Fourth, the proposed organization facilitates the most effective combat employment of all of Marine Tactical Air (TACAIR) assets and UASs, via an efficient use of assets, training, time, and money resulting in several positive effects across the MAGTF.

Additionally, this concept provides the MAGTF commander with an aviation combat element (ACE) which provides strategic flexibility through energy efficiencies, and controlled costs. Operational and tactical flexibility are provided through risk mitigation to a single fixed wing OAS capability while providing multiple basing options. This guarantees the Ground Combat Element (GCE) will continue to receive the high level of expertise in OAS, specifically the Close Air Support (CAS) the GCE expects from the ACE. Furthermore, this concept will significantly aid in the extension of the service life of the JSF fleet by equipping the ACE with another fixed wing attack asset that can efficiently provide persistent presence through increased time on station. Finally, this proposed organization is envisioned to last until approximately 2030 at which time, modular, multi-role UAS technology should be mature enough and affordable enough to replace the fixed wing light attack aircraft.

Part I: Aviation Training

The platform matters, but not as much as the man controlling it in an integrated environment...I can honestly say that we would have had more kills than the entire ACE here (Afghanistan) if we were weaponized.

- LtCol J.W. "Chewy" Frey, Commanding Officer VMU-3¹³

The single-minded intent of aviation training under this proposal is to develop OAS excellence within permissive mission environments within the VMU, VMGR, and Fixed Wing Light Attack squadron (VMLA) squadrons. Both the VMU and the VMGR squadrons have similar training obstacles to overcome, and the forced integration of aircrew training across all three units will facilitate the development of OAS proficiency and competency.

Historically, most UAS missions in the Marine Corps are tasked and controlled by the intelligence community. While providing significant intelligence to the MAGTF, the non-doctrinal tasking has not allowed the VMU squadron a smooth transition for being tasked by an

Air Tasking Order cycle in support of a ground commander.¹⁴ It is likely that the RQ-7B Shadow UAS will carry weapons in the near future, but it is already equipped with a laser designator and is more than capable Terminal Guidance Operations (TGO). However, as there is no aviation experience pre-requisite to be UAS Mission Commanders (MCs) many have little to no experience with aviation fires. While the formal training model does not currently exist to properly develop all UAS MCs, in VMU-3, every MC now attends Forward Air Controller Airborne (FAC(A)) ground school and receives academics in armed reconnaissance doctrine and tactics.¹⁵ These are significant improvements due in large part to the personal drive of their commanding officer. Meanwhile, the U.S. Air Force currently trains all MQ-9 Reaper aircrew in CAS execution.¹⁶

Looking at the VMGR, the only inherent experience with aviation fires beyond battlefield illumination resident within the squadron is from any previously qualified Forward Air Controller (FAC) / Joint Terminal Attack Controller (JTAC) who is back in the squadron after a ground officer tour. To address this in the near term, the KC-130 community will receive an experience loan in the form of TACAIR Naval Flight Officers (NFOs) and pilots. The program's intent is to ensure that the VMGR community has a solid foundation of aviation fires experience prior to the cessation of the TACAIR NFO supply.¹⁷ Furthermore, Harvest Hawk is unique in that while several crewmembers are required to operate the KC-130J, only two are actively involved in the execution of aviation fires: the pilot and the Fire Control Officer (FCO). Remaining crewmembers still have tasks that are constant to all VMGR missions such as visual lookout responsibilities and systems management.¹⁸

Additionally, both the VMU and VMGR have similar requirements as far as numbers and quality of trained crews capable of executing the emerging mission tasks relating to aviation

fires. Neither unit (VMU or VMGR) needs to have the majority of the squadron qualified and proficient in OAS skills. The long term sourcing of FCOs and the specific Marine Corps Tasks (MCTs) that Harvest Hawk will fulfill are unknown. Currently, a VMGR anticipates that it will only require three crews of 16 available to be qualified for OAS missions.¹⁹ Both units require the small cadre of trained crews to be highly skilled aircrew, able to execute without oversight and responsible for the development of Tactics, Techniques, and Procedures (TTP) as neither is inheriting a mature combat system, or will have resident expertise to rely on as current Marine OAS platforms AH-1 / UH-1, FA-18, AV-8B.²⁰ In this type of environment, there is a strong tendency for tactical development to stagnate. In an effort to prevent the blind leading the blind and mitigate the tactical risk of fratricide, these units deserve a training model that will allow them to succeed.

The question of how a VMU should train towards excellence in aviation fires is not within the scope of this study. Looking to 2030, all UASs in the Marine Corps above Group 1 should be assigned to the VMU squadrons.²¹ Assuming the logistics UASs reside within a VMU, an individual UAS aircrew's career progression would be very similar to that of today's FA-18D Weapons Systems Officer (WSO) or EA-6B Electronic Counter-Measures Officer (ECMO).²² At minimum, UAS operators and mission commanders must think of themselves as aviators and take a rigorous approach to develop pride and ownership of their Military Occupational Specialty (MOS) community. To foster development of the UAS community, the Marine Corps must establish the UAS officer aircrew as a primary MOS. UAS aircrew would be designated and winged NFOs upon completing an initial course of instruction similar to Aviation Pre-flight Indoctrination (API) and NFO primary training.²³ Second tour aviation command and control officers (MOS 7200 field) would complete the same UAS primary MOS course and would be

ideal to cross train in the VMLA, thus developing the aviation command and control field as aviators while taking advantage of their tremendous C2 background. Once assigned to an operational VMU squadron, they would conduct initial UAS training and execution on logistics and intelligence missions. As the UAS aircrew builds proficiency and knowledge similar to any other aviator's Training and Readiness (T&R) model, they would eventually progress into missions working for ground commanders involving aviation fires.²⁴ Qualified UAS aircrew on their second VMU tour would be identified to cross train in the VMLA squadron and / or the VMGR squadron as FCOs with advanced qualifications and designations as Weapons and Tactics Instructor (WTI). This lateral movement within the MAG would serve to deepen the development and broaden the experience base of all aircrew.

The intent for VMGR training under this model is to develop highly trained executors of OAS without burdening the VMGR squadron. The current Deputy Commandant for Aviation (DCA) directed that the training syllabus for Harvest Hawk aircrew would be seven sorties, requiring approximately 17.5 flight hours. The draft T&R for core skills and mission skills phase will likely have 10-11 sorties, requiring approximately 25-27.5 flight and simulator hours. Additional training sorties will be added to the core plus skills and mission plus sections of the T&R manual to develop advanced mission skills.²⁵ While these training requirements may not seem high, they will have an impact on a VMGR's ability to provide assault support and effect current training timelines for those assault support missions.²⁶

Under the proposed model, qualified KC-130 pilots with JTAC experience would cross train in the VMLA squadron to develop crew coordination skills, mission tactics expertise in CAS, FAC(A), Armed Reconnaissance (AR), and Strike Coordination and Reconnaissance (SCAR). Once that is achieved to a proficient level, pilots and Fire Control Officers (FCOs) would

complete a minimized flight syllabus in the Harvest Hawk focused on the employment of combat systems. Furthermore, the intent is that the VMGR would not have to develop FCOs from within the squadron. Highly qualified second tour VMU and VMLA NFOs would be selected to cross train in the Harvest Hawk platform, and train along side the KC-130 pilots selected for the mission. This reduces KC-130 training sortie requirements while generating the expertise for the KC-130 community who already have a full T&R without additional Harvest Hawk missions.

Finally, the VMLA squadron will be responsible for tactical standardization, development, and will also significantly aid the growth of aviation fires knowledge within the VMU and VMGR communities. Initially, the VMLA will be established with highly experienced aircrew as the Marines sundown, or retire, the FA-18, AV-8B, and EA-6B. Over time, a small requirement for Category One (CAT 1) pilots and NFOs will arise with training time very similar to that of the UAS aircrew described above. Their initial training will take a fraction of the time it takes to train any current strike-fighter aviator. Cross training will occur in two manners. First, Pilots and NFOs from the VMLA will cross train in the VMU and VMGR communities to bring their knowledge and expertise into those units akin to Marine Aviation Weapons and Tactics Squadron-1 (MAWTS-1) instructors flying in squadrons during OIF I to provide extra highly qualified aircrew.²⁷ Second, qualified and selected UAS aircrew and KC-130 pilots will cross train in the VMLA to develop their fires expertise.

This proposal does not incur an increase in flight hours for either the VMU or VMGR. The addition of the VMLA reduces the F-35B's requirement to support JTAC / Joint Fires Observer (JFO) training and allows the F-35B community to focus on other core missions. Furthermore, significantly more integrated training will be available to the GCE, specifically for JTAC / JFO training, as the VMLA's primary focus is support to the GCE.²⁸

Part II: Organization / Command Relationships

Future operational environments will place a premium on agile expeditionary forces, able to act with unprecedented speed and versatility in austere conditions against a wide range of adversaries. We must be a two fisted fighter — able to destroy enemy formations with our scalable air-ground-logistics teams in major contingencies, but equally able to employ our hard earned irregular warfare skills honed over decades of conflict.

- USMC Commandant, General James T Conway²⁹

Current Organization

In order to appreciate the impacts of this study's proposed re-organization, past, and present organization and command relationships must be understood. Marine UASs (VMU) were initially organized under the MAG, but migrated to the Marine Air Control Group (MACG) based on the high C2 requirements to deconflict, rather than integrate UASs in Marine airspace.³⁰ This schism between the aviation and the UAS community is illustrated by the location of instructors at MAWTS-1 within the Command, Control, and Communication department (C3), rather than the TACAIR department.

As UAS employment concepts and technology have evolved, the ability to command and control UASs has improved, and the desire to integrate these capable assets with manned aircraft and in direct support of ground operations has grown. As Marines move towards weaponized UASs, they need to maximize their effectiveness as an emerging aviation fires platform, hence the need to return to the MAG. The VMUs currently have highly saturated training and readiness requirements without the additional training requirements for weapons and advanced mission sets, although their T&R is currently in revision to incorporate these requirements.³¹ Additional reasons to re-organize under the MAG are covered in training and doctrine, but include creating more of a squadron ready room culture of standardization and tactical development, increased standardization among aviation fires providers, and clarifying the needed shift to balance UASs working for both Intelligence and Operations.

For the VMGR, no changes are required from its current organization, basing locations, and command relationships; it is already established in TACAIR MAGs. However, from an organizational perspective, what does need to change is the mindset of the MAG with respect to the VMGR. No longer should a VMGR be viewed simply as an assault support asset or, more specifically, as an aerial refueling platform. The MAG needs to embrace its responsibility to provide highly qualified aircrew, initially FA-18D WSOs, to serve as FCOs.

Proposed Organization

What must be stressed when considering this proposed re-organization is that no additional units or headquarters are being created. Units that are currently in cadre status or slated to be established as F-35B units will become the VMLAs. VMGRs will remain as they are, and VMUs will simply move from the Air Control Group into the closest geographical TACAIR MAG. This re-organization is executable and needed.

Once re-organized, the intent for these three squadrons in a common MAG would be to task organized similar to a Marine Expeditionary Unit (MEU) composite squadron in response to the assigned mission. Several different deployment scenarios exist including: the tasked organized composite squadron could deploy under the command of the largest detachment, deploy as a detachment of any individual aircraft as would be done currently, deploy as an entire squadron, and as part of the MAG. These deployment options integrated as part of several different MAGTF options such as a Marine Expeditionary Force (MEF) or a MEB that includes a forward basing option suitable to all aircraft; or a Special Purpose MAGTFs for theater engagement, which is ideal for these aviation units because of the flexibility, and relatively light footprint of these squadrons.

For the re-organization of the VMU and VMLA squadrons, no additional higher headquarters requirements are necessary. Initially, none of the units will need to move from their current home base location.

VMU Squadrons:

1. Move VMU-1, MACG-38, 3D MAW into MAG-11, 3D MAW. Remain based at Marine Corps Air Ground Combat Center, 29 Palms, California.
2. Move VMU-3, MACG-38, 3D MAW into MAG-12, 1 MAW.
3. Move VMU-2 into MAG-14, 2D MAW. Remain based at Marine Corps Air Station (MCAS) Cherry Point, North Carolina.
4. Acquire robust group 4 capability.
5. Eventually co-locate VMLA / VMU / VMGR once UAS airspace issues are resolved with Federal Aviation Administration (FAA).³²

VMLA Squadrons:

1. Establish four operational squadrons and one fleet replacement training squadron of 12 light attack aircraft each.
 - a. Establish two operational squadrons and the fleet replacement squadron in MAG-11 at MCAS Miramar.
 - i. Eventually, base at Marine Corps Air Ground Combat Center, 29 Palms, California.
 - b. Establish two squadrons in MAG-14 at MCAS Cherry Point.

This re-organization facilitates the cross training of aircrew within all three squadrons, while establishing a common higher command, and placing all fixed wing OAS assets including the F-35B within a common MAG facilitating standardization and integration among the ACE.

Part III: Doctrine

Fifty percent of the current (UAS) Mission Essential Tasks (METs) are based on the application of fires. However, tasking and control for UAS employment has been relegated to the Intelligence community for combat operations.

- LtCol J.W. "Chewy" Frey, Commanding Officer VMU-3³³

The proposed organization, equipment, and training of these units centered on the VMLA squadron is most effective for counterinsurgency and irregular warfare operations in permissive threat environments. However, these units have roles in theater level conventional operations.

Each of these units would have capability within the following mission areas as part of a major theater war (MTW): Rotary Wing (RW) escort, FAC(A), Tactical Air Coordinator Airborne (TAC(A)), Multi-sensor Imagery (MSI) or Intelligence, Surveillance, Reconnaissance (ISR), Armed Reconnaissance (AR), and Strike Coordination Armed Reconnaissance (SCAR).³⁴ Complete implementation of the concept will permit the ACE to support both the MAGTF and joint commander more efficiently.

Having evaluated the applicable doctrine specific to the proposed missions of all three units, there are no required changes. Historically and non-doctrinally, Marine UAS assets are tasked and controlled by the intelligence community, but as UASs rapidly expand in capability and mission sets, a balance must be achieved to properly integrate UASs and maximize their capabilities. UASs, capable of serving both intelligence development and support to operational commanders, should be tasked according to their doctrine via an ATO cycle similar to how FA-18Ds are tasked for Tactical Reconnaissance (TACRECCE) missions.³⁵ Of note, impacts to doctrine were limited to joint and service specific doctrine affecting execution of the assigned mission. Other potential doctrinal changes are more appropriately covered previously under organizational and command relationships.

The Six Functions of Marine Aviation

Using the six functions of Marine aviation as a lens to evaluate the capability of these combined units indicates the combination could contribute to all six functions. Reference Appendix B, Table five and six for a detailed description of current and proposed aviation assets and their mission capability. The only current asset meeting some portion of all six functions of Marine aviation is the FA-18D, however, with a limited role in assault support of battlefield illumination and limited command and control role of TAC(A).³⁶ Looking at the proposed ACE

of the future, it becomes evident that the UAS, and KC-130J capability expands into OAS and its subsets of CAS, AR, and SCAR.³⁷ Furthermore, the UAS will expand into electronic warfare, and assault support, specifically air delivery.³⁸ It is clear that the Marine aviation transformation underway will add capability across the spectrum of the six functions.³⁹

While this additional capability looks good in a chart, it is a paper tiger without the VMLA to account for the development of those communities. The proposed VMLA squadrons bring robust capability across all functions of Marine aviation. Within OAS, the VMLA squadron will serve as the ACE experts in the dominant Marine missions of CAS, FAC(A), AR, and SCAR. Furthermore, with the cross training of VMU aircrew, they will develop as visual and sensor reconnaissance experts. The added mission of Assault Support Coordinator Airborne (ASC(A)) in addition to TAC(A) makes the VMLA squadron a very capable platform in the command and control area. Moreover, there is potential for the VMLA to increase capability into electronic warfare, retaining capability in the reactive anti-air warfare area with limited self-protect capability similar to that of an AH-1. The expertise and focus in the OAS mission sets are a significant multiplier to tomorrow's ACE, but the tremendous expansion of capability into assault support missions provides the MAGTF with a true 'jack of all trades' focused on the expected Marine missions.

Under this proposal, existing VMU and VMGR units gain capability through the integration of the VMLA squadrons, and Marine aviation gets more out of what it already plans to have. By spreading OAS capability across more platforms in the ACE, specifically within fluid mission areas of CAS, FAC(A), AR, and SCAR, the ACE gains flexibility. While the F-35B will retain all of the multi-mission capability it is designed for, the addition of the VMLA will allow the F-35B squadrons to focus training and combat execution in the areas the rest of the ACE is unable,

like advanced Electronic Warfare (EW), Deep Air Support (DAS), and Anti-Air Warfare (AAW).⁴⁰ Overall, this proposal supports a more agile, flexible, and efficient use of ACE assets.

Part IV: Personnel

The quality of the box matters little. Success depends upon the man who sits in it.

-Baron Manfred von Richthofen, the Red Baron⁴¹

VMLA personnel

Currently, Marine Aviation's F-35B acquisition plan is for 21 operational squadrons, three Reserve squadrons, three Fleet Replacement squadrons, and one Operational Test and Evaluation squadron.⁴² The initial total number of required F-35Bs, 690, is based on future war requirements studies conducted by the Center for Naval Analyses (CNA).⁴³ However, for various reasons ranging from fiscal constraints, UAS proliferation, and inter-service issues with the U.S. Navy, the total number of F-35Bs for the Marine Corps has dropped three times from 690 to the current number of 420.⁴⁴ In order to meet planned operational commitments, the Marine Corps must maintain 24 or more total squadrons of fixed wing attack assets; however, on-going debates provide signs that the Marines may not get all 420 required F-35Bs. It is unfortunately plausible that the number may fall as low as 380 or even 320.⁴⁵

For the purposes of this proposal, it is an assumption that the Marine Corps would endure another F-35B reduction, and receive 380 F-35Bs total. This results in a net loss of the equivalent of four operational TACAIR squadrons comprised of 10 aircraft each.⁴⁶ Even if the Marines receive all 420 F-35Bs, a MAGTF shortfall of TACAIR could result based on the anticipated U.S. Air Force / U.S. Navy strike-fighter shortfall.⁴⁷ If the Marines only get 380 F-35Bs, that will likely yield a total composition of 20 TACAIR squadrons, 19 operational squadrons and one reserve squadron. With the addition of the four operational VMLA squadrons, the Marines would retain 20 F-35B squadrons, and 24 total TACAIR squadrons. The

organization of operational squadrons and reserve squadrons would be more flexible and is an area for further research.

	Fleet TACAIR Squadrons	Fleet VMFA Squadrons	F-35B Aircraft	Fleet VMLA Squadrons	Light Attack Aircraft
Planned	24	24	420	0	0
Proposed	24	20	380	4	75
Difference	0	-4*	-40	4	75

Table 1: Planned and Proposed TACAIR squadron and aircraft available

*Note: F-35B squadrons are a mix of 10 and 16 aircraft squadrons; this table reflects a loss of four 10 aircraft squadrons.

While it is simplistic, it is also a realistic argument that the loss of four planned TACAIR squadrons combined with the Marine manpower gained from the stand down of the Joint EA-6B, Joint FA-18, and Marine only AV-8B fleet replacement squadrons provides roughly a one to one ratio for personnel to stand-up the five VMLA squadrons for personnel. The current tables of organization for AV-8B, FA-18 A+ / C, FA-18D, and EA-6B show a consistent rate of at least 19 to 20 personnel per airframe; and total personnel numbers meet or exceed the proposed table of organization for the OV-10X squadron.⁴⁸ While the F-35B maintains the same rate of 19 to 20 personnel per airframe, its total personnel strength is less as it has less aircraft in the squadron. Specifically, a ten aircraft F-35B squadron's draft table of organization is a total number of 200 personnel, including 18 officers of which 13 are aviators.⁴⁹ Contrast that with the table of organization for the 1990s Observation squadron (VMO) which flew the retired OV-10D and you see a net increase of 34 total personnel, with a plus up to 39 officers, and 34 aviators, reflecting the dual crewed cockpit of the VMLA aircraft. While the OV-10D table of organization is greater, it has the same personnel to aircraft ratio and two additional airframes.

There are two areas of concern with respect to staffing. The primary area of concern is the additional NFOs required for the VMLA. However, there are sufficient numbers from both the FA-18D and EA-6B communities as the sundown of both platforms continues.⁵⁰ Furthermore, augmenting the VMLA NFOs with aviation trained artillery, infantry, and armor officers on temporary or permanent basis could provide relief if an NFO shortage arises. The second area of concern depends on whether or not the VMLA is established from an existing TACAIR squadron (AV-8B, EA-6B, and FA-18) or from a planned F-35B squadron. If it comes from a JSF squadron, the additional personnel above the 200 available from the F-35B table are an issue. It is expected that the OV-10X table of organization would be reduced approximately 5-10 % based on changes in manpower policy, and maintenance department organization.⁵¹ The additional airframe will require some additive numbers in Marine Aviation Logistic Squadron (MALS), but this is limited to approximately 14 Marines.⁵² At worst case, if all VMLAs came from planned F-35B squadrons, a deficiency of approximately 200 personnel may result.

There are no additional personnel requirements for the VMU or VMGR units that are specific to this proposal. The implications to VMU and VMGR personnel under this proposal are specific to training and career progression and covered earlier in this study.

VMLA Career Progression

Proposed VMLA pilots would initially come from the sundowning communities of FA-18, AV-8B. Generation of new pilots will begin after a limited training pipeline is established. Properly known as CAT 1 pilots, they would complete a much abbreviated flight school syllabus as compared to an F-35B pilot, more similar to a current KC-130 pilot training syllabus. VMLA pilots would have similar career progression models to those of the proposed UAS aircrew and very similar to that of today's NFO or KC-130 pilot.

VMLA NFOs would initially come from the sunsetting communities of FA-18, and EA-6B. CAT 1 NFOs would also be developed via a much abbreviated flight school syllabus that would completely encompass the UAS aircrew and additional flight training, resulting in an NFO initially dual-rated as basic UAS aircrew and basic VMLA aircrew. Once in the fleet as a basic NFO, their training and career progression would be similar to that of a current WSO / ECMO with the additional focus that early in the beginning of their second fleet tour, selected NFOs would begin to cross train on group 4 UASs, and the Harvest Hawk as FCOs throughout the course of their career.

There is no increase in the required total force structure. Marine aviation has planned for 24 TACAIR squadrons and the individuals simply need to be re-allocated to reflect the introduction of the VMLA squadrons. This provides the desired balance of fires expertise in all three squadrons, centered on the VMLA squadron, while minimizing additional training sortie requirements in both the UAS and KC-130 communities.

Part V: Materiel, Logistics, and Facilities

The Secretary of Air Force will: Field ISR, light attack, and light mobility capabilities appropriate for conducting U.S. led operations against irregular adversaries...

- Guidance for the Development of the Force⁵³

Marine aviation should not blindly follow guidance and direction issued to the U.S. Air Force. However, the intent of the direction to the U.S. Air Force is applicable to the future of Marine TACAIR. The Marine Corps needs to acquire two new airframes. First, based on still evolving UAS technology, the Marine Corps should immediately acquire a manned fixed wing light attack aircraft for employment for at least two decades. Second, immediately determine the requirements to develop a timeline for a 2016 Initial Operational Capability (IOC) of a robust group 4 UAS. The defined requirements for both aircraft are in the subsequent sections and

include a recommendation for the specific fixed wing light attack aircraft. As the ideal system to meet all Marine requirements is still in the embryonic stage, no specific Group 4 UAS is recommended.

When determining the requirements for the ideal fixed wing light attack aircraft for the Marine Corps, current U.S. Air Force and U.S. Navy initiatives have been examined. The U.S. Air Force currently has three on-going similar initiatives. The first immediate effort is the Afghan Light Air Support (LAS), a Central Command (CENTCOM) requirement to procure 20 light attack aircraft to establish an indigenous Afghan advanced training and combat flying capability. Second, the Light Attack Armed Reconnaissance (LAAR) effort is a U.S. Air Force program to establish the capacity to train U.S. pilots in a light attack capability to facilitate Building Partnership Capacity (BPC). Third, the potential, future OA-X program is the U.S. Air Force program for an expanded fleet of LAAR aircraft for direct combat employment beyond training U.S. pilots and use in BPC.⁵⁴ LAS and LAAR as well as the U.S. Navy's Imminent Fury program will greatly influence the scope and look of the OA-X program. Marine aviation needs to get involved in the requirements development for the OA-X program; this is the most likely program to provide an aircraft capability meeting Marine Corps needs.

Using the current U.S. Air Force LAAR Capability Request for Information (CRFI) document as a starting point, the following will briefly describe the required capabilities of an airframe meeting the Marine's needs.⁵⁵ Complete detailed system requirements and flight performance characteristics are in Appendix C. The OA-X aircraft the Marine Corps needs varies from some U.S. Air Force concepts in that the Marine Corps is not interested, nor should it be, in acquiring a purely COIN aircraft or in training foreign air forces. The responsibility for those missions should remain with the U.S. Air Force. The Marines; however, do require a light attack aircraft

meeting most of the U.S. Air Force's requirements with additional capability including high off boresight cannons, ability to control multiple UAS in a network denied environment, assault support capability including limited combat assault support transport, air delivery, air logistical support, and tactical recovery of aircraft and personnel, and increased survivability.

Using the U.S. Air Force's LAAR requirements as a baseline for comparison, there are currently three front-runners in the U.S. Air Force's LAAR competition. Each one has a few specific strengths and weaknesses. Embraer's A-29 Super Tucano aircraft is the true off the shelf technology and is already in action with the U.S. Navy under their light attack effort known as the Imminent Fury program.⁵⁶ The Hawker-Beechcraft AT-6B Texan, the attack version of the current U.S. primary flight school trainer aircraft, is developing quickly and boasts avionics by Lockheed-Martin, making it very inter-operable with current and emerging U.S. assets.⁵⁷ Joining the competition late, Boeing's OV-10X is the least developed of the three aircraft, but is the only multi-engine competitor, coupled with the assault support capability previously mentioned.⁵⁸ Upgrades to Marine Corps Air Stations already in progress for the F-35B more than meet the needs of any of the competition aircraft as they all require notably less materiel, logistical and facility support requirements than the F-35B.

Both the AT-6B and the A-29 have great capability and one of them may in fact be the LAAR choice for the U.S. Air Force. The AT-6B has the additional benefit that its trainer variant is already in service with the DoD.⁵⁹ However, the OV-10X's capability goes beyond light attack and includes a logistical, assault support, battlefield mobility, increased survivability, and limited sea basing capability. These capabilities make the re-introduction of the modernized OV-10X Bronco the best answer to the Marine Corps requirements. Furthermore, the additional space in the OV-10X could be used to control multiple UASs from an additional on-board crew station.

The 1960s era OV-10D was capable of taking off in less than 2,300 feet and landing in less than 2,000 feet at an airfield elevation of 2,000 feet and at 40 degrees Celsius, the OV-10X is expected to improve upon that.⁶⁰ The Marine Corps should acquire 75 OV-10Xs to form one fleet replacement squadron and four operational squadrons either through the OA-X program or on its own.

As currently defined by the U.S. Marine Corps UAS Concept of Operations (CONOPS), the modular group 4 UAS the Marine Corps plans to acquire, Marine Corps Tactical UAS (MCTUAS), will possess advantages in speed, range, and payload capability. This will enable its employment by the MAGTF in a variety of missions including intelligence development, target acquisition and identification, electronic warfare, signals intelligence, laser designation, precision strike, Wide Area Airborne Surveillance (WAAS), voice and data communications relay, digital mapping, and shallow water mine detection. The MQ-1 Predator UAS is representative of today's group 4 UASs, but that may mean it will look like the "Wright Flyer" when compared to the UASs of 2020 in ten short years.

The time to develop a UAS that compliments all facets of the MAGTF is now. A versatile, common, and modular airframe will bring the ACE tremendous flexibility with mission payloads. Yet, in accordance with Moore's Law, which describes the observation of computer processing speed and memory doubling every two years since 1970, it will be the rapid ability to integrate new technology through software updates into the proposed modular airframe that will make the MCTUAS truly evolutionary. The Marine Corps has made significant progress to address the known shortfall in electronic warfare assets, but at this time has not planned for a UAS that is capable in all facets of electronic warfare, or in any anti-air warfare roll. The process of defining the exact requirements for the next generation group 4 UAS are underway.

To ensure success, the MCTUAS must have significant room for software growth, and a high fidelity compatible data-link with the JSF making it capable of cross cueing.⁶¹ Specific attention must be paid to how to process and analyze the litany of information being collected from the MCTUAS. Further study should focus on the feasibility of developing a common, modular airframe that will suit the above missions, and additionally, aerial logistics, command and control, and an anti-air warfare capability. One modular airframe will minimize maintenance footprints and provide the most mission flexibility to the MAGTF.⁶²

Logistics and Facilities

From a purely logistical perspective, several significant efficiencies will occur with the acquisition of a light attack aircraft and the establishment of VMLA squadrons. First, the fuel required for TACAIR squadrons and the fuel to extend them airborne, will be 85-90% less than is required for legacy strike fighters or the F-35B.⁶³ With TACAIR as the largest single consumer of fuel in the MEB, that fuel reduction is very significant. When tasked to provide a total of 36 hours of overhead coverage per day in a permissive environment, the OV-10X requires approximately 6,090 gallons while the F-35B requires approximately 99,000 gallons of fuel or a reduction of 92,910 gallons per day.⁶⁴ To put this in terms of a MAGTF, a MEB uses approximately 444,000 gallons of fuel per day, and approximately 73% of that fuel is for the ACE. Of that 73%, over 50% of that is for TACAIR squadrons. The VMLA squadron would use approximately 16% of the fuel of current TACAIR squadron or an F-35B squadron.⁶⁵

With respect to facilities, several assumptions simplify the implementation of this concept. Since this concept does not create additional commands beyond the VMLA FRS, the plans already underway for 24 TACAIR squadrons provide sufficient ramp space, basing, berthing, fuel, and hangar and maintenance space for both organizational and intermediate levels at both

MCAS Miramar and MCAS Cherry Point to accommodate the inclusion of the five VMLA squadrons. Current ordnance magazines, and storage facilities are sufficient as well since the OV-10X carries no ordnance that does not currently exist in U.S. Marine Corps inventories or will with JSF, AH-1Z, and UH-1Y. Both air stations would require some upgrades in the form of simulators. However, what is notably lacking would be a production and depot level facility for OV-10X. NAS North Island is a current depot level facility for the FA-18 and previously served as an OV-10 depot level facility. The combination of previous experience and sundowning the FA-18 make Naval Air Station (NAS) North Island an attractive option for depot level maintenance.

Additional research is required in all ten of the traditional logistics elements in order to account for additional facility requirements for maintenance and airfield infrastructures, ground support equipment, and hangars. Supply support and support equipment, specifically, spares allowances for both U.S. Navy and Marine Corps (T / E) responsibilities, ground support equipment (range, depth and costs), contractor support (engine, airframe, ordnance and electronics systems), tooling, and publications must be accounted for and are beyond the scope of this project.

Part VI: Cost

The daily fuel requirements in the Helmand province [of Afghanistan] for the 2nd Marine Expeditionary Brigade are over 88,000 gallons a day... Most all of that comes along this fairly tenuous supply line... We can and we must do better... We've got to make sure that we are operating at max efficiencies and effectiveness with regard to the energy that we are providing on a daily basis.

- USMC Commandant, General James T Conway⁶⁶

The simplistic cost analysis is an accurate baseline of cost magnitude. However, it requires much more rigor to be complete. The analysis will focus on the few primary factors of acquisition, including Operational and Support costs (O&S) and fuel involved with the

implementation of this concept. When evaluating cost as it pertains to this concept, it is important to focus on costs' impact to several critical Marine initiatives relating to energy efficiency, battlefield effectiveness, lightening the MAGTF, and decreasing Marine reliance on fossil fuels and tenuous supply lines.⁶⁷ The study of the critical cost factors specific to this proposal supports the reader's ability to make an informed judgment regarding the feasibility of executing this concept.

Fiscal Background, Assumptions and Limitations

The DoD is at a crossroads. It is today's reality of rapidly and exponentially increasing costs for high technology equipment like strike fighters, aircraft carriers, and tanks that has placed the DoD in a position which it must become more fiscally responsible as represented by Augustine's Law in Appendix A, Figure four.⁶⁸ If the DoD acquisition process fails to evolve according to the 2010 Quadrennial Defense Review (QDR), a catastrophic equipment shortage will eventually arise.⁶⁹

This study will use the DoD accepted terms for cost portions of a systems life cycle, and is limited to the first three cost factors: 1) research and development costs, associated with the concept refinement phase, technology development phase, and the system development and demonstration phase, 2) investment costs, associated with the production and deployment phase, (3) O&S costs, associated with the sustainment phase.⁷⁰

Expected research and development costs for the OV-10X are minimal as this concept strives to pursue off the shelf technology and already proven airframes. As a testament to the Bronco airframe, OV-10s still serve today in Columbia, the Philippines, with NASA and the Department of State. The combination of the known quantity, the OV-10 airframe, and the "off the shelf"

combat systems technology would significantly reduce both the time and cost of the research and development phase for the Marine Corps. Furthermore, significant international interest at the February 2010 Singapore air show, as well as potential domestic use for Homeland defense requirements, border patrol, even forest fire fighting could provide considerable amortization of airframe production and overall support cost elements.⁷¹

Investment costs encompass not only acquisition of the aircraft, but all costs associated with initial deployment of the aircraft; however, this study will limit its scope to acquisition costs of the aircraft.⁷²

O&S costs include all costs of operating, maintaining, and supporting a fielded system, specifically, costs of personnel, equipment, and supplies including fuel.⁷³ One of the single largest impacts to O&S costs is the impact of personnel including pay, and establishment of the manpower structure. Based on the concept that the personnel required to establish the four VMLA squadrons comes from existing planned structure for four F-35B squadrons, this overcomes the most significant difficulty in implementation. All O&S cost figures were baselined to 2008 U.S. dollars using the *Consumer Price Index (CPI) Conversion Factors to convert to 2007 Dollars*.⁷⁴

Acquisition Cost

With the upward spiraling costs for DoD acquisitions, it is unlikely that the F-35B's price tag will ever decrease. 2010-dollar estimates for the cost of a single F-35B vary widely from \$40 million to the March 2010 estimate from the Government Accounting Office stating a unit cost of \$112 million (Summarized in Appendix B, Table seven). For the purposes of comparison, this study uses a very conservative price of \$75 million per F-35B.⁷⁵ The actual costs of OA-X competition aircraft are proprietary information at this time, but Air Combat Command (ACC) is

using a desired price range of \$10-15 million per aircraft.⁷⁶ However, the added capability of the OV-10X and the additional engine will likely put the OV-10X at about \$15-20 million per aircraft. For the purposes of comparison, the most expensive estimate of \$20 million per OV-10X aircraft depicts the 'worst case' from the Bronco's point of view.

Simply in acquisition of aircraft pricing, the tradeoff between 40 F-35Bs for 75 OV-10Xs results in a savings of at least \$1.5 billion dollars over the course of several years even after the spending of one billion required to acquire the 75 OV-10Xs. However, in the event of a reduced JSF purchase, the unit cost of the JSF will likely increase. A cost increase of 5% per JSF on the remaining 380 aircraft still provides a net cost of zero for the OV-10X acquisition, without considering all of the tremendous savings in O&S costs over the lifetime of both aircraft.

Operating Cost

While a cost savings of likely more than \$1.5 billion dollars is an attractive figure; it is the efficiencies gained in O&S costs over the life cycle of the OV-10X that will provide the greatest savings across the MAGTF for many years. In an effort to compare apples to apples, the O&S cost comparison will be limited to the anticipated cost per flight hour of each airframe, which at this time is at best an estimate. ACC has completed a rigorous O&S comparison of the OA-X concept comparing U.S. Air Force legacy fighters (24 F-16s and 12 F-15Es) to an OA-X aircraft flying the same 36 four-hour sorties. The results were impressive; the OA-X squadrons use approximately 5% of the fuel of the legacy fighters to provide the same flight time, resulting in significant savings in many areas. A specific comparison of the OV-10X and the F-35B showed a reduction of 92,910 gallons per day for a total savings of \$262,000 in fuel alone.⁷⁷ Fuel is just one factor involved with the O&S costs, and current ACC projections for an OA-X O&S cost are \$1,500 / hour, compared to \$9,000 – \$18,000 / hour for F-16 and F-15E.⁷⁸ \$1,500 / hour for the

OA-X may be optimistic, and this study uses the existing O&S data for the OV-10D scaled for 2008 dollars. See Appendix B, Table 8 for an average O&S cost per flight hour of \$6,913.⁷⁹

F-35B O&S cost estimates range from the optimistic to the extremely pessimistic depending on the source and their agenda; however, this study will use a baseline of \$30,700 per flight hour in 2008 dollars based on a budget review briefed in January 2010 by Naval Air Systems Command.⁸⁰ Note, that while O&S cost does include many variables for the F-35B including the fuel used by an aerial refueler, it does not directly account for O&S of the aerial refueling assets. Even when using what are likely inflated OV-10X numbers and conservative F-35B cost data, it is clear that the O&S cost difference is more than four times greater than the OV-10X.

Finally, the aspects of cost beyond acquisition and O&S costs of the OV-10X must be assessed. Under this proposal, the MAGTF gains an organization focused on nothing more than air-ground attack excellence. The cost savings to the MAGTF in JTAC / JFO production and the quality of CAS provided to the aspiring JTAC / JFOs will be significant. Referencing Appendix B, Table 3, the ordnance and time on station that a single section of OV-10Xs will bring would facilitate approximately 2.5 times the controls for JTAC / JFO training, as a section of F-35Bs.⁸¹

Conclusions / Recommendations

All Marine Corps aircraft in support of overseas contingency operations are... consuming service life at a rate sometimes three times higher than that scheduled for the lifetime of the aircraft. This will eventually result in...earlier retirement of the aircraft than originally programmed.

- USMC Commandant, General James T Conway⁸²

U.S. airpower represents one of our joint force's greatest asymmetric advantages over the enemy... the decision to employ these joint air-based fires will come from leaders who understand that to be effective these fires must be employed rapidly and precisely...Effective employment often requires persistent observation, integrated intelligence, surveillance, and reconnaissance (ISR), and shortened approval procedures.

-General James N. Mattis, USMC, Commander, USJFCOM⁸³

In accordance with the Commandant's vision of lightening the MAGTF, becoming more energy efficient, and supporting enhanced company operations; coupled with the SECDEF's guidance to re-balance the force while maintaining conventional dominance, this proposed reorganization accomplishes several key objectives. No single objective can justify the expenditure of resources with all of the on-going Marine aviation transformation programs at this time; yet when taken as a whole, the proposed reorganization deserves further study.

First, this proposal addresses the real capability gap in the lack of an ideal complementary escort to the MV-22 with the acquisition of the OV-10X.

Second, this addresses the numerous training problems confronting the rapid development in aviation fires of both the VMU and VMGR squadrons by establishing a primary officer MOS for UAS aircrew and integrated aircrew training across all three squadrons.

Third, this provides a buffer to maintain relevant fixed wing Marine TACAIR in the event that the perceived U.S. Air Force and U.S. Navy strike fighter shortfall materializes, and Marine F-35Bs quickly become tasked as a national asset similar to EA-6B in the past two decades.

Fourth, this notably lightens the logistical support requirements for the MAGTF, reduces the burden on supply lines of a fixed wing land based squadron, and provides increased time on station and coverage, through the significant reduction in required fuel.

Fifth, the presence of an additional fixed wing attack asset will reduce the sortie requirement and extend the service life of the F-35B by not requiring it to be employed as FA-18s and AV-8Bs have been for the last several years, creating the flight hour and fatigue issues on both airframes. In most cases, since 2003, airframes have accrued roughly two years worth of planned flight time in a single six-month deployment to OIF or OEF.⁸⁴

Lastly, it allows time for UAS technology to continue to mature as the Marine Corps defines its aviation assets for the future beyond 2030.

The concept has several additional positive impacts throughout the ACE and the MAGTF that go beyond my original thesis.

First, it is affordable and, if implemented as depicted, can save several billion dollars over the next two decades.

Second, the F-35B community will gain more flexibility to train for missions only it is capable of conducting, as they will not have to bear the entire burden for fixed wing CAS towards JTAC and JFO production.

Third, the OV-10X will provide CAS expertise towards the development of Marine JTACs and JFOs at much more efficient cost and in accordance with its training missions.

Fourth, the concept also reduces the training burden on the KC-130 community while providing a path to excellence in the Harvest Hawk mission.

In summary, this proposed structure provides tactical expertise and standardization in all three units, maximizing the flexibility of the ACE to support several mission areas and enhanced company operations. The complete concept is the most efficient, and effective tactical employment of ACE assets, providing a more capable ACE manned, trained, and equipped for the Marine's expected permissive environment missions, yet capable in all threat environments.⁸⁵

APPENDIX A
ILLUSTRATIONS

Organization of the Marine Air Control Group

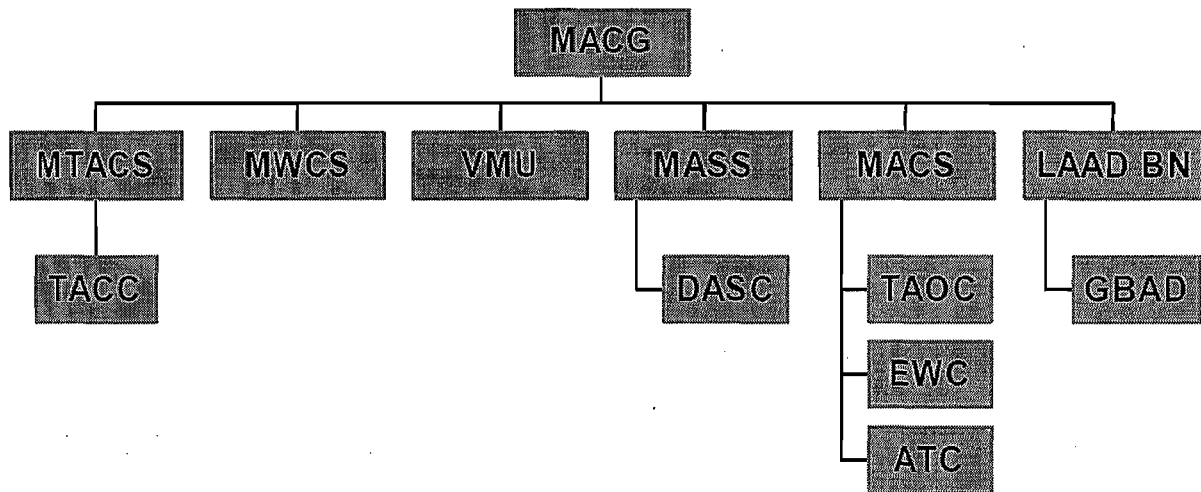
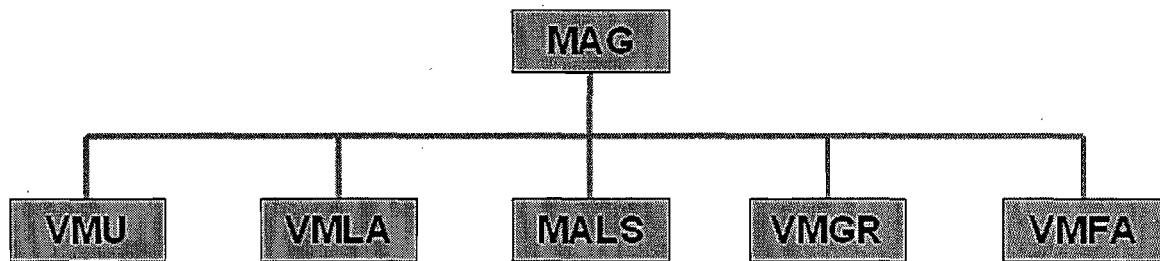


Figure 1: Current MACG Command Organization



APPENDIX B

TABLES

OV-10D Performance Data			
1) Take-off weight 15,000 pounds			
2) Drag Index 117			
3) Ordnance: 1,500 pounds			
4) Fuel: 1600 useable internal and 700 external, 2300 pounds total			
5) Landing weight: 11,200 pounds			
6) Fuel data to execute interpolated from climb / descent profiles			
OV-10D Take-Off Data			
Power	Normal Power, Flaps 20	STOL, Flaps 20	Max Power, Flaps 20
Temperature (Celsius)	40	40	40
Aircraft Gross Weight	15K	15K	15K
Pressure Altitude	2K	2K	2K
Weather / Winds	None	None	None
Take-Off Roll (Feet)	4200	3750	2300
OV-10D Landing Data			
At all aircraft gross weight less than 13K, at 40 Celsius and 2K pressure altitude, all landing rolls are less than 2,000 feet			
OV-10D Fuel Calculations			
Phase	Fuel Required	Time (mins)	Distance
Start-up and Taxi	100	10	N/A
Mil power climb to 15,000 MSL @ 125 KIAS	200	12.5	30
Cruise at 15,000 MSL	500	75	200
Loiter at 15,000 MSL	545	60	N/A
Descent	66	14	35
Permissive Environment Mission Results			
No attack Loiter time		2.75 hours	
Attack Loiter time		2 hours	
*Note: OV-10D estimated to conduct 6 attacks in 2 hours (4 level and 2 multi-dive attacks)			
*Note: Data should be viewed as 'worst case' as OV-10X will gain efficiencies in engine and airframe performance.			
Ref: 1 June, 1984, NAVAIR 01-OV10D-1, NATOPS FLIGHT MANUAL, NAVAIRSYSCOM, pages 270-330			

Table 1: OV-10D Mission Planning Data

PLANNING ASSUMPTIONS

- 1) Two aircraft launch and recover from same air station, 10 mins for start-up and taxi
- 2) Two aircraft fly max endurance profile to / from the operating area (150 NM)
- 3) Maximum internal fuel, no external fuel F-35B, one external tank OV-10X
- 4) Transit at minimal fuel burn altitude above 12,000ft MSL. No wind or weather factors
- 5) Orbit using 20 NM legs at best altitude above 14,000 MSL at maximum endurance
- 6) After every ten minutes of holding, execute one of the following attack profiles
 - a) Level altitude attack above 15,000 MSL, 32 NM total distance. Execute twice for every diving attack.
 - b) Diving attack recovering at 3,000 MSL, 32 NM total distance
- 7) Descend at best distance and airspeed to conserve fuel
- 8) Land with 10 mins of fuel remaining under VFR conditions.

OV-10X Ordnance:	F-35B Ordnance:
4 AGM-114 Hellfire (Left outer wing pylon station)	GAU-22/A 25 mm cannon external gun pod with 220 rounds on centerline
Sponson attachment left: GBU-12 Sponson attachment right: GBU-38	Internal: two GBU-32s on BRU-67, 2 AIM-120
30 mm gun turret centerline station with 600 rounds minimum	Wingtip stations: CATM-9X
Right External Tank	4 wing pylons: 4 pylon mounted GBU-12s

Configuration, Ordnance, and Flight Profile Requirements for Tables 3, and 4

Terminal Attack Controls Required for JTAC Certification & Qualification			
Initial JTAC certification		Maintain JTAC qualification	
Control Requirements	Number Required	Control Requirements	Number Required
Type 1	6	Type 1	2
Type 2	1	Type 2	1
Type 3	0	Type 3	0
Fixed Wing	6	Fixed Wing	3
Ground laser	1	Ground laser	1
Expend Ordnance	4	Expend Ordnance	1
Non-permissive	4	Non-permissive	2
Night	2	Night	1
Day	1	Day	0
Total Required	12	Total Required	6

Table 2: Required JTAC Controls

Tasked to provide the following controls:				
Control Description	# Required	Time (mins)	OV-10X Sorties to complete	F-35B Sorties to complete (unrefueled)
Type 1 attacks with gun permissive pattern	6	30	0.25	.67
Type 2 attacks with PGM (2 ground laser) non-permissive	4	30	0.25	.67
Type 3 attack with 10 min window	1	20	0.17	.44
Night Type 1 attacks with gun permissive pattern	6	30	0.25	.67
Night Type 2 attacks PGM (2 ground laser) non-permissive	4	30	0.25	.67
Night Type 3 attack with 10 min window	1	20	0.17	.44
Totals	22	160	1.34	3.56

Table 3: JTAC Controls Provided by One Section of OV-10X or F-35B

Fuel to provide 36 hours of overhead coverage in a permissive environment with attack profiles					
	# Sorties	Duration (hours)	Fuel / Sortie (Pounds)	Total Fuel (Pounds)	Total Fuel (Gallons)
OV-10X	18	2	2,300	41,400	6088
F-35B	50	.72	13,500	675,000	99,264
Difference			11,200	633,600	93,176

Table 4: Required Fuel Permissive Mission Environment

		6 FUNCTIONS OF MARINE AVIATION										
6 FUNCTIONS		FA-18A/C	FA-18D	EA-6B	AV-8B	KC-130J	AH-1WZ	UH-1N/Y	MV-22	CH-46E	CH-53D/E	RQ-7B
OFFENSIVE AIR SUPPORT	CLOSE AIR SUPPORT (CAS)	X	X		X	X*	X	X				
	DEEP AIR SUPPORT-AI	X	X		X		X					
	DEEP AIR SUPPORT-AR	X	X		X		X	X				
	DEEP AIR SUPPORT-SCAR	X	X		X		X	X				
ANTI-AIR WARFARE	OFFENSIVE AAW	X	X		X		X					
	ANTI-AIR WARFARE	X	X		X							
	REACTIVE-AAW	X	X		X							
AERIAL RECONNAISSANCE	FORMAL IMAGE PRODUCT		X									X
	TARGET OF OPPORTUNITY	X	X	X	X	X	X	X	X	X	X	X
COMMAND AND CONTROL OF AIRCRAFT AND	FAC(A)	X	X		X		X	X				
	TAC(A)		X					X				
	ASC(A)							X				
ASSAULT SUPPORT	COMBAT ASSAULT TRANSPORT					X		X	X	X	X	
	AIR LOGISTICAL SUPPORT					X			X			
	AIR EVACUATION					X		X	X	X	X	
	AIR DELIVERY					X		X	X	X	X	
	TACTICAL RESCUE OF AIRCRAFT AND PERSONNEL							X	X	X	X	
	AERIAL REFUELING					X						
ELECTRONIC WARFARE	BATTLEFIELD ILLUMINATION	X	X		X	X	X	X				
	ELECTRONIC ATTACK	X	X	X	X							
	ELECTRONIC PROTECT	X	X	X	X				X			
	ELECTRONIC SUPPORT			X								

Table 5: Current ACE Assets and the 6 functions of Marine Aviation

6 FUNCTIONS OF MARINE AVIATION										
6 FUNCTIONS		F-35B	OV-10X	KC-130J	AH-1Z	UH-1Y	MV-22	CH-53K	GROUP 3 UAS	GROUP 4 UAS
OFFENSIVE AIR SUPPORT	CLOSE AIR SUPPORT (CAS)	X	X	X	X	X			X	X
	DEEP AIR SUPPORT-AI	X			X				X	X
	DEEP AIR SUPPORT-AR	X	X	X	X	X			X	X
	DEEP AIR SUPPORT-SCAR	X	X	X	X	X			X	X
ANTI-AIR WARFARE	OFFENSIVE AAW	X	X	X	X				X	X
	ANTI-AIR WARFARE	X								
	REACTIVE-AAW	X	X		X					
AERIAL RECONNAISSANCE	FORMAL IMAGE PRODUCT	X	X	X	X	X			X	X
	TARGET OF OPPORTUNITY	X	X	X	X	X	X	X	X	X
COMMAND AND CONTROL OF AIRCRAFT AND	FAC(A)	X	X		X	X				
	TAC(A)	X*	X	X		X	TBD		X	X
	ASC(A)		X	X		X	TBD		X	X
ASSAULT SUPPORT	COMBAT ASSAULT TRANSPORT		X	X		X	X	X		
	AIR LOGISTICAL SUPPORT		X	X			X			
	AIR EVACUATION		X	X		X	X	X		
	AIR DELIVERY		X	X		X	X	X		X
	TACTICAL RESCUE OF AIRCRAFT AND PERSONNEL		X			X	X	X		
	AERIAL REFUELING			X						
ELECTRONIC WARFARE	BATTLEFIELD ILLUMINATION		X	X	X	X				
	ELECTRONIC ATTACK	X	TBD	X					X	X
	ELECTRONIC PROTECT	X	TBD	X	X		X	X		
	ELECTRONIC SUPPORT	X							X	X

Table 6: Proposed ACE Assets and the 6 functions of Marine Aviation

F-35B airframe estimates (XXXX year Dollars)	
Cost Source	COST U.S. MILLIONS
CRS RL 30563	121.6 (2007)
Government Accountability Office	112 (2010)
Aviation Week	68 / 80 (2014)
CRS RL 30563 Update	77 / 81.2 (2009)
U.S. Air Force FY 2009 Budget Estimates	79 / 83.1 (2009)
Acquisition Comparison Cost	75 (2010)

Table 7: F-35B Cost Estimates per Airframe

Note 1: The intent of the table is to validate the assumption that 75 million USD for a single F-35B in 2010 dollars is both a realistic and conservative figure. These numbers should be interpreted as an accurate order of magnitude in 2010 USD only.

Note 2: The actual cost of an individual Joint Strike Fighter varies widely based on numerous factors including Model variant, year of procurement, low rate initial production, full rate production, customer, inflation etc... This table is not intended to over-simplify the complexities involved with the cost of the JSF program.

OV-10 Total O&S Cost per Flight Hour: includes mission personnel, consumable parts, depot level repairables (AVDLR), fuel, depot									
	1986	1987	1988	1989	1990	1991	1992	1993	1994
Total O&S Cost	\$39,971,523	\$55,275,496	\$55,173,994	\$84,593,715	\$73,784,891	\$56,526,879	\$35,759,158	\$17,214,848	\$429,683
Flight Hours	15,722	15,413	14,600	13,862	11,959	11,804	13,432	5,352	1,330
Cost per Flight Hour (CPH)	\$2,542	\$3,586	\$3,779	\$6,103	\$6,170	\$4,789	\$2,662	\$3,217	\$323
Adjusted for 2007 by CPI	4805.29301	6543.79562	6618.21366	10205.6856	9793.65079	7289.1933	3932.05318	4615.49498	451.748252
Average 2007 (without 94)	6725.42252	2008 AVG:	6913.3						

Table 8: OV-10X O&S Cost Scaled for 2007

Cost Comparison F-35B vs. OV-10X		
Acquisition Cost		
	F-35B	OV-10X
Number of aircraft	40	75
Cost per aircraft in 2010 millions of USD	\$75	\$20
Total	\$3,000	\$1,500
Difference	\$1.5 Billion	
Operating Cost per flight hour		
	F-35B	OV-10X
Cost per flight hour	\$30,700	\$6,913
Difference	\$23,787	

Table 9: Acquisition and O&S Cost Comparison, F-35B, OV-10X

APPENDIX C
USMC LAAR / OA-X AIRCRAFT REQUIREMENTS

Critical Requirements: Fixed-wing aircraft must meet all of the requirements listed below:

1. Properly certified for day/night visual flight rules/instrument flight rules (VFR/IFR) operations.
2. Properly certified to meet acquisition requirements and allow for U.S. Military operation. Systems/capability must meet U.S. government releasability / exportability requirements.
3. Accommodate pilots 64 inches – 74 inches tall and sitting heights of 34 inches – 38 inches.
4. Aircraft flight controls:
 - a. All aircraft flight and fuel controls, and critical/essential circuit breakers must be accessible from front cockpit, with seat belts/shoulder harnesses fastened.
 - b. Aft cockpit capable of being reconfigured for flight control including conducting instrument approaches and landings for use as an advanced trainer.
5. Capable of placing two disassembled down aircraft in a single C-17 including maintenance support to re-assemble upon arrival.
6. Aircraft must support a 900 flight hours per platform, per year, operations tempo with an aircraft availability rate of ninety percent (90%) Mission Capable (MC) for completion of day and night missions under Visual Meteorological Conditions (VMC). Platforms must be capable of sustaining an eighty percent (80%) Fully Mission Capable (FMC) rate for the completion of missions under Instrument Meteorological Conditions (IMC), in the environmental conditions expected in Partner Nations (PN) Theatre of Operations (i.e. up to 50-degrees Celsius).
7. Air conditioning system capable of cooling the aircraft cockpit and avionics within operational limits for outside temperatures up to 50 degrees Celsius including solar gain.
8. On-board oxygen generating system (OBOGS).
9. Flight duration: Aircraft, equipped with external fuel tanks and a common design payload, must fly 5.0-hour sorties plus 30 minutes fuel reserves. Aircraft must have a 900 nautical mile (NM) self-deployment ferry range.
10. Aircraft is to have a 25,000 feet MSL operational altitude and ability to 30,000 feet MSL.

11. Capable of force extension to match aerial refueled MV-22 combat radius (threshold). This may include receiving aerial refueling (objective) from U.S. Navy / U.S. Marine Corps configured tanker aircraft, primarily KC-130J.
12. Capable of conducting operations from a surface of a California Bearing Ratio (CBR) of four or better. This encompasses any surface that a Marine KC-130 can operate from including semi-prepared surfaces (dirt, grass, gravel, etc.) and more austere environments
13. Sufficient dust and sand filters to be capable of conducting desert environment operations.
14. Takeoff within 1,500 feet (threshold) / 1,000 feet (objective) of available runway surface and meet a 200 ft/nm climb gradient at pressure altitudes up to 2,000 feet and temperatures up to 40 degrees Celsius with a common design payload at a typical mission weight.
15. Takeoff within 1200 feet of available runway and meet a 200 ft/nm climb gradient at sea level and temperatures up to 40 degrees Celsius with common design payload at a typical mission weight.
16. Land within 2000 feet of available runway at pressure altitudes up to 6000 feet and temperatures up to 40 degrees Celsius with a common design payload and the maximum landing weight for the aircraft.
17. Capable of operating from an austere, forward operating base without any ground support other than fuel being available for re-fueling operations.
18. Two powerplant(s) capable of burning JP-8 or Jet-A fuel. Two engine requirement is for increased survivability of platform.
19. Continuous cruise speed: 270 Knots True Air Speed (KTAS) (minimum) at 15,000 feet density altitude on a standard day and full fuel minus that fuel required to taxi out, take off, and climb to 15,000 feet above ground level (AGL) from sea level with a common design payload and configuration.
20. Capability to carry and insert via landing or air assault up to five combat loaded Marines.
21. Capability to carry internally logistic re-supply cargo, minimum of 75 cubic feet. Up to 3,200 pounds.
22. Capability to externally carry logistic re-supply and air delivery.
23. Capability to carry two wounded Marines via internal litters.
24. Dual seat with dual controls to facilitate dual use as light attack/armed reconnaissance as well as an advanced trainer.

25. Zero altitude-zero airspeed ejection seats.
26. Common multi-function display (MFD) cockpit configuration for all aircraft including Wide Area Augmentation System (WAAS) and Vertical Navigation-certified Global Positioning System (GPS) navigation capability to allow day/night, all-weather instrument flight, especially into airfields which do not possess navigational aids.
27. Flight visibility: Aircraft must allow a full 270 horizontal degree field of view from the cockpit field centered on the nose of the aircraft. Minimal obstructions permitted, i.e. window frames, canopy rails, low wing, heads-up display (HUD).
28. Cockpit must have a HUD with an air-to-ground system capable of computing and displaying the continuously computed impact point (CCIP), and continuously computed release point (CCRP), strafe, and manual weapon aiming computation/release.
29. Cockpit must be inter-operable with the Joint Helmet Mounted Cueing System / Quad-eye (Day and Night Operations) for both aircrew positions.
30. Night Vision Goggle (NVG) compatible cockpits, including lighting and instrumentation.
31. Must have a defensive measures package including a radar-warning receiver (RWR), missile warning system (MWS), and chaff and flare dispensers.
32. Armored cockpits and engine compartment to protect from small arms fire. Self-sealing fuel tanks required.
33. Infrared (IR) suppression for engine(s)
34. Avionics: IFR capable. Dual Communication with single Nav/ Hobbs meter/ Mode C reporting transponder, Global Positioning System (GPS), audio panel and integral intercom meeting U.S. Military Standard (Mil Std) (compatible with U.S. Air Force-standard headsets and/or helmets). Must be GPS approach compatible.
35. Accurate altitude in AGL and MSL above both the target and ground under the aircraft at all attitudes.
36. Communications suite shall consist of:
 - a. Internal crew intercom via VOX type system ,i.e., not 'hot mike'
 - b. Joint Tactical Radio System (JTRS) capability, i.e. not hard wired and non-updateable as current RTs for ARC-210 in legacy FA-18.
 - c. Re-programmable VMF-capable radio system
 - d. Ability to communicate to Air Traffic Control (ATC) facilities and operational agencies, both line of sight (LOS) and beyond line of sight (BLOS) via voice on:
 - i. Civil/ Military VHF Voice

- ii. Military Ultra High Frequency (UHF) and Voice Civil UHF
- iii. SATCOM capable
 - 1. SATCOM (Dedicated/ Demand Assigned Multiple Access (DAMA)/Next-gen[MUOUS])
 - 2. Intelligence Broadcast System (IBS) capable to interface with the GIG
 - 1. IBS - a connection that allows the broadcast of intelligence updates, threat warnings etc via a data-based SATCOM network.
 - 2. Global Information Grid (GIG) is the Pentagon view of how all of the information systems will plug together in a high-bandwidth network to access just about anything you want on the battlefield.
- iv. HF capable
- v. SINCGARS
- vi. HAVEQUICK
- e. Able to transmit/receive simultaneously on three (3) radios.
- f. The voice communications system shall be capable of current and future secure voice communications on all three (3) radios.

37. Data link ability to provide future capability (BLOS required).

- a. Transmit and receive real-time, full-motion video and still imagery. Video downlink capability compatible with Remote Operations Video Enhanced Receiver (ROVER). Selectable and omni-directional C&L band transmitters to maximize signal for range to receiving station and azimuth, as well as IP-based streaming video capability (similar to the PRC-117G).
- b. Variable message format (VMF) digital communications capability compatible with the ground forward air control / joint terminal attack control (FAC/JTAC) systems.
- c. Link-16 or newer compatible.
- d. Blue Force Tracker (BFT) compatible.
- e. Future capability to control multiple UAS (minimum 4) with LOS to all UAS from on-board crew station in a cyber denied environment.

38. Intelligence, Surveillance and Reconnaissance (ISR) subsystems

- a. The desired ISR sensor suite should be capable of providing electro-optical and infrared full motion video and photographs. Photographs must be capable of NIIRS rating 6.0 or better.
- b. Capable of laser designation, laser marking, IR marking, laser spot tracking, and self-derivation of TLE Category 2 or better coordinates.
- c. Capable of allowing post flight download.
- d. Capable of recording all sensors including location data and reviewing in-flight as well as post-flight.
- e. Cockpit display resolution must not degrade the raw image of the sensor.

- f. Short-range radar using a waveform similar to range gate high out to approximately 20NM. Must be capable of air and surface / sea target search and capable of tracking targets in both air and ground modes.(objective)
39. The aircraft must be capable of employing a variety of air-to-ground weapons and munitions, up to an employment altitude of 25,000 feet AGL, including aerial gunnery, unguided free-fall munitions, precision munitions and battlefield illumination devices. The aircraft must be capable, but not limited, to the following:
- a. At least four (threshold) / six (objective) weapons stations that are 1760 and Universal Armament Interface (UAI) compliant.
 - b. Carry a minimum of two 500-pound class Precision Guided Munitions (PGMs)
 - i. All weapon stations should be capable of employing 500 lb class PGMs
 - ii. Two weapon stations must be four round AGM-114 (and follow-on JAGM) capable
 - iii. Two weapon stations must be external fuel capable.
 - c. Must have a laser designator to employ laser-guided weapons.
 - d. Must have the capability to generate Category 2 or better TLE coordinates with onboard sensors
 - e. Gunnery
 - i. Capability to employ aerial gunnery
 - ii. Turret:
 - 1. Capability to employ slew-able 30 mm gun turret with (600 threshold rounds / 1200 objective rounds), from +/- 160 degrees from the nose of the aircraft, i.e., not detracting from the hard points.
 - 2. The turret will be slave-able to the aircraft's boresight line
 - 3. The turret will be slew-able via: 1) a front seat NVG capable Helmet Mounted Cueing system (threshold) 2) on board targeting sensor (threshold) and 3) rear cockpit NVG capable Helmet Mounted Cueing system (objective)
 - iii. In addition to the turret threshold requirement, the aircraft will have the ability to employ a minimum of two synchronized .50 Cal guns with 300 (threshold) rounds each / 600 (objective) rounds each.
 - f. Capability to employ 2.75 inch rockets
 - g. Capability to employ rail launched munitions
 - h. Capability to employ overt and covert air-dropped flares (illumination rounds)
 - i. Weapons interface databus to integrate current applicable weapons U.S. DoD inventory
 - j. Capability to employ self-protect Aim-9X sidewinder missiles

B. Aircraft desired requirements

- 1. Anti-ice/de-ice system to allow flight in moderate icing conditions

2. Aerobatic capable of performing the following maneuvers with clean configuration (no stores): aileron roll, barrel roll, chandelle, cloverleaf, Cuban eight, Immelman turn, lazy eight, loop, and split-S.
3. Capable of launching and recovering from current and future U.S. Navy LHD class carriers.
4. Aircraft is to have a 30,000 feet MSL operational altitude.

Glossary of Acronyms and Terms (GOAT)

** The definitions below apply to terms as they are used in this paper*

Aerial Reconnaissance: Reconnaissance undertaken with an airplane or other flying device in order to secure information about the enemy, the terrain, or the weather.

Air Control Group: Coordinate all aspects of Air Command and Control and Air Defense within the Marine Aircraft Wing. Provide the Command and Staff functions for the MACG Commander when deployed as part of the Aviation Combat Element of the Marine Air Ground Task Force. Comprised of the following subordinate units: Tactical Air Command Squadron, Wing Communications Squadron, Air Support Squadron, Unmanned Aerial Vehicle squadron, and Low Altitude Air Defense (LAAD) Battalion, Air Control Squadron.

Air Combat Command (ACC): a command that is the primary provider of air combat weapon systems to the U.S. Air Force; operates fighter, bomber, reconnaissance, battle-management, and rescue aircraft.

Air Tasking Order (ATO): A method used to task and disseminate to components, subordinate units, and command and control agencies projected sorties, capabilities and/or forces to targets and specific missions. Normally provides specific instructions including call signs, targets, controlling agencies, etc., as well as general instructions.

Air Threat Levels: The conditions which relate to the enemy's air defense capability against airborne friendly aircraft. There are three levels of air threat: Low: An air threat environment which permits combat operations and support to proceed without prohibitive interference. Associated tactics and techniques do not normally require extraordinary measures for preplanned or immediate support. Medium: An air threat environment in which the specific aircraft performance and weapons system capability allow acceptable exposure time to enemy air defenses. This air threat environment restricts the flexibility of tactics in the immediate target/objective area. It is an environment in which the enemy may have limited radar and/or electro-optical acquisition capability at medium ranges, but the air defense system is not supported by fully integrated fire control systems. High—An air threat environment created by an opposing force possessing air defense combat power including integrated fire control systems and electronic warfare capabilities which would seriously diminish the ability of friendly forces to provide necessary air support. This air threat environment might preclude missions such as immediate close air support, as the requirement for effective radio communications and coordination may not be possible.

Anti-Air Warfare: A U.S. Navy/U.S. Marine Corps term used to indicate that action required to destroy or reduce to an acceptable level the enemy air and missile threat. It includes such measures as the use of interceptors, bombers, antiaircraft guns, surface-to-air and air-to-air missiles, electronic attack, and destruction of the air or missile threat both before and after it is launched. Other measures which are taken to minimize the effects of hostile air action are cover, concealment, dispersion, deception (including electronic), and mobility.

Armed Reconnaissance (AR): A mission with the primary purpose of locating and attacking targets of opportunity, i.e., enemy materiel, personnel, and facilities, in assigned general areas or along assigned ground communications routes, and not for attacking specific briefed targets.

Assault Support: The use of aircraft to provide tactical mobility and logistic support for the MAGTF, the movement of high priority cargo and personnel within the immediate area of operations, in-flight refueling, and the evacuation of personnel and cargo.

Assault Support Coordinator (airborne): An aviator who coordinates, from an aircraft, the movement of aviation assets during assault support operations.

ATARS: Advanced Tactical Airborne Reconnaissance System installed on several fleet Marine FA-18Ds capable of electro optical, infrared, and synthetic aperture radar imagery collection. Formal ACE manned tactical reconnaissance platform and system.

ACE: The core element of a Marine air- ground task force (MAGTF) that is task-organized to conduct aviation operations. The aviation combat element (ACE) provides all or a portion of the six functions of Marine aviation necessary to accomplish the MAGTF's mission. These functions are anti-air warfare, offensive air support, assault support, electronic warfare, air reconnaissance, and control of aircraft and missiles. The ACE is usually composed of an aviation unit headquarters and various other aviation units or their detachments. It can vary in size from a small aviation detachment of specifically required aircraft to one or more Marine aircraft wings. The ACE may contain other Service or foreign military forces assigned or attached to the MAGTF.

Category 1 (CAT 1) Aircrew: Aircrew who have either just completed flight school and become designated as FRS qualified pilots and NFOs, or have recently completed the FRS and are on their first flying tour in a operational squadron.

Close Air Support (CAS): Air action by fixed and rotary-wing aircraft against hostile targets which are in close proximity to friendly forces and which require detailed integration of each air mission with the fire and movement of those forces.

Command and Control of aircraft and missiles: A function of Marine aviation executed by a system that provides the aviation combat element commander with the means to command, coordinate, and control all air operations within an assigned sector and to coordinate air operations with other Services. It is composed of command and control agencies with communications-electronics equipment that incorporates a capability from manual through semiautomatic control.

Command and control officers (MOS 7200 field): Occupational field encompassing all of the Marine Air Command and Control System and performing sub-set functions of command

and control of aircraft and missiles. Occupational fields include Air Control, Air Support, and Anti-Air Warfare.

Core skills: capabilities required to perform basic functions, resident in the 1000- and 2000-levels of the T&R. These basic functions serve as tactical enablers that allow crews to progress to more complex Mission Skills. Core Skills are introduced in FRS training and are further refined and expanded at the operational squadron level

Counter Insurgency (COIN): Those military, paramilitary, political, economic, psychological, and civic actions taken by a government to defeat insurgency.

Direct Air Support Center (Airborne) (DASC(A)): An airborne aircraft equipped with the necessary personnel, communications, and operations facilities to function as a direct air support center.

Department of Defense (DoD)

DOTMLPF-C: doctrine, organization, training, materiel, leadership and education, personnel, and facilities. In this study, logistics is substituted for leadership and education.

Electronic Counter-Measures Officer (ECMO): NFO on the EA-6B Prowler.

Electronic Warfare: Any military action involving the use of electromagnetic and directed energy to control the electro-magnetic spectrum or to attack the enemy. Also called EW. The three major subdivisions within electronic warfare are electronic attack, electronic protection, and electronic warfare support.

Enhanced company operations (ECO): describes an emerging Marine mission approach that maximizes the tactical flexibility of decentralized mission accomplishment and operations. ECO is facilitated by improved command and control, intelligence, logistics, and fires capabilities. It is reliant on increased access to, and organic control of, functional support.

Fire Control Officer (FCO): The additional crew member on the weaponized KC-130J known as Harvest Hawk. The Fire Control Officer controls all sensor and weapons employment from a rapidly on/off loadable weapons station in the fuselage of the KC-130J. At the time of writing, the FCO's outside observation is limited to the sensor field of view.

Fleet Replacement Squadron (FRS): non-operational squadron that strictly provides initial or refresher training in basic airframe operation.

Forward Air Controller Airborne FAC(A): A specifically trained and qualified aviation officer who exercises control from the air of aircraft engaged in close air support of ground troops. The forward air controller (airborne) is normally an airborne extension of the tactical

air control party. A qualified and current forward air controller (airborne) will be recognized across the Department of Defense as capable and authorized to perform terminal attack control.

Ground/supported commander: In the context of a support command relationship, the commander who receives assistance from another commander's force or capabilities, and who is responsible for ensuring that the supporting commander understands the assistance required.

Group 3: Aircraft take-off weight less than 1,320 pounds, operates below 18,000 feet MSL, no defined airspeed capability.

Group 4: Aircraft take-off weight greater than 1,320 pounds, operating altitude below 18,000 feet MSL, and any airspeed. Some group 4 UASs have operational ceilings greater than 18,000 MSL, but do not typically operate above that altitude.

Harvest Hawk KC-130J: The weaponized KC-130J being fielded in the Marine Corps. Harvest Hawk is planned to employ a 30MM cannon, Viper Strike and Griffin (lightweight, laser guided and GPS guided munitions), and AGM-114 Hellfire missiles.

Initial Operational Capability (IOC): The first attainment of the capability to employ effectively a weapon, item of equipment, or system of approved specific characteristics that is manned or operated by an adequately trained, equipped, and supported military unit or force.

Joint Fires Observer (JFO): A trained Service member who can request, adjust, and control surface-to-surface fires, provide targeting information in support of Type 2 and 3 close air support terminal attack control, and perform autonomous terminal guidance operations.

Joint Forces Air Component Commander (JFACC): The commander within a unified command, subordinate unified command, or joint task force responsible to the establishing commander for making recommendations on the proper employment of assigned, attached, and/or made available for tasking air forces; planning and coordinating air operations; or accomplishing such operational missions as may be assigned. The joint force air component commander is given the authority necessary to accomplish missions and tasks assigned by the establishing commander.

Joint Strike Fighter (JSF) F-35B: The short take off and vertical landing version of the advanced tactical fighter that the Marine Corps is acquiring as a replacement for FA-18 A+/C/D, EA-6B, and AV-8B. The Joint Strike Fighter is a fifth generation fighter bringing significant leaps in capability to the ACE specifically in electronic warfare, intelligence, and anti-air warfare.

Joint Terminal Attack Controller (JTAC): A qualified (certified) Service member who, from a forward position, directs the action of combat aircraft engaged in close air support and other offensive air operations. A qualified and current joint terminal attack controller will be recognized across the Department of Defense as capable and authorized to perform terminal attack control.

LAAR: Light Attack Armed Reconnaissance aircraft. In this study, representative examples include the A-29 Super Tucano, AT-6B Texan, and OV-10 X Bronco.

Major Theater War (MTW)

Marine Air Group (MAG): A single command organization under which are several operational flying squadrons. In this study, it is proposed to re-structure TACAIR MAGs to comprise JSF squadrons, KC-130 squadrons, UAS squadrons, and Fixed Wing Light Attack Squadrons.

Marine Air Ground Task Force (MAGTF): the Marine Corps' principle organization for all missions across the range of military operations, composed of forces task-organized under a single commander capable of responding rapidly to a contingency anywhere in the world

Marine Aviation Logistics Squadron (MALS): The mission of MALS is to provide Aviation Logistics support, guidance, planning, and direction to the Marine Aircraft Group (MAG) Squadrons on behalf of the MAG Commanding Officer, as well as Aeronautical Support Equipment.

Marine Aviation Weapons and Tactics Squadron-1 (MAWTS-1): Marine Aviation center-of excellence; provides standardized advanced tactical training and certification of unit instructor qualifications that support the T&R.

Military Occupational Specialty (MOS)

MQ-9 Reaper: The General Atomics MQ-9 Reaper (originally the Predator B) is an Unmanned Aerial Vehicle (UAV) used by the U.S. Air Force, the U.S. Navy. The MQ-9 is the first group 4 representative UAS designed for long-endurance, high-altitude surveillance, and strike. The MQ-9 is a larger and more capable aircraft than the earlier MQ-1 Predator. The increased power allows the Reaper to carry 15 times more ordnance and cruise at three times the speed of the MQ-1.

Marine Wing Support Squadron (MWSS): The mission of Marine Wing Support Squadron is to provide all essential Aviation Ground Support requirements to designated components of an Aviation Combat Element and all supporting or attached elements of the Marine Air Control Group.

MV-22 Osprey: The Bell-Boeing V-22 Osprey is a multi-mission, military, tilt rotor aircraft with both a vertical takeoff and landing (VTOL) and short takeoff and landing (STOL) capability. It is designed to combine the functionality of a conventional helicopter with the long-range, high-speed cruise performance of a turboprop aircraft. As the Marine Corps modernizes assault support capabilities, the MV-22 will form the backbone of the assault support along with the CH-53K heavy lift helicopter and the UH-1Y which brings more robust assault support capability than the predecessor UH-1N.

Intelligence, Surveillance, Reconnaissance (ISR): An activity that synchronizes and integrates the planning and operation of sensors, assets, and processing, exploitation, and

dissemination systems in direct support of current and future operations. This is an integrated intelligence and operations function.

Naval Flight Officer (NFO): NFOs currently serve in Marine platforms of the EA-6B and FA-18D and KC-130J Harvest Hawk. It is proposed to train future UAS aircrew as NFOs, as well as fixed wing light attack aircrew.

Offensive Air Support: One of the six functions of Marine Aviation, which encompasses missions such as Close Air Support, Forward Air Controller Airborne, Armed Reconnaissance, and Strike Coordination and Armed Reconnaissance.

Permissive air mission environment: A mission environment including threat, and weather that is generally low threat, but may include some aspects of a medium threat environment. Low threat does not infer that there is no threat to aircraft.

Proficient: means the individual aircrew has successfully performed or updated a training event within the designated training and readiness manual re-fly interval (e.g. successfully completed and logged the event into the training management system). For example, the re-fly for event EXT-221 is 365 days and an aircrew successfully performed EXT-221 60 days ago. The aircrew has a 'proficient' status for EXT-221 and the pilot's proficiency status for that event will remain 'proficient' for the next 305 days.

Qualified: Status assigned to aircrew based on demonstration of proficiency in a specific skill or mission set. All qualifications are assigned one or more T&R events related to that qualification, known as qualification events. When an individual aircrew completes all qualification requirements including qualification events, the individual may be granted the respective qualification by the commanding officer. The individual proficiency status of these qualification events are used to determine qualification status.

Rotary Wing (RW) escort: Designated as the Escort Flight Lead (EFL), this element is tasked to control and provide fires in support of the assault aircraft mission. For Marine aviation, this is typically a mixed element of AH-1/UH-1 helicopters to provide maximum flexibility in types of fires and command and control capability.

RQ-7B Shadow: unmanned aerial system used by the U.S. Army and Marine Corps. The RQ-7B is a group three representative UAS and the Marine's bridge to a true group 4 UAS capability in the 2016-2020 timeframe. The RQ-7B will become the first weaponized Marine UAS.

Six functions of Marine Aviation: Aerial Reconnaissance, Electronic Warfare, Offensive Air Support, Anti-Air Warfare, Assault Support, and Command and Control of Aircraft and Missiles.

Strike Coordination Armed Reconnaissance (SCAR): A mission flown for the purpose of detecting targets and coordinating or performing attack or reconnaissance on those targets. Strike coordination and reconnaissance missions are flown in a specific geographic area and

are an element of the command and control interface to coordinate multiple flights, detect and attack targets, neutralize enemy air defenses and provide battle damage assessment.

Strategic Expeditionary Landing Field (SELF): 8,000 ft long expeditionary runway at Marine Corps Air Ground Combat Center, 29 Palms, California.

Tactical Air (TACAIR): Within the Marine Corps, the following assets are considered part of the TACAIR community: FA-18, AV-8B, EA-6B, and KC-130. This study recommends the addition of all UAS assets to the TACAIR community.

Tactical Air Coordinator Airborne TAC(A): An officer who coordinates, from an aircraft, the actions of other aircraft engaged in air support of ground or sea forces as an extension of the Marine Air Command and Control System / ACE commander.

Table of Organization (T/O): a table listing the number and duties of personnel and the major items of equipment authorized for a military unit.

Training and Readiness (T&R): program intended to implement a comprehensive, capabilities based training system that provides mission skill proficient crews and combat leaders to MAGTF and combatant commanders.

UAS: That system whose components include the necessary equipment, network, and personnel to control an unmanned aircraft.

VMLA: Marine Fixed Wing Light Attack Squadron. This study proposes the establishment of five squadrons of 12 aircraft each, operating the OV-10X Bronco.

VMU: Marine Unmanned Aerial Vehicle Squadron, currently operating the RQ-7B Shadow.

VMGR: Marine Aerial Refueler Transport Squadron, currently operating the KC-130J. Currently fielding the weaponized variant, Harvest Hawk.

Weapons Systems Officer (WSO): Naval Flight Officer designated in the FA-18D.

Endnotes

¹ Robert Gates, "Remarks to Air War College (Montgomery, AL), As Delivered by Secretary of Defense Robert M. Gates" (Air University, Maxwell-Gunter Air Force Base, Montgomery, AL, April 21, 2008).
<http://www.defense.gov/speeches/speech.aspx?speechid=1231>

² (Scutro 2009) This article is one of many alluding to the U.S. Navy's desire to rapidly demonstrate the light attack concept in combat with a four aircraft compliment to Afghanistan sometime in 2010.

³ (Passant 2010) LtCol Passant is an FA-18 pilot with over 4,000 Hornet hours. His recent deployments include OIF 1, and two follow-on tours to OIF, one as the Commanding Officer, VMFA-314.

⁴ (Passant 2010) Aero scout missions conducted in Al Anbar, Iraq during VMFA(AW)-121's deployment in 2007 regularly were comprised of MV-22s, and AH-1W, and UH-1Ns as the escort. FA-18Ds served as the escort as well often because of the vastness of the operating area. Due to the large area of operation, the MV-22 was able to conduct missions with rapid flexibility; however, the escorts were limited by their time and distance of support. Forward Arming and refueling Points (FARP) had to be established to support the escort aircraft, increasing logistics requirements and decreasing tactical flexibility.

⁵ (Lieberman 2010)

⁶ (Pope and Blankenbicker 2010) Major Ryan Pope, MAWTS-1 KC-130 instructor and combat experienced JTAC, is the current head of all Harvest Hawk tactics, techniques and procedures development. Capt Marc Blankenbicker, FA-18D WSO, is the lead Fire Control Officer for initial Harvest Hawk development.

⁷ Bolkcom, Christopher, *Navy-Marine Corps Strike-Fighter Shortfall: Background and Options for Congress*. CRS Report for Congress, (Washington, DC: Congressional Research Service, April 10, 2009) 2. After the U.S. Air Force retired the EF-111 in 1998, the Joint forces relied exclusively on the U.S. Navy / U.S. Marine Corps EA-6Bs for Electronic Warfare. Over the past 12 years, Marine EA-6Bs have been predominantly tasked by the JFACC as opposed to the MAGTF commander; making them essentially a Joint asset.

⁸ Office of the Secretary of Defense. *Quadrennial Defense Review*. (Washington, DC: Office of the Secretary of Defense, February 1, 2010), 87.

⁹ Marine Corps Combat Development Command (MCCDC). *MAGTF Planner's Reference Manual*. MSTP 5-03. (Quantico, VA: MCCDC, July 2, 2010), 113.

¹⁰(Christie 2008) Appendix A, figure 4 of Augustine's Laws depicts the historical exponential increase in acquisition cost of high technology defense items, specifically tactical fighters, aircraft carriers, and tanks. At the time of writing, the JSF program was on or near the curve, but is now rapidly moving above the curve. Important aspects of this cost debate relate to the timeframe being used. Many DoD cost experts argue that a single aircraft type no matter how much the cost is cheaper than maintaining a fleet of several aircraft type as was done during the Viet Nam War. That view is valid during Viet Nam as the 'curve' of Augustine's Laws was virtually linear at the time. To clarify, the operating and support costs of a high technology fighter such as the F-4 were not an order of magnitude above that of a light attack aircraft such as the OV-10A. As the costs have spiraled, the divergence between the two cost curves has produced an order of magnitude difference that nullifies the above argument.

¹¹ Victor Maduka. "Considerations for Employment of Marine Helicopters in Future Conflicts: How Much Risk is Acceptable?" (Master's thesis, Marine Corps University, 2008). 9-15.

<http://www.dtic.mil/cgibin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA490607>

This study uses the term survivability to describe how effective an aircraft is at avoiding being hit by ground fire, the aircraft's ability to return to base in the event of combat damage, as well as the aircraft's capability to protect its aircrew. A properly equipped fixed wing light attack aircraft will likely be more survivable than the MV-22 it escorts due to increased speeds and operating ceilings. Critical aircraft survivability equipment includes advanced

chaff and flare dispensers, advanced flares to include kinematic flares, and an integrated missile warning system. While OV-10 survivability is often cited as a reason for its retirement, Gulf War losses are only two aircraft, with three surviving aircrew. The single engine AV-8B experienced four aircraft lost to enemy action and only two pilots survived. The combination of improved and integrated aircraft defensive systems and the improved sensor package would allow the Bronco to operate in an altitude sanctuary above 1st, and 2nd generation MANPADs. While not outlined as a requirement, DIRCM would be a good additional combat system for later acquisition.

¹² Senate Committee on Armed Services. *Statement of General James N. Mattis, USMC, Commander, United States Joint Forces Command*. 111th Cong., 2nd sess., March 9, 2010.
<http://www.jfcom.mil/newslink/storyarchive/2010/sp030910.html>

¹³ (Frey, 2010)

¹⁴ Derived from personal knowledge and experience while serving as a MAWTS-1 instructor from 2005-2009.

¹⁵ (Frey, 2010)

¹⁶ Pete Gersten, "The Warfighter's view from the ground." (Lecture, National Defense University, Washington, DC, December 14, 2009). Colonel Gersten was serving as the Commander, 432nd Air and Air Expeditionary Wing and spoke as subject matter expert on U.S. Air Force UAS/RPV training and employment.

¹⁷ (Pope and Blankenbicker 2010)

¹⁸ (Pope and Blankenbicker 2010)

¹⁹ (Pope and Blankenbicker 2010)

²⁰ Knowledge derived as an aviation fires instructor at MAWTS-1 2005 to 2009.

²¹ Marine Corps Combat Development Command (MCCDC). Fires and Maneuver Integration Division Capabilities Development Directorate. *Concept of Operations for United States Marine Corps Unmanned Aircraft Systems Family of Systems*. (Quantico, VA: MCCDC, November 10, 2009), 20.

²² Marine Corps Combat Development Command (MCCDC). Fires and Maneuver Integration Division Capabilities Development Directorate. *Concept of Operations for United States Marine Corps Unmanned Aircraft Systems Family of Systems*. (Quantico, VA: MCCDC, November 10, 2009), 56.

²³ Marine Corps Combat Development Command (MCCDC). Fires and Maneuver Integration Division Capabilities Development Directorate. *Concept of Operations for United States Marine Corps Unmanned Aircraft Systems Family of Systems*. (Quantico, VA: MCCDC, November 10, 2009), 42-45.

²⁴ (Frey, 2010)

²⁵ (Pope and Blankenbicker 2010)

²⁶ (Pope and Blankenbicker 2010)

²⁷ Derived from personal knowledge while serving as a MAWTS-1 instructor from 2005-2009.

²⁸ (Lieberman, Rusnok and Dehner 2010); (Campbell 2010) Maj Thomas Campbell USMC currently serving as the MAWTS-1 Air Officer Department (AOD) head, is a combat experienced JTAC, and is responsible for graduate level training of Air Officers.

²⁹ U.S. Marine Corps. *Marine Corps Vision and Strategy 2025*. July 28, 2008, 3.
http://www.onr.navy.mil/~media/Files/About%20ONR/usmc_vision_strategy_2025_0809.ashx (accessed 15 September, 2009)

³⁰ Mark Tobin, "A Case Study of Transforming the Marine Air Control Group," (Master's thesis, Air Command and Staff College, 2006), 17.

³¹ (Coble 2010)

³² Derived from knowledge and expertise as a MAWTS-1 Instructor, major evolution coordinator, and operations planner at MAWTS-1 2005-2009. Currently, the FAA does not permit UAS aircraft to operate in the same airspace as commercial or general aviation aircraft. This creates significant difficulties in basing and training UASs must take-off, operate and recover within the confines of restricted airspace. This is a long-term airspace issue with the FAA that will see resolution in the future as UAS technology becomes commercial. In addition, this is a significant issue for Homeland Security and Border Patrol operations.

³³ (Frey, 2010)

³⁴ Marine Corps Combat Development Command (MCCDC). *Assault Support*. MCWP 3-24. Quantico, VA: MCCDC, May 20, 2004, C-1 to C-13.

³⁵ *Naval Tactics Techniques and Procedures Combat Aircraft Fundamentals VMU*, 3-22.3 VMU (Navy Warfare Library Publications, October 2009). 2-18. Current U.S. Marine Corps UAS tasking doctrine states that requirements should be vetted through the intelligence sections, but that actual tasking should be completed by the operations chain. In the recent conflicts of OIF and OEF, U.S. Marine Corps UASs were often tasked non-doctrinally and controlled by the intelligence chain. This incorrect employment is being corrected currently in OEF with VMU-3. The most flexible employment of the UAS asset is to have tasking originate with operations regardless of whether the UAS is supporting intelligence development or actual operations. This provides increased visibility on the capability and employment of the asset on the battlefield.

³⁶ Brian Schenk, and Jay Moorman, Jay. "6 Functions of Marine Aviation." (Lecture, Weapons and Tactics Instructor Course, MCAS Yuma, AZ, September, 2009).

³⁷ (Pope and Blankenbicker 2010)

³⁸ Marine Corps Combat Development Command (MCCDC). Fires and Maneuver Integration Division Capabilities Development Directorate. *Concept of Operations for United States Marine Corps Unmanned Aircraft Systems Family of Systems*. (Quantico, VA: MCCDC, November 10, 2009), 37.

³⁹ Headquarters U.S. Marine Corps. Deputy Commandant for Aviation. *FY 2010 Marine Aviation Plan*. (Washington, DC: Headquarters U.S. Marine Corps, November 17, 2009), 3-5.

⁴⁰ (Rusnok and Liberman and Dehner 2010)

⁴¹ (Shaw 1985, 182)

⁴² (Wiegel 2010)

⁴³ Bolkcom, Christopher, Murch, Anthony, *F-35 Lightning II Joint Strike Fighter (JSF) Program: Background, Status, and Issues*. CRS Report for Congress, (Washington, DC: Congressional Research Service, August 29, 2008) 8, 9.

⁴⁴ *ibid* page 9. Initial U.S. Marine Corps JSF requirements were for 690 F-35Bs. Throughout the life of the JSF program, it has been incrementally reduced to 642, then to 609, and now to 420.

⁴⁵ (Under Secretary of Defense, Acquisition, Technology and Logistics 2007, C-3); (Bolkcom, 2009, 1)

⁴⁶ (Bennett and NAVAIRSYSCOM 2010) NAVAIRSYSCOM brief showing the U.S. Marine Corps and U.S. Navy F-35 planned procurement at 340 aircraft each as opposed to U.S. Marine Corps desired 420. Air Force times article discussing continuing budgetary issues of the F-35 program with Pentagon officials stating that further increases in cost will result in a fighter reduction.

⁴⁷ Bolkcom, Christopher, *Navy-Marine Corps Strike-Fighter Shortfall: Background and Options for Congress*. CRS Report for Congress, (Washington, DC: Congressional Research Service, April 10, 2009) 2. CRS study showing joint strike fighter shortfall approximately 2018.

⁴⁸ Current table of organization numbers for the following squadrons are EA-6B: 250, FA-18C: 222, FA-18D: 263, and AV-8B: 329.

⁴⁹ Michael Dehner, email message to author, March 2, 2010. Attached file is an excel spreadsheet titled "16AC F-35B Aug 08 troop list (15 Oct 09 mod)". This is the DRAFT table of organization for a sixteen and ten aircraft F-35B squadron.

⁵⁰ Headquarters U.S. Marine Corps. Deputy Commandant for Aviation. *FY 2010 Marine Aviation Plan*. (Washington, DC: Headquarters U.S. Marine Corps, November 17, 2009), 3-5.

⁵¹ Analysis of existing OV-10D table of organization shows total personnel strength of 234, 39 officers, and 34 aircrew. Initial study shows that applying current manning practices of today's squadrons should result in a net decrease of 10 personnel to 224. Twelve personnel billets are removed including three billets from Administration, two from Intelligence including the Intelligence Officer who is now a non-chargeable MAG asset, one from Operations, one NATOPS clerk from Safety, and five from the corrosion control shop. Two billets are added, specifically one for information technology, and two FLIR technicians. Further reductions in squadron table of organization are likely as corrosion control, hydraulics, and structures are all now a single maintenance shop of airframes. Also, there are likely reductions across the MAG especially in ordnance and avionics as many of the combat systems and weapons are common to all three units, VMLA, VMGR, and VMU; specifically the Hellfire missile system.

⁵² Referencing the OV-10D table of organization, the augments required for the MALS for the OV-10D totaled 23 Marines. 9 of the 23 will be resident at MALS and are not aircraft specific including the administration clerk, three supply clerks, the NDI operator, two GSE mechanics, and two ordnance technicians.

⁵³ David Torres-Laboy, email message to author, February 1, 2010. Attached word document titled "LAAR Supporting Doctrine" includes the unclassified quote cited from the classified document "Guidance for the Development of the Force FY 2011-15 Update: Jul 2009." This is working document from the U.S. Air Force's LAAR effort office, covering applicable doctrine and direction influencing the LAAR effort.

⁵⁴ David Torres-Laboy, email message to author, February 1, 2010. Attached word document titled "20100121_Light Attack Top 4_v2 (21 Jan 10)" is an information only paper summarizing current U.S. Air Force light attack initiatives.

⁵⁵ U.S. Air Force Air Combat Command. *Capability Request for Information (CRFI)* Air Combat Command (ACC) *Light Attack/Armed Reconnaissance (LAAR)*. July, 2009. [http://74.125.113.132/search?q=cache:4BQM1eVQcYUJ:https://www.fbo.gov/download/62d/62dc6d0664e664f04f030029b850d24f/LAA+Capability+Request+for+Information+final+v2.docx+Capability+Request+for+Information+\(CRFI\)+LAAR&cd=2&hl=en&ct=clnk&gl=us](http://74.125.113.132/search?q=cache:4BQM1eVQcYUJ:https://www.fbo.gov/download/62d/62dc6d0664e664f04f030029b850d24f/LAA+Capability+Request+for+Information+final+v2.docx+Capability+Request+for+Information+(CRFI)+LAAR&cd=2&hl=en&ct=clnk&gl=us) (accessed August 10, 2009)

⁵⁶ (Clay 2010)

⁵⁷ Hawker-Beechcraft. "Joint Capability Technology Demonstration Briefing." February, 2008.

⁵⁸ Boeing. "OV-10(X) Super Bronco Briefing." 2009.

⁵⁹ Hawker-Beechcraft. "Joint Capability Technology Demonstration Briefing." February, 2008.

⁶⁰ Naval Air Systems Command (NAVAIRSYSCOM). *NATOPS FLIGHT MANUAL OV-10D AIRCRAFT*. NAVAIR 01-OV10D-1. (Philadelphia, PA: NAVAIRSYSCOM, June 1, 1984), 11-1 – 11-59.

⁶¹ <http://en.citizendium.org/wiki/masint> Cross cueing is defined as the passing of detection, geo-location and targeting information to another sensor without human intervention. This definition fits the majority of context with which it has been used, specifically the context within the UAS concept of operations.

⁶² Marine Corps Combat Development Command (MCCDC). Fires and Maneuver Integration Division Capabilities Development Directorate. *Concept of Operations for United States Marine Corps Unmanned Aircraft Systems Family of Systems*. (Quantico, VA: MCCDC, November 10, 2009), 24-27.

⁶³ Pietrucha, M. W., and Torres-Laboy, D. J. "Making the Case for the OA-X Light Attack Aircraft." *Air Land Sea Bulletin* 2010, no. 1 (Jan 2010): 18.

⁶⁴ (Brinson 2010) ; (OV-10D NATOPS 1984). Using the lowest found price per gallon of fuel for the DoD of \$2.82 / gallon, the savings for 36 hours of coverage is exactly \$262,756, rounded in the study to \$262,000. Attack profiles used for both aircraft were as follows: once on station, loiter at maximum endurance airspeed at best altitude above 15,000 MSL. Loiter for ten minutes, and then execute a med altitude level attitude delivery using 32NM for increased fuel burn distance. Next, loiter for ten minutes at maximum endurance airspeed and altitude. Repeat level altitude attack. Repeat ten minute loiter. Now, attack via a diving profile with a minimum altitude of 3,000 MSL and climb back to loiter altitude for increased fuel burn. Repeat that cycle until required to return to base for fuel. F-35B mission profiles were provided by the JSF Program office using the U.S. AIR FORCE aircraft performance model called "NSEG." Aircraft performance data used in the model comes from Lockheed Martin as part of their "240-4.7 database."

<http://www.nationaldefensemagazine.org/archive/2010/April/Pages/HowMuchforaGallonofGas.aspx>

⁶⁵ Marine Corps Combat Development Command (MCCDC). *MAGTF Planner's Reference Manual*. MSTP 5-03. (Quantico, VA: MCCDC, July 2, 2010), 113. Using the tables for sustainment operations of an MPS, which is a MEB size element, arrive at a number of 444,000 gallons or 296,148,000 pounds. Of that 73% if for the ACE or 216,188,040 pounds.

⁶⁶ Taylor, Dan. "Conway: Assessment Team Uncovers Heavy Fuel Waste in Afghanistan." *Inside the Navy*, October 19, 2009. http://www.insidedefense.com/login.asp?cookie_test_flag=1 (accessed January 10, 2010).

⁶⁷ Peterson, Zachary. "Marines to Pursue 'Expeditionary Energy,' Less Dependency on Contractors." *Inside the Navy*. January 18, 2010. http://www.insidedefense.com/login.asp?cookie_test_flag=1 (accessed January 25, 2010).

⁶⁸ (Christie 2008)

⁶⁹ (Christie 2008)

⁷⁰ Office of the Secretary of Defense. *Operating and Support Cost-Estimating Guide*. (Washington, DC: Office of the Secretary of Defense Cost Analysis Improvement Group, October, 2007), 2-1.

⁷¹ Jennings, Gareth. "Singapore Air Show 2010: Boeing pins hopes on revived Bronco." *Janes defence*. February 5, 2010. http://www.janes.com/news/defence/jdw/jdw100205_1_n.shtml (accessed February 10, 2010).

⁷² *ibid*, 2-2. Investment. Consists of production and deployment costs incurred from the beginning of low-rate initial production through completion of deployment. Typically includes costs associated with producing and deploying the primary hardware; system engineering and program management; peculiar and common support equipment, peculiar training equipment/initial training, technical publications/data, and initial spares and repair parts associated with production assets; interim contractor support that is regarded as part of the system production and is included in the scope of the acquisition program baseline; and military construction and operations and maintenance associated with system site activation.

⁷³ *ibid* 2-2. O&S. Consists of sustainment costs incurred from the initial system deployment through the end of system operations. Includes all costs of operating, maintaining, and supporting a fielded system. Specifically, this consists of the costs (organic and contractor) of personnel, equipment, supplies, software, and services associated with operating, modifying, maintaining, supplying, training, and supporting a system in the DoD inventory. May include interim contractor support when it is outside the scope of the production program and the acquisition program baseline. O&S costs include costs directly and indirectly attributable to the system (i.e., costs that would not occur if the system did not exist), regardless of funding source or management control. Direct costs refer to the resources immediately associated with the system or its operating unit. Indirect costs refer to the resources that provide indirect support to the system's manpower or facilities. For example, the pay and allowances (reflected in compo standard rates) for a unit-level maintenance technician would be treated as a direct cost, but the (possibly allocated) cost of medical support for the same technician would be an indirect cost.

⁷⁴ Oregon State University. *Consumer Price Index (CPI) Conversion Factors to Convert to 2007 Dollars*. May 7, 2008. <http://oregonstate.edu/cla/polisci/faculty-research/sahr/cv2007x.pdf> Feb 10, 2010.

⁷⁵ (Bolkcom, 18); David Fulghum. "EW Not Only Roadblock to Israeli JSF Plans." *Aviation Week*. February 27, 2009.; Roxana Tiron. "Gates picks vice admiral to run troubled F-35 Joint Strike Fighter jet program." *The Hill*, March 16, 2010.; (Bolkcom, 2); U.S. Air Force. *USAF Committee Staff Procurement Backup Book FY 2009 Budget Estimates*. <http://www.saffm.hq.af.mil/shared/media/document/AFD-080204-081.pdf> USAF Committee Staff Procurement Backup Book FY 2009 Budget Estimates (accessed February 15, 2010); Government Accounting Office. *Joint Strike Fighter Additional Costs and Delays Risk Not Meeting Warfighter Requirements on Time*. <http://www.gao.gov/new.items/d10382.pdf> (Accessed March 31, 2010)

⁷⁶ (Torres-Laboy 2010)

⁷⁷ (Brinson 2010) ; (OV-10D NATOPS 1984)

⁷⁸ Pietrucha, M. W., and Torres-Laboy, D. J. "Making the Case for the OA-X Light Attack Aircraft." *Air Land Sea Bulletin* 2010, no. 1 (Jan 2010): 18.

⁷⁹ Naval Air Systems Command. *NAVAIR Flight Hour Program Data-ATMSR Report from VAMOSOC*. Unpublished technical data for various Marine Corps aircraft. This data covers total operating and support costs for FA-18, AV-8B, and OV-10 from 1986-1994.

⁸⁰ (NAVAIRSYSCOM 2010)

⁸¹ (Campbell 2010); (TACP Training and Readiness Manual 2008). Use the data in Appendix B that shows that 1.34 sections of OV-10Xs are estimated to provide 22 controls. For the F-35B, 3.56 sections are estimated to provide the same 22 controls without using aerial refueling. Using linear interpolation, a section of OV-10Xs is estimated to provide 16.4 controls, while an F-35B section is estimated to provide 6.2 controls.

⁸² House Committee on Armed Services, *2010 Posture of the United States Marine Corps*, 111th Cong., 2nd sess., February 24, 2010, 10. If the Marine Corps had had a fixed wing light attack capability seven years ago, many of the flight hour and airframe fatigue issues of FA-18 A+/C/D would have been greatly reduced. This is a valid analogy of what will likely occur with service life management of the JSF if another attack asset is not available to

balance its employment and it is tasked as FA-18 and AV-8B have been for the past several years. As UASs advance, this will provide some mitigation of JSF tasking.

⁸³ Senate Committee on Armed Services. *Statement of General James N. Mattis, USMC, Commander, United States Joint Forces Command*. 111th Cong., 2nd sess., March 9, 2010.
<http://www.jfcom.mil/newslink/storyarchive/2010/sp030910.html>

⁸⁴ House Committee on Armed Services, *2010 Posture of the United States Marine Corps*, 111th Cong., 2nd sess., February 24, 2010, 11.

⁸⁵ Hoffman, F. G., "What Pete Ellis Might Think About Today Alternatives for *Operation Plan 21*," *Marine Corps Gazette*, 93, no. 11 (Nov 2009): 12-26.

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