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FUTURE WAR PAPER

Manned-Unmanned Teaming: How the F-35 Supports the GCE

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Table of Contents

The Marine Corps' first aviator, Alfred A. Cunningham, wrote in the September 1920 *Gazette*: "The only excuse for aviation in any service is its usefulness in assisting the troops on the ground to successfully carry out their operations."[1] In the article titled, "Value of Aviation to the Marine Corps," Major Cunningham continues to discuss ways aviation would prove to be beneficial to the Corps. In 1920, USMC aviation was challenged by new technology, managing high operational tempo, and funding shortfalls while trying to identify the role it would play in the Corps for the next 10 -15 years and beyond. Today's Aviation Combat Element (ACE) is dealing with those same issues as it transitions from legacy platforms to the F-35. The most important question pertaining to aviation that the USMC asked Major Cunningham was, "Of what practical use is it to us?"[2] Many Marines outside of the aviation community are asking that same question today regarding the F-35. The F-35 is described as "the cornerstone of a multi-mission joint force." However, as the Marine Corps transitions its fixed wing tactical aviation force to being solely comprised of the F-35, there is increased risk of losing sorties to the Joint Force Air Component Commander (JFACC).[3] An ACE comprised only of F-35s will undoubtedly leave the USMC Ground Combat Element (GCE) once again asking, "Of what practical use is it to us?" For Marine aviation to ensure that it continues to perform its primary purpose of supporting the GCE over the next 10 – 15 years, the USMC must retain F-35 sorties in support of the Marine Air-Ground Task Force (MAGTF). To ensure the F-35 is employed in support of the Marines on the ground, the USMC must change the way it operationally employs aircraft to maximize the Aviation Combat Elements' future ground attack capabilities via the pairing of F-35 and Unmanned Aircraft Systems (UAS).

TERMINOLOGY AND DEFINITIONS

One of the difficulties with involving aviation science and technology in discussions on the operational employment of aircraft is the varying definitions for terms between the Department of Defense (DOD) and civilian industry. In an effort to eliminate confusion and provide a common framework before moving into a deeper discussion of the problem facing Marine aviation and recommended ways forward, it is necessary to clearly define some of these terms. The first of these terms is Unmanned Aircraft Systems, which the DOD dictionary defines as, "that system whose components include the necessary equipment, network, and personnel to control an aircraft that does not carry a human operator and is capable of flight with or without human remote control."[4] The next term is Manned-Unmanned Teaming (MUM-T) which the *2017 Marine Aviation Plan* defines as, "aviation options for commanders to use manned, unmanned, or a combination of the two" to best suit mission requirements.[5] The final term that is necessary to define is autonomous weapon system, which DOD Directive 3000.09 *Autonomy in Weapons Systems* defines as, "a weapon system that, once activated, can select and engage targets without further intervention by a human operator. This includes human-supervised autonomous weapon systems that are designed to allow human operators to override operation of the weapon system, but can select and engage targets without further human input after activation."[6] The common understanding of these terms provides a framework for the discussion of recommended courses of action to address the problems facing Marine aviation.

PROBLEM STATEMENT AND BACKGROUND

Marine aviation has historically employed aircraft with advanced technology and capabilities. If the USMC operates the F-35 similarly to the F-18 Hornet and AV-8B Harrier, not only will this provide little to no increase in aircraft on-station time and tactical range, it will also

fail to maximize the sensor suite and command and control capabilities of the F-35 while decreasing kinetic offensive air support available to the GCE. Maintaining the stealth capability of the F-35 requires ordnance to be carried internally, limiting the standard combat loadout to two 1,000 pound air-to-ground bombs (which is a reduction of 50 percent from the F-18 and AV-8B). Providing the GCE with no significant increase in operational flexibility, on-station time, target acquisition, command and control, or operational range with a 50 percent reduction in kinetic capability will not lead to the transformation on the battlefield that is often promised with the Joint Strike Fighter (JSF).

In addition to a reduced offensive capability, the F-35 has an increased maintenance and operating cost. Naval Air Systems Command (NAVAIR) estimates the F-35 will require 50 direct maintenance man-hours per flight hour, which is more than three times the rate of the current USMC tactical aviation fleet.[7] Applying the increase in maintenance man-hours to the reduction of offensive capability equates to over six times the required maintenance time in order to provide the GCE with the same offensive air support. The ACE is unable to sustain this increased maintenance requirement as evident by the current aviation readiness crisis.[8] Accompanying the increased maintenance requirement is an increased cost per flight hour. *Forbes* magazine reports that the F-35 cost per flight hour is close to two and half times the cost of the F-18 and AV-8B.[9] Given these increased financial and maintenance requirements, Marine aviation cannot afford to operationally employ the JSF in a traditional manner while providing the GCE a reduced capability.

Historical evidence and the *2017 Marine Aviation Plan* indicate that the JSF will be part of Marine aviation for the next 30 years.[10] In addition, the *2017 Marine Aviation Plan* reiterates the USMC plan to acquire a multi-mission ship-board UAS capable of conducting kinetic strikes

while operating at altitudes up to thirty thousand feet and ranges complementary to the F-35.[11] UAS have a traditional service life of twenty years, meaning the JSF and the future Marine Expeditionary Force (MEF) level MAGTF Unmanned Expeditionary capability combination will be the backbone of Marine tactical aviation until at least the year 2040 and probably beyond. The emphasis and long-term investment the Marine Corps has placed in the JSF and the MEF level UAS require a change in the way the service operationally employs these aircraft. Employing these aircraft as individual elements inside of the Marine Corps concept of operations will not only fail to meet the future requirements of the USMC, but will also leave the GCE once again asking, "Of what practical use is it to us?"[12] However, changing the operational approach and forming a manned-unmanned team comprised of the JSF and the future MEF level UAS will mitigate the above mentioned issues and ensure in the future that the ACE continues to demonstrate "its usefulness in assisting the troops on the ground to successfully carry out their operations."[13]

In the *1986 Omnibus Agreement for Command and Control of Marine Tactical Aviation in Sustained Operations Ashore* the Joint Chiefs of Staff (JCS) wrote that the "MAGTF Commander will retain operational control of his organic air assets. The primary mission of the MAGTF air combat element is the support of the MAGTF ground element."[14] While the USMC view is often that this means Marine aviation can only be employed in accordance with the MAGTF Commander's guidance, the 1986 Omnibus as well as historical evidence proves this to be a flawed belief. The Omnibus agreement goes on to clarify operational control by saying, "Nothing herein shall infringe on the authority of the Theater or Joint Force Commander, in the exercise of operational control, to assign missions, redirect efforts, and direct coordination among subordinate commanders to insure unity of effort in accomplishment of his overall

mission or to maintain integrity of the force."[15] Additionally, prior to 1986, Marine aviation was often tasked to support missions other than the support of the GCE. For example, during World War II in the Pacific Theater, Marine aviation was primarily tasked with maintaining air superiority and air interdiction while Navy carrier aircraft supported the Marines on the ground. The senior Marine in the Pacific Theater, LtGen Holland Smith, campaigned to not break up the MAGTF saying, "the troop experience of senior marine pilots combined with the indoctrination of new pilots in infantry tactics should insure greater cooperation and coordination between air and ground units."[16] During the World War II transition of Marine aviation, the Corps' aviators lost focus of their primary mission and USMC aircraft were not employed in coordination with any ground element. The ACE's loss of prioritization combined with the Joint Force Commander's authority to assign missions and redirect assets should serve as a warning to Marine aviation as it transitions to the F-35.

As Marine aviation continues to transition from legacy aircraft to the JSF, it is faced with many of the same issues as the Corps' first aviators. The Marine Corps has emphasized the acquisition of a platform referred to as "the cornerstone of a multi-mission joint force," leaving the majority of Marines on the ground concerned that the ACE will not continue to perform its primary role of supporting the GCE. In that regard, employing the JSF as an individual element inside the overall concept of operations fails to transform the battlefield as promised. The increased financial and maintenance requirements associated with the JSF, combined with the fact that it will be a cornerstone of Marine tactical aviation until at least the year 2040, requires the Corps to evaluate the way it operationally employs aircraft and explore the teaming of the F-35 and UAS to maximize the ACE's future ground attack capabilities.

CURRENT USMC MANNED-UNMANNED TEAMING

The current Marine Corps method of task-organizing USMC aviation assets and executing concepts of operation based on individual platforms combined with the overall state of aircraft readiness limits the ability to conduct combined operations using multiple different platforms. The limited nature of MUM-T within the USMC is the result of several factors which include the F-35 and Marine Unmanned Aerial Vehicle (VMU) Squadron basing plan, current Marine Corps UAS capabilities, and F-35 and UAS Training and Readiness (T&R) manual requirements.

The basing plan for the Marine Corps F-35 and VMU squadrons is laid out in the *2017 Marine Aviation Plan*. The on-going JSF transition currently bases aircraft permanently at three locations: Marine Corps Air Stations (MCAS) Beaufort, Iwakuni, and Yuma.[17] The VMU alignment plan has a stated goal to, "locate each VMU aboard a Marine Corps Air Station. Alignment aboard an air station will facilitate future UAS fielding and provide the necessary infrastructure for the VMUs to establish habitual relations with Marine Aviation Logistics Squadrons (MALS) and their group headquarters."[18] While the alignment with MALS and Marine Air Group (MAG) headquarters is essential to the logistical and command and control aspect of aviation, the real value in this alignment should be a focus on operational employment and the ability to "establish habitual relations" with other platforms in order to task-organize in support of the GCE. In addition to a misguided focus of effort, the alignment plan further restricts the development of MUM-T because of the actual basing locations. Currently, VMU squadrons are permanently based at four locations: MCAS Yuma, Cherry Point, Kaneohe Bay, and Marine Corps Base Camp Pendleton. MCAS Yuma is the only one of these locations that also has F-35 squadrons until FY2025 when an AV-8B squadron at MCAS Cherry Point

transitions to the JSF.[19] The Marine Corps' view of these two platforms as individual assets as opposed to elements of a holistic aviation system designed to support the Marine on the ground is a striking example of how the current concept of operations fails to fully integrate all aviation assets. Neglecting to permanently base two of the platforms that are the backbone of future operational employment for Marine aviation together, severely restricts their ability to conduct MUM-T operations and demonstrates why the Marine Corps must change the way it currently operationally employs its aircraft.

The next factor that is defining what USMC MUM-T currently looks like is the capabilities of Marine Corps UAS platforms. The Marine Corps' most capable UAS is the RQ-21A "Blackjack". The RQ-21A is a Group 3 UAS, meaning it operates at altitudes below 18,000 feet and airspeeds less than 250 knots, however the optimal operating parameters for the RQ-21A is from 3,000 to 5,000 feet, 60 knots, and a line of sight range of 50 kilometers.[20] The RQ-21A is a capable Intelligence, Surveillance, and Reconnaissance (ISR) platform with electronic warfare capabilities, but the limited operating envelope limits its ability to truly integrate into the ACE's operating concept. The F-35 has an optimal operating altitude above 30 thousand feet and airspeed greater than 400 knots. The delta between the two platforms operating characteristics is too great for them to provide each other with mutual support. While this was never the intent of the RQ-21A, the gap between the two platforms prevents Marine aviation from conducting MUM-T with two assets that will be cornerstones of Marine tactical aviation until at least the year 2040.

In addition to the Blackjack's limited operating envelope, its payload is limited to electro-optical and infrared cameras, laser range finder, and infrared point. There are several glaring deficiencies in the RQ-21A's payload limiting MUM-T such as the lack of a Laser Target

Designator (LTD), the inability to carry ordnance, and no capability for digital interoperability. A laser target designator provides the capability to provide targeting information as well as guidance for laser-guided bombs. The lack of a LTD limits the RQ-21A's ability to integrate into the Close Air Support (CAS) process. Currently, the RQ-21A has the ability to locate targets, generate targeting data, and pass the targeting information via voice to the attacking platform, but it cannot provide terminal guidance. As a result, the attacking aircraft, in this instance an F-35, is required to provide its own terminal guidance which results in the manned aircraft producing an increased electromagnetic signature and an increased vulnerability to surface-to-air and air-to-air threats. The Blackjack's inability to carry ordnance creates a scenario where it is always dependent on external assets for a kinetic solution.

Given the F-35s reduced air-to-ground ordnance capacity, compared to legacy platforms, a situation where targets remain unprosecuted because of a lack of kinetic capability is easy to envision. Marine aviation's lack of an UAS with kinetic capability combined with the F-35's standard combat loadout limits MUM-T and restricts ACE's ability to assist the Marines on the ground to successfully carry out their operations. The final RQ-21A capability shortfall that impacts MUM-T is its inability for digital interoperability. One of the greatest strengths of the F-35 is the capability of its sensors and the ability to push data to off-board contributors. The RQ-21A air vehicle as well as the Ground Control System's (GCS) inability to integrate into the digital system causes a reduction in battlespace awareness for all elements of the MAGTF. Because the RQ-21A does not have the ability to conduct digital interoperability, its ability to conduct MUM-T is limited to voice integration. The current capabilities of Marine Corps UAS platforms are not only defining USMC MUM-T, but they are also limiting the Corps' ability to achieve the full potential of MUM-T in support of the GCE.

Aviation T&R manuals play an important role in setting the battle rhythm for individual squadrons, establish priorities for individual communities, and have the ability to develop cross platform relationships based on shared training requirements. T&R manuals have increased importance in communities such as the F-35 and RQ-21A as they incorporate operating concepts from legacy platforms and establish new Tactics, Techniques, and Procedures (TTPs). These initial T&R manuals are the basis for establishing a foundation as these communities continue to evolve that will endure for the entire lifecycle of the platform. For example, according to the *2017 Marine Aviation Plan*, the RQ-21A "achieved Initial Operational Capability (IOC) in January of 2016" and as of January 2018, the current T&R manual is dated May 2015.[21] An examination of the RQ-21A T&R manual reveals that of the 47 events required to become a Weapons and Tactics Instructor (WTI), only 10% require integration with external aviation support.[22] Compounding the lack of opportunities to integrate with other elements of the ACE is an absence of any academic training on the employment or capabilities of the F-35. Headquarters Marine Corps Aviation's failure to require VMU squadrons to integrate with other aviation assets or, at the very least, to have an academic understanding of all platforms within the ACE is a missed opportunity to build the foundation of future MUM-T concepts of employment.

The F-35 achieved IOC in 2015 and reached full operational capability in late 2017, however its current T&R manual was signed in June 2013.[23] Similar to the RQ-21A, the F-35 is composed of aviators that transitioned from other platforms such as the F-18 and AV-8B. While these aviators bring an abundance of experience, they also bring TTPs from legacy platforms that may not maximize the F-35's employment. As the F-35's first T&R manual, signed four years prior to the platform reaching full operational capability, is unable to mandate training that produces a pilot that has the readiness to maximize the employment of the ACE's future ground

attack platform. The failure to adapt to an increase in capability becomes very evident when analyzing the F-35, F-18, and AV-8B T&Rs side by side. Similar to the legacy platforms, the F-35 T&R has no mention of MUM-T and only requires UAS integration during one event and that event is not a requirement for any qualification or progression.[24] If the mission of the F-35 is to support the MAGTF Commander during combined, joint, or expeditionary operations, then Marine aviation must reevaluate how it operationally employs aircraft and begin to build the foundations of future MUM-T through a rewrite of the F-35 T&R.

Currently, Marine aviation conducts MUM-T on a very limited and basic level, primarily through voice procedures with an external agency acting as the connecting file between the platforms. The traditional manner of employing Marine aviation as individual platforms and the limitations of current UAS assets contributes to this near-sighted view and limits the ability to develop MUM-T concepts of employment that will maximize the ACE's future ground attack capabilities via the pairing of the F-35 and UAS. Alfred A. Cunningham said, "The only excuse for aviation in any service is its usefulness in assisting the troops on the ground to successfully carry out their operations."[25] If Marine aviation is going to remain focused on its original concept, then the ACE must change the way it operationally employs its aircraft.

RECOMMENDATIONS FOR FUTURE USMC MANNED-UNMANNED TEAMING

Air Force Chief Scientist Gregory Zacharias, in an interview with *Defense Systems* about artificial intelligence engineered in the F-35, said, "much higher degrees of autonomy and manned-unmanned teaming are expected to emerge in the near future . . . this involves an attempt to have another platform fly alongside a human, perhaps serving as a weapons truck carrying a bunch of missiles."[26] Since 2012, the Marine Corps has been on the leading edge of the Department of Defense (DoD) in regards to F-35 operational employment when it activated

the first F-35 squadron. In 2017, Marine aviation continued to set the pace for the DoD by relocating that same squadron to the Western Pacific in preparation for deploying the F-35 with the 31st Marine Expeditionary Unit (MEU). If Marine aviation wants to continue to influence how the F-35 is employed and the ACE wants to ensure it continues to support the MAGTF, the USMC must change the way it operationally employs aircraft to maximize air-to-ground capabilities via MUM-T. In order to efficiently and effectively employ a concept of operations involving MUM-T, the ACE must build the foundation now as these platforms mature by reevaluating the F-35 T&R manual, realigning VMU and F-35 squadrons, and developing MUM-T doctrine.

The *2017 Marine Aviation Plan* states, "the training and readiness program will remain the cornerstone for Marine aviation" and because of this importance, the ACE needs to reevaluate the use of legacy training programs to ensure the readiness of "next generation" aircraft.[27] As previously discussed, current aviation T&R manuals approach training as if the aircraft was an isolated platform that only operated independently. This can partly be explained because of the limited ability for legacy platforms to truly integrate with other assets and, as a result, the subject matter experts' experience is focused on solely training to the specific platform. Aerial platforms that will determine the future operational employment of Marine aviation have an inherent ability to exchange information and integrate as part of the system in order to provide commanders with a solution tailored to the requirement. While it remains necessary for introduction and core skill phases to remain focused on performing the basic functions associated with the individual platform, it is the advanced phases of training that need to be reevaluated. As aviators advance in their career progression, the focus of training must shift to the integration of capabilities across manned and unmanned platforms. The ACE's continued

ability to successfully perform all six functions of Marine aviation in support of the MAGTF Commander will require the use of MUM-T. As part of the "cornerstone for Marine aviation," the F-35 T&R manual has the ability to force the development of TTPs for MUM-T by requiring the integration of group 5 UAS. A group 5 UAS is capable of operating at altitudes above 18,000 feet and has no airspeed restrictions. Marine aviation does not currently have a group 5 UAS, however the MAGTF Unmanned Expeditionary capability is expected to IOC in 2026.[28] Teaming the F-35 now with a US Air Force group 5 UAS will begin the process of changing how the ACE operationally employs its aircraft and lays the foundation for the eventual MUM-T of the F-35 and MAGTF Unmanned Expeditionary capability. MUM-T introduction to the F-35 T&R should not increase the number of required training events to achieve qualifications or career progression, but should represent a change in how the aircraft is employed. Instead of viewing the aircraft as an individual element it must be viewed as part of a system of integrated and teamed assets that provide the commander with a wide range of optimal solutions. Because of the F-35's limited standard combat loadout and increased operating and maintenance costs, the completion of any T&R air-to-ground event beyond the initial or core skill phases must involve MUM-T.

The F-35 basing plan and the realignment of VMU squadrons from the Marine Aircraft Control Group (MACG) to the MAG has ramifications on the ACE's ability to conduct MUM-T operations. The implementation of these plans is another example of the need to change the way the Corps operationally employs its aircraft because the execution of these independent plans results in less than 25% of VMU squadrons being permanently located within their operational range of F-35 squadrons until FY2025.[29] The current capability limitations of Marine Corps UAS requires VMU squadrons to be co-located with the F-35 and placed under the same MAG

Headquarters in order to develop the foundation of a concept of employment based on MUM-T. VMU-3 currently based at MCAS Kaneohe Bay, HI, with MAG-24 is the squadron most in need of realignment.[30] Moving VMU-3 to MCAS Iwakuni, Japan, and MAG-12 will provide Marine UAS support to the Western Pacific and allow the squadron to align with VMFA-121 which is developing TTPs for F-35 employment in an expeditionary operating environment. The alignment of a VMU and F-35 squadron in the Pacific AOR creates the ability for Marine aviation to develop the MUM-T capability in an expeditionary environment while the concept of MUM-T is evolving and becoming fully operational. Placing the RQ-21A and the F-35 within the same MAG is a step toward the creation of F-35 and VMU composite squadrons once the Marine Corps acquires a group 5 UAS truly capable of MUM-T. According to the *2017 Marine Aviation Plan*, the MAGTF Unmanned Expeditionary capability will have full digital interoperability and be shipboard capable with strike capability operating at ranges and altitudes complementary to the F-35.[31] Using the MUM-T concept of operations, the VMU and F-35 composite squadrons would operate similar to current HMLA squadrons, in a complementary manner that maximizes the capabilities of each platform as well as creating collective capabilities able to execute all six functions of Marine aviation in support of the Marine on the ground. Changing the ACE's concept of operational employment to the integrating and teaming of manned and unmanned platforms in order to maximize future ground attack capabilities will eventually require the establishment of composite VMU and F-35 squadrons, but the first step is to co-locate these squadrons under the same MAG Headquarters.

In addition to co-locating and establishing composite squadrons that will enable the Marine Corps operational squadrons to assist in the development of MUM-T doctrine, there exists a requirement for Marine Aviation Weapons and Tactics Squadron One (MAWTS-1) and

Marine Operational Test and Evaluation Squadron One (VMX-1) to develop formal MUM-T doctrine. These two squadrons are uniquely qualified and tasked with the incorporation of science and technology in the development, testing, and employment of aviation weapons and tactics in support of the future needs of the MAGTF.[32] The *2017 Marine Aviation Plan* discusses the opportunity for collaboration between the squadrons saying, "now co-located with MAWTS-1, VMX-1 is optimally postured to conduct experimentation, tactical demonstrations (TACDEMOs), concept development support, and operational testing in order to rapidly deliver warfighting capability to the fleet."[33] The aviation plan details a few of the joint developmental projects, however all of the concepts remain focused on the capabilities of the individual platforms and don't change how the Corps operationally employs its aircraft. The ability for Marine aviation to maximize its future ground attack capability in support of the GCE requires the teaming of the F-35 and UAS. This change in concept of operations must at least partially be driven from the Marine Corps' aviation weapons school. The Aviation Development, Tactics and Evaluation (ADT&E) department of MAWTS-1 has the mission of developing concepts of operation and aviation doctrine through the conduct of TACDEMOs.[34] Each year during MAWTS-1's two service-level training events, Weapons and Tactics Instructor (WTI) Course, ADT&E and external agencies conduct TACDEMOs with the focus on validating or pursuing emerging innovative TTPs. TACDEMOs conducted during WTI have the ability to stress and validate all elements of the MAGTF in a simulation of the full spectrum of combat operations. The unparalleled access to subject matter experts, technical support, and aviation assets produces the opportunity for the TACDEMOs to serve as the formal developmental grounds for Marine Corps MUM-T doctrine and TTPs. Using the Corps' aviation weapon school house and operational test squadron will validate the MUM-T concept and create a synergistic effort

between the formal school house and operational squadrons. MAWTS-1 and VMX-1 are in the enviable position of having the ability to develop and validate MUM-T doctrine which will reshape the ACE's concept of operations while maximizing future ground attack capabilities and allow the USMC to retain F-35 sorties in support of the MAGTF.

In the future, the untapped capabilities of the F-35, such as artificial intelligence, will result in the increased ability to operationally employ aircraft using MUM-T.[35] Since the initial operational F-35 squadron, the Marine Corps has been a driving force in the development of F-35 employment and TTPs. However, the technological advances of the F-35 will require Marine aviation to reevaluate its concept of operations if the Corps wants to remain influential in the maturation process of F-35 employment. The ACE's reevaluation of its operational employment requires an increased focus on its original concept by using MUM-T to maximize air-to-ground attacks in support of the MAGTF. The foundation of a concept of employment involving MUM-T must be developed during the maturation process of the F-35 by reevaluating the F-35 T&R manual, realigning VMU and F-35 squadrons, and developing MUM-T doctrine.

CONCLUSION

The Marine Corps first demonstrated its air-ground combined-arms concept in January 1914, during an annual fleet exercise when Marine aviation supported Marine ground elements of the Advanced Base Brigade.[36] Given the issues facing today's Marine aviation community, it is appropriate that this first example of USMC aviation in support of Marine ground forces is provided in the Marine Corps *Aviation Operations* chapter called "The Role of Marine Aviation" under the section entitled "The Evolution of Marine Aviation: Adapting to Meet the Threat."[37] Because of the technological advances and increased capabilities of the F-35 and the role of the JFACC many Marines outside of the aviation community are concerned about what role Marine

aviation will play in supporting the GCE for the next 10 – 15 years and beyond. Since the inception of Marine aviation, "the primary purpose for the Marine Corps having airplanes is their use in close support of ground units."[38] Throughout the history of USMC aviation its role has remained support of the GCE; however because of the limited air-to-ground loadout and increased financial and maintenance requirements associated with the F-35, the USMC must change its aviation concept of operations to maximize the ACEs' future ground attack capabilities through the execution of MUM-T.

Marine Corps aviation's current method of task-organizing assets and executing operations based on individual platforms, combined with a focus on individual aircraft readiness instead of functional readiness, limits the ACE's ability to support the Marine on the ground via MUM-T. However, as the USMC transitions to a fixed wing tactical aviation force solely comprised of the F-35, the ACE must transition to an operational approach that involves MUM-T to ensure the Corps remains capable of executing all six functions of Marine aviation in support of the MAGTF. In order to successfully transition to a concept of operations involving MUM-T, the ACE must build the foundation now as these platforms mature by reevaluating the F-35 T&R manual, realigning VMU and F-35 squadrons, and developing MUM-T doctrine. The current T&R manual's use of legacy training programs does not provide the necessary training for a platform with autonomous capability and the ability to digitally integrate throughout the battlespace. Restructuring the F-35 T&R manual to require the integration a group 5 UAS will serve as a forcing function for the development of MUM-T TTPs. Next, the USMC needs to align VMU and F-35 squadrons to encourage the development of MUM-T TTPs in an operational environment while the concept of MUM-T is evolving and becoming fully operational. Placing these squadrons in the same parent MAG is the first step in the creation of a

F-35 and VMU composite squadron that is fully capable of conducting MUM-T operations. Finally, MAWTS-1 and VMX-1 must provide the formal direction of Marine Corps MUM-T doctrine and TTPs. The Corps' aviation weapon school house and operational test squadron are positioned to reshape the ACE's concept of operations through the development and validation of MUM-T doctrine.

In conclusion, Marine aviation has a legacy of innovation and adaptation centered around how to better support the Marine on the ground. The uncertain nature of combat operations has required the ACE to anticipate and react to unforeseen challenges. Marine aviation's proactive approach to innovating, updating, and validating doctrine has a history of producing optimal solutions for the MAGTF Commander. If Marine aviation is going to uphold this tradition, then today's leaders must change the way the Corps operationally employs aircraft to maximize the ACE's future ground attack capabilities via manned-unmanned teaming.

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[3] Headquarters United States Marine Corps, *2017 Marine Aviation Plan* (Washington, DC: Headquarters United States Marine Corps, 2017), 47.
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[5] Headquarters United States Marine Corps, *2017 Marine Aviation Plan,* 146.
[6] US Department of Defense, *Autonomy in Weapon Systems,* Directive 3000.09, May 8, 2017, 13.
[7] Department of the Navy, *FY2018-2019 F-35 Annualized Sustainment Contract,* Patuxent River, Maryland: Naval Air Systems Command, March 27, 2017, https://www.fbo.gov/index?s=opportunity&mode=form&id=9b5d6936181bf476694fd118c54016bd&tab=core&_cview=1. NAVAIR's mission is to assist the entire life-cycle of all aviation assets through research, design, acquisition, evaluation, and engineering support.

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