REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
01-05-2013	Master of Military Studies Research Paper	September 2009 - April 2010

4. TITLE AND SUBTITLE
F-35B on the MEU: Innovation or Just New Technology?

5a. CONTRACT NUMBER
N/A

5b. GRANT NUMBER
N/A

5c. PROGRAM ELEMENT NUMBER
N/A

6. AUTHOR(S)
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5d. PROJECT NUMBER
N/A

5e. TASK NUMBER
N/A

5f. WORK UNIT NUMBER
N/A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
USMC Command and Staff College
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2076 South Street
Quantico, VA 22134-5068

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

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

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

11. SPONSORING/MONITORING AGENCY REPORT NUMBER
N/A

12. DISTRIBUTION AVAILABILITY STATEMENT
Unlimited

13. SUPPLEMENTARY NOTES
N/A

14. ABSTRACT
The introduction of the F-35B provides the USMC an opportunity to rexamine the requirements and redefine the capabilities of the fixed wing component of the Aviation Combat Element (ACE) within the Marine Expeditionary Unit (MEU). The current six-plane detachment provided by the AV-8B maintains several shortfalls within the overall operating philosophy of USMC aviation. The F-35B now expands the mission set across all six functions of Marine Corps Aviation. The expectations of additional mission requirements, expectation to operate in A2AD environments, increased avionics will require a greater sortie generation capability than currently provided by the six (6) AV-8Bs. This paper analyzes the current shortfalls inherent in the current six-plane model and proposes one possible solution consisting of eight (8) F-35Bs. This solution generates capability options in line with current and expected sortie generation requirements as well as possible future operating concepts in distributed operations.

15. SUBJECT TERMS
Joint Strike Fighter, JSF; Aviation Detachment; Marine Expeditionary Unit, MEU; Aviation Combat Element (ACE)

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE	UU		Marine Corps University / Command and Staff College
Unclass	Unclass	Unclass			19b. TELEPONE NUMBER (*Include area code*) (703) 784-3330 (Admin Office)

United States Marine Corps
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MASTER OF MILITARY STUDIES

TITLE:
F-35B JOINT STRIKE FIGHTER ON THE MEU:
INNOVATION OR JUST NEW TECHNOLOGY?

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

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AY 12-13

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Date: 11 April 2013

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Date: 11 April 2013

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Executive Summary

Title: F-35 Joint Strike Fighter on the MEU: Innovation or Just New Technology?

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Thesis: The legacy six-plane fixed-wing allocation to the MEU requires scrutiny and analysis in light of the proposed concepts for the operational problems of A2AD. The expanded capabilities and mission sets of the F-35B provides an opportunity to reexamine and restructure the fixed-wing component of the MEU ACE.

Discussion: Innovation does not exist solely within the technology of new capabilities of the F-35B and its introduction to the USMC. True innovation will be in the operating construct and force structure to maximize the capabilities of the technology. These capabilities and operating constructs must be applied to the evolving solutions to the problems presented to the naval forces of the future. These rapidly changing concepts and new technologies that the F-35B brings to the force, creates an opportunity for the USMC to evaluate current force structure, ensuring the fullest utilization of capabilities, while at the same time ensuring efficiencies are maximized during a period of budget constraints.

A review of emerging doctrines of JOAC and operations in A2AD environments, in conjunction with the current deployment of fixed-wing aircraft on amphibious shipping reveals a shortfall of requirements for effective employment in A2AD environments. The six-plane detachment model also contains several shortfalls in regards to actual employment opportunities, sortie generation rates, and pilot time-to-train requirements. In order to meet the requirements of JOAC and maximize the capabilities of the F-35, a more mission-focused modular design for the operating force structure of F-35 MEU detachments will create an efficient and flexible force capability for the commander.

Conclusion: The goal of this paper is to instigate discussion and critical review of the current operating construct and capabilities of the six-plane detachment construct of the MEU. The increase in aircraft to an eight-plane detachment model would expand capabilities and provide assets required for evolving mission sets in the face of the expanding technology of the nation's enemies. This study provides one realistic solution to correct the sortie generation models, which will further create options and capabilities available in line with future operating concepts of JOAC and distributed operations. The study is meant to stimulate discussion and an in-depth review of requirements versus capabilities of the fixed-wing aviation assets of the MEU to optimize force organization structure in the future.

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While the nature of war is constant, the means and methods we use evolve continuously…One major catalyst of change is the advancement of technology. As the hardware of war improves through technological development, so must the tactical, operational, and strategic usage adapt to its improved capabilities both to maximize our own capabilities and to counteract our enemy's.

- MCDP-1 Warfighting

Introduction

Since French observation balloons used at the Battle of Fleurs in 1794, technological advances and subsequent applications resonate throughout military aviation theory and overall warfare doctrinal thinking. Whether technology provides a capability or limitation, aviation employment concepts depend on emerging technology. Today, the need to operate in anti-access / area denial (A2AD) environments dominate new emerging combinations of electronic warfare, networked forces, and distributed operations dominate the emerging concepts of the Joint Operating Access Concepts (JOAC) and the Concept for Distributed Operations (CDO). These concepts "create an advantage over an adversary through the use of separation and coordinated, interdependent, tactical actions."[1] The solution for the Marine Corps aviation assets that will operate in these environments is the F-35 Joint Strike Fighter (JSF). The JSF provides 5th generation fighter capabilities, creating a large technological leap in current Marine Corps aircraft, including electronic warfare (EW) capabilities, reduced radar signature, increased sensor fusion, open architecture avionics, and network warfare potentials necessary to operate successfully in these A2AD environments.

The Joint Capabilities Integration and Development System (JCIDS) utilizes the model of operating concepts driving doctrine, which correspondingly drives the organization, training, material, leadership, personnel, and facilities (DOTMLPF) within an organization.[2] In the current acquisition framework and required timelines the material (equipment) often exists before the evolving doctrine. In this regard, the underlying concepts of JOAC and CDO, with the addition of new technological capabilities, provide the needed doctrinal and organizational motivations for change that mold the future force development of the USMC.

The culmination of these evolving operational concepts, introduction of new technology, and impending budgetary constraints create an opportunity for an examination of the current organizational structure within the Marine Expeditionary Unit (MEU) regarding forward-deployed and amphibious-based aviation assets. Innovative ideas and new operating concepts that maximize capabilities should drive the formation of new operating concepts. A simple equipment replacement in the form of one aircraft for another within the Aviation Combat Element (ACE) does not meet the direction laid out in the 2010 National Security Strategy. To achieve this vision, new technology and the operating concepts of the military forces must be scrutinized. Stephen Peter Rosen defines a major military innovation as a change within the method of an organization fights in terms of its force organization to win the campaign or a "new theory of victory."[3] Therefore, innovation will not exist solely in the technology of the new aircraft. True innovation will develop within an organization with a change to the operating construct and force structure, which maximize the capabilities of the technology. Quoting Secretary of Defense, Donald Rumsfield,

"We need to change not only the capabilities at our disposal, but also how we think about war. All the high-tech weapons in the world will not transform the US armed forces unless we also transform the way we think, the way we train, the way we exercise and the way we fight."[4]

Over the next twenty years, the F-35B Short Takeoff/Vertical Land (STOVL) version will replace the entire fleet of AV-8B Harrier aircraft operating from amphibious shipping. As F-35Bs become the fixed-wing component of the ACE on forward-deployed MEUs, this technological leap provides an opportunity for innovation in the tactics, techniques, and procedures (TTPs) across all six functions of Marine Corps aviation, which do not exist today in the AV-8B. The new capabilities of the F-35B necessitate a top-down review of MEU fixed-wing operating concepts and organizational structure. Critical analysis and discussion of the organizational structure within the ACE must occur to enhance the capabilities of the MEU in terms of the new emerging Joint Operating Access (JOAC) and CDO. This paper proposes a shift from the current six-plane detachment to a eight-plane detachment consisting of two four-plane modules to provide enhanced capabilities in conjunction with the introduction of the F-35B.

Today's Problem: Need for Change

The existing operating concept for fixed-wing assets attached to an amphibious-based MEU consists of a six-plane detachment of AV-8B aircraft. With few exceptions, the standard MEU operating concept and accepted model has always been six aircraft. The original proof-of-concept from the 1970s perpetuates in today's operating forces. The original construct of employing a complement of helicopters and Harriers aboard a "Sea Control Ship," was advocated by then, Secretary of the Navy Admiral Elmo Zumwalt, utilizing the USS Guam (LPH-9). In 1974, six AV-8Bs along with a

helicopter contingent were deployed on board the USS Guam to the Mediterranean Sea as a proof of concept deployment. This proposed operating structure created a counter model to the large capital ship model that existed around the aircraft carrier and the resultant battle group. The conventional carriers of the time utilized 5000 sailors and cost of $1.5 billion presented "an impossible burden besides representing a relatively vulnerable and inflexible weapon," and that multiple smaller carriers provided more flexibility and lower operating costs.[5] As the wars in Iraq and Afghanistan end today, this problem of decreasing budgets, place restraints on the force structure of the operating forces.

Although, the US Navy rejected the Sea Control Ship, this model did provide the model for STOVL aircraft for both the British Royal Navy and the Spanish Navy. The first Russian Aircraft Carrier, *Kiev*, first sailed in 1976 with Yak-36 "Forger" VTOL aircraft onboard. The original concepts of the Russian carrier included an estimated 15 fixed-wing (Yak-36) and 25 rotary-wing (Ka-25) aircraft embarked for anti-submarine operations.[6] The USMC pursued the concept in the creation of the ACE within the Marine Amphibious Unit (MAU) (the precursor to the MEU of today). HMM-265 became the first Medium Marine Helicopter Squadron to work with AV-8As into its composite squadron aboard the USS Tarawa (LHA-1) in 1980. Throughout the 1980s, and the replacement of the AV-8A by the AV-8B, the standard number of AV-8B aircraft on a MEU detachment remained at six aircraft.

Currently, the six-plane AV-8B detachment provides all the fixed wing sorties for a deployed MEU to support all the MEU's mission essential tasks (METs). This comprises all the strike, close air support, and reconnaissance provided for amphibious

offensive, defensive, and special operations. The detachment also provides the Navy METs of the Surface Subsurface Search Coordination (SSSC), Defense of the Amphibious Task Force (DATF) and Offensive Anti-Air Warfare (OAAW). Both the Navy and USMC commands in their roles as Commander of the Amphibious Task Force (CATF) and Commander of the Landing Force (CLF) allocate the resources and capabilities of the detachment for mission prioritization. The AV-8B Training and Readiness (T&R) Manual (NAVMC 3500.51A) defines the structure and sortie generation capabilities of the six-plane detachment and summarized in the "Detachment" column under AV-8B of Appendix A. This model defines a six-plane, nine-pilot detachment capable of indefinitely maintaining a "3T3T2" model or eight total sorties per day.[7] Sortie generation rates are based on a 70% "Ready Basic Aircraft" (RBA) rate of all aircraft in the unit.[8] That is, of the six AV-8B aircraft, 70% or four of the aircraft should be available for flight. The problem arises when not all of the four aircraft are available or one of the aircraft has a maintenance malfunction preventing it from flying or aborting the mission airborne. In order to prevent this problem, the gap between the 70% requirement (four jets) and the model's utilization of only three aircraft creates a backup availability.

Controversy with the T&R manual's projected model arises within the AV-8B community due to historical evidence and daily training operations at home. Historical evidence reveals the six-plane model of the 1980s and 1990s could generate more sorties over today. In 1985, the AV-8B "Day Attack" was being flown. The "Day Attack" aircraft had a maintenance man-hour per flight hour rate of less than 15 hours.[9] During Desert Storm in 1991, flying AV-8B "Day Attack," readiness rates averaged 90 percent

mission capable (MC) and 84% full mission capable.[10] Today, the USMC operates both the AV-8B II Night Attack Aircraft and the AV-8B II+ Radar aircraft. These aircraft incorporate FLIR systems and/or Radar systems, much more complex avionics system, and a different engine. In 2005, the maintenance overhead had risen to 25 maintenance-man hours per hour of flight.[11] The maintainability of the aircraft today and the aircraft of 1985 cannot be expected to utilize the same model with the same results.

Appendix B contains the monthly average "Ready for Tasking" (RFT) historical data for all deployed AV-8B squadrons and detachments for FY11 and FY12.[12] A cursory analysis reveals that approximately only 50% of the time the units are maintaining that 70% baseline expected within the model. The basic assumption of 70% RBA aircraft has become a goal within a squadron or detachment's maintenance department, versus a day-to-day capability of operation. This validates the need to reduce the operational model to utilization of only 3-planes. The squadron may possess the capability may to fly more aircraft, but it cannot be guaranteed one hundred percent of the time.

The AV-8B maintenance requirements may be results of a legacy aircraft but similar comparisons and assumptions can be made with the F-35. Current JSF Program Based Agreements indicate 12-hour maintenance man-hours per flight hour threshold with a goal of 8-hours while maintaining an objective 75% readiness rate.[13] This may be seen as a huge improvement over the current AV-8B but one must wonder if this number is realistic. The F-35B is a relatively new aircraft and long-term maintenance data does not exist. However, comparing similar technology by the same manufacturer, the F-22 Raptor possessed a similar threshold of 12-hours within its program contracts, but has

exceeded it in the past with great controversy. Direct maintenance man-hours for the F-22 were 18.1 in 2008.[14] The current numbers again increased recently until manufacturing processes fabricated for the F-35 improved maintenance of the radar reflective skin of the aircraft and now are within the 12 maintenance man-hour requirements. Within the USMC, readiness shortfalls also exist with the MV-22. The overall V-22 program specification defines the minimum acceptable readiness rate as 82% with a preferred rate of 87%. The three deployed MV-22 squadrons deployed to Iraq maintained readiness rates of 68%, 57%, and 61%.[15] These readiness rates may relate to spare parts and material availability rather than maintenance-man hours but the end result is aviation units failing to meet the aircraft availability planned for the operational construct in which they exist.

These readiness figures reveal that the USMC should not expect large increases in aircraft readiness due to technology. The old legacy aircraft assumptions will apply with future generations of aircraft. Therefore, the legacy model assumptions within the six-plane detachment, regardless of aircraft type, can continuously sustain a 3T3T2 model. Utilizing this sortie generation model, the concept of a six-aircraft detachment, utilizing the above model contains flaws across several key issues: 1) doctrinal fixed-wing employment considerations, (2) a requirement versus capability argument, (3) current Navy flight deck restrictions, and (4) pilot crew-day limitations.

Fixed-Wing Doctrinal Employment

Single-seat aircraft rarely fly operational missions utilizing a single aircraft but fly in sections of two aircraft and divisions of four aircraft in order to maintain situational

awareness utilizing combat wingman.[16] Therefore, the ability to fly three aircraft at a single time does not provide the commanding officer much additional flexibility; the operational model must either be two aircraft or four aircraft in order to achieve maximum capabilities in accordance with doctrine. The lack of single aircraft missions is unlikely to change in the future. Additional aircraft and their wingmen provide additional situational awareness, redundancy, and tactical solutions to each mission set across all six functions of Marine aviation. There exist occasions to fly single aircraft missions but the increase in failure to mission, due to the lack of redundancy and situational awareness, and the risk to force, due to the lack of back-up in case of emergency or enemy engagement increases significantly. These risks weigh largely into operational risk management models for the commander and often preclude the benefits gained by employing single aircraft.

MEU Requirements versus Capabilities

The second flaw of the six-plane construct then relates to the first. What is the requirement for fixed-wing operations for the MEU? What mission requirements justify the capabilities of the fixed-wing detachment in terms of sortie generation? Does a MEU require the capability to fly a section of aircraft or is the requirement two sections of fixed-wing support either at the same time or aligned to each other to increase the capacity of the support as in subsequent vulnerabilities windows in pre-planned CAS missions? The question must be answered before the proper number of assets and capabilities brought to bear on the problem.

The Training and Readiness Manuals of each airframe define the Mission Essential Task List (METL) from the Marine Corps Task List (MCTL) in terms of core skills, mission skills, core plus skills, and mission plus skills. The core and mission skill sets define the number of pilots capable of performing this mission for each size of unit. The core plus and mission plus skill sets define the METL for low-probability mission sets and theater specific requirements. This problem is compounded in the expected expansion of capabilities the F-35B brings to the MEU. (See Appendix F.) The AV-8B is currently only operating across five of the six functions of Marine Aviation, neglecting electronic warfare.[17] Of these five functions, the Harrier possesses limited capabilities in Command and Control of Aircraft and Missiles and Antiaircraft Warfare. For command and control, the Harrier is limited to only utilizing line of sight radios with no datalink or auto-relay communication capability. Although the new addition of the AIM-120 AMRAAM adds some ability in the antiaircraft warfare arena, the aircraft lacks capabilities in terms of kinetics of the missile and radar/avionics sophistication to employ the missile to its full capacity. In the remaining three functions of Marine Aviation, the AV-8B is limited by its dated technology and capabilities in terms of payload, speed, and range when compared to the newer F-35B.

The addition of the F-35B provides enhancements across all six functions of the Marine Aviation and a larger opportunity and requirement to employ the aircraft. Avionics upgrades within the JSF will provide enhancements in "Command and Control." A new phased array radar will greatly enhance multi-sensor imagery reconnaissance (MIR) in terms of the armed reconnaissance (AR) mission. The flight characteristics and capabilities of the fifth generation fighter provides greater

survivability against A2AD threat, including complex IADS or anti-air threats. This capability provides the MEU more expanded offensive anti-aircraft capability over the limited self- or point-defense capability of the AV-8B Harrier. Each of these improvements increases the operational concepts that can be utilized with the F-35B and continue to expand the mission sets in the realms of Electronic Warfare (EW) and Offensive Anti-Air Warfare (OAAW).

This increase in mission sets returns the discussion back to the "requirements versus capabilities" argument and the preferred employment model. The capabilities of fixed-wing aircraft have rapidly given the AV-8B a MIR mission due to its availability, range, and speed capability over unmanned aerial vehicles on the MEU. The F-35B only enhances this capability with improved sensors and data architecture that will increase the desire to utilize the capability. In terms of anti-air warfare or operations in A2AD environments, the sustained three-aircraft sortie generation model provides inadequate force for the operating environment. The new tactics require a minimum of four aircraft airborne to operate effectively in these environments. If the USMC is going to require this capability, it has to provide the assets. In this case a minimum of a four-jet sustainable flight schedule is required for current air-to-air radar tactics, preempting the six-plane model that can only sustain three aircraft. Again, the question goes back to the proper definition of requirements for fixed-wing operations of the MEU and assigning the proper assets to provide that capability.

Flight Deck Limitations

The crux of the third argument is the inherent complexity of merging two competing organizations into a reinforced helicopter squadron. The AV-8B detachment is integrated into the Medium Marine Helicopter squadron, utilizing the same spaces and most importantly, the flight deck, which becomes the number one resource constraint. Current practices onboard amphibious shipping only allocates a single flight deck crew, limited to a typical 12-hour work or crew-day. With this single crew, the ship provides a 12-hour flight deck window due to its personnel limitations. This 12-hour window is further restricted into a by flight deck preparation, such as "FOD walks"[18] and aircraft movements, typically scheduled for an hour on each end of the flight deck window resulting in a ten-hour window in which aircraft can actually fly.

This 10-hour window is then shared between both the rotary wing and fixed wing assets onboard. Again the AV-8B model for maximum sustainable sortie generation requires a 3T3T2 model which conflicts with the rotary wing models. All the helicopters must clear the flight deck landing spots in order for the AV-8Bs to launch. Therefore, the requirement for AV-8Bs to launch in the middle of the flight deck window necessitates helicopter operations, especially maintenance being performed on these helicopters which often requires the use of spread-spot operations in the landing area. Due to this confliction between operations, typical fixed-wing operations result in Harrier flights at the start of the flight deck window as the first launch and last launches of the day. This model removes the middle AV-8B flights in order to allow helicopter operations and maintenance to work unimpeded through the middle of the day. This also places the AV-

8B detachment into the need to now fly a 4T4 model in order to still generate the required eight sorties further placing the detachment at risk of losing a operational or training sortie due to the maintenance requirements described in previous sections.

The T&R-defined model, 3T3T2, or the "book-ending" model described above in a 4T4 structure creates little flexibility for the commander when fit into a ten-hour flight deck window. The "Turn" portion typically requires between two and two-and-half hours to accomplish,[19] resulting in aircraft only being able to take off two hours after landing. This will quickly result in encompassing the majority ten-hour flight deck window provided by the Navy.

3 JETS	TURN	3 JETS	TURN	2 JETS
1.3 hour (flight) +	2.5 hours (turn) +	1.3 hour (flight) +	2.5 hours (turn) +	1.3 hour flight

This model encapsulates 8.9 hours of the flight deck and leaves little room for error, delays, or more importantly operational creativity for the commander. The "book-ending" model is displayed below.

? JETS	TURN	? JETS
1.3 hour (flight) +	up to 7.4 hours (turn) +	1.3 hour (flight)

This model allows for a large "Turn" window, either add additional fixed wing sorties utilizing hot refueling, same pilots, and no configuration changes or providing 7.4 hours of flight deck time to the helicopter operations and maintenance. This model seems to have advantages but to obtain the same eight sorties, the detachment has to conduct "surge" operations to fly a 4T4 model every day, risking failure.

More importantly when pilot crew days are introduced as a limiting factor, and the requirement to prepare or brief for a sortie begins two to three hours minimum before the sortie, the availability of pilots severely limits the capability of the unit.[20] The additional requirement of a Landing Signals Officer (LSO), who controls the aircraft from the tower, hampers the operational capability to fly this model with a nine-pilot detachment.

Crew day limitations also provide another failing in the operational model in conjunction with the Navy's 12-hour flight deck window. Wars and contingency operations occur 24-hours a day. With only nine AV-8B pilots and the requirement to provide a LSO with the same crew day limitations, it becomes impossible to cover 24-hour operations or maintain an alert condition, without violating the crew-day limits imposed within OPNAV documents and unit standard operating procedures (SOPs). At first glance it is a simple problem. If the detachment is required to provide a section of aircraft on alert over a 24-hour window, two pilots are required every eight hours, equaling six pilots. Add on the need for an LSO during the same eight-hour window, and the total becomes nine and the problem is solved.

However, nothing in aviation is one hundred percent all the time. The above "simple" solution does not provide back-ups to any of the problems that will inevitably occur. Regardless of the aircraft, AV-8B or F-35B, unforeseen problems will exist in the form of maintenance and system failures during startup even once aircraft are airborne, necessitating a return to base. Typically air operations utilize "spinning" backups to prevent these routine failures but require the use of extra pilots and aircraft – something the detachment does not have in the 24-hour model.

If both aircraft gets airborne with no problems, two jets and two aircraft are now removed from the equation but have a predetermined lifespan. The pilots are recommended to only be airborne for 6.5 hours[21] and the aircraft has a maintenance service cycle that must be maintained. So now the problem becomes more complex. Does the alert have to be maintained in case of failure of the airborne mission? If so, pilots have to be brought in early of their scheduled eight hours and aircraft must be prepped. The pilot rotation schedule has been placed in a loop that it cannot reset. The maintenance cycle is also disrupted. The detachment is immediately in a "surge" environment (determined by the 3T3T2 model) based on the necessity to have four aircraft available. It can quickly be deduced that 24-hour operations are impossible for a 6-plane, 9-pilot detachment. There is no solution to the 24-hour problem except accepting risk in terms of either a risk to mission (inability to provide the asset at the right time) or a risk to force (fatigue-induced pilot error.)

Pilot Training

The fourth argument, which is hard to capture in data but easy to conceptualize, is the atrophy of pilot skills and loss of mission skill proficiency while forward deployed on a MEU. This operating concept must require the detachments, when not conducting real-world operational tasking, to continue to maintain currency as well as progress their pilots' skills. The USMC cannot afford to allow pilots to not progress for seven months on each deployment. The career progression models and personnel requirements of the USMC necessitate that pilots continue to progress or a "hollow force" and lack of

experience in the form of instructor pilots quickly generates in the personnel turnover every three years.

The need to continually train when not employed operationally necessitates that the employment concepts of the MEU generate the ability to train pilots. The ability to train attack pilots requires targets and training range that do not exist while transiting ocean or at sea for seven months. The lack of ranges and competition for flight time with the rotary wing assets onboard the squadron creates difficult in maintaining currency and proficiency. Atrophy of mission skills exist through the community during deployment and that must be handled with the proper risk management. More importantly, the young pilot's skill progression stalls during long deployments. If locked into all the previous problems of employment models, maintenance requirements, flight deck restrictions, it can easily be seen that a pilot may make little or no progress during the entire length of a six-month deployment.

An examination of the career progression of an AV-8B pilot is depicted in the AV-8B T&R manual is shown in Appendix E[22]. The figure includes nine months at the Fleet Replenishment Squadron (FRS) completing their 1000 Phase training. From nine months to 24 months the pilot completes his/her 3000 Phase of training, which encompasses all the mission skills and become a completely combat ready wingman across all mission sets.[23] However, this is also the time that junior pilots will make their first deployment or second deployment interrupting their skill progression.

Skill progression and proficiency maintenance in the 3000 Phase require pilots to drop ordnance. The first chart in Appendix E indicates thirteen sorties to achieve mission skill "proficiency" as the absolute minimum number of flights for a young pilot. The

second chart indicates eight separate mission profiles that each pilot must maintain "proficiency" in to be considered current in the mission skill. All these sorties except the EXP-3500 (Expeditionary Shore-Based Operations) require ordnance to be released from the aircraft. All of these flights have a re-fly interval in which to maintain proficiency/currency in that particular skill, the most restrictive of which is 90 days.[24]

By the end of a six or seven-month deployment it is possible that a pilot will not be mission skill currency and young pilots have completely stagnated in skill progression. To further complicate matters, this is not a problem exclusive to the mission skills set in Appendix E, but also to the Fundamental Phase and 2000 level skills that require ordnance and terrain to fly over such as the Low Altitude Tactics (LAT) syllabus. From the above discussion, a forward deployed pilot rapidly becomes a burden upon coming home attempting to redo every sortie that he/she has become delinquent. For a young pilot it becomes feasible to incomplete his Section Lead qualification during his/her first 3-year tour in a front-line squadron. Multiple pilots that incomplete the required syllabus prevents the required qualified pilot turnover within the AV-8B community and becomes a self-perpetuating problem. This training shortfall must be avoided by changing the deployment model and training availability aboard ship for the F-35B. A need to change the concept of fixed-wing employment while attached to a MEU in a training environment must allow pilot skill progression.

Tomorrow's Vision

Now that today's problems with the utilization of a six-plane AV-8B detachment have been identified, one must look at the underpinning operational concepts being developed within the Department of Defense (DoD) and USMC for employment of future forces. Strategic visions of tomorrow's military priorities profess the requirement to maintain forward presence and maintain US capabilities against a technologically advanced enemy across the spectrum of military operations.[25] Current U.S. foreign policy focuses these capabilities in a "rebalance to the Pacific" and although not specifically tied to a world power in the region, an inference to China's military capacity against American dominance must not be understated. These facts pose the expected requirement of the USMC's MEU concept to provide the United States a force projection arm in the region. This power projection capability must provide a realistic operating capability in the environment to provide deterrence and military capabilities in larger grand strategy of U.S. foreign policy in the Pacific region.

The concepts of Air-Sea Battle and distributed operations profess an interoperable force, capable of providing deterrence through providing forward presence without delays for force build-up provides the concepts necessary to operate in an operational problem.[26] The forces of the future, as described in *Joint Vision 2020* prescribe the concepts of force inter-operability, dominant maneuver, and precision engagement.[27] The enemy, through his extended A2AD weapons could prevent a build up of forces either at forward bases or sea bases. Unlike today's concepts revolving around a single capital ship, the concepts of JOAC and distributed operations create requirements for a new operation model that provides freedom of action and provide the commander multiple options in crisis mitigation. This "dominant maneuver" requiring dispersed forces,

"capable of scaling and massing force or forces."[28] The specifically strengthens the deterrence concepts as budget restraints in the future reduce forward deployed naval assets such as submarines and the wide span of the Pacific Theater strains the US Air Force strategic refueling capability and assets. These capabilities include "correcting the [People's Liberation Army] PLA-US imbalance in long-range strike for high-value and/or time-sensitive targets," emphasis on electronic warfare capabilities, and the interoperability of data links, C2 and [Intelligence, Surveillance, Reconnaissance] ISR infrastructures.[29] Specific potential confrontations with PLA forces in the Pacific Theater show requirements reveal operational-level employment considerations for the F-35 above the airplane versus missile tactical end-game. Highly sophisticated threats cannot be defeated by the technology of the F-35 alone. "By the 2020s, the PLA's [integrated air defenses] IADs would likely include sophisticated components such as fifth-generation fighters and S-300/400 SAM system with ranges of hundreds of kilometers."[30] The F-35 presents the opportunity through its technological capabilities to survive in these A2AD environments and to utilize new operating concepts to generate force mismatches involving both distribution and saturation of military strength by operating from small forward bases and sea platforms presents the opportunity in conjunction with electronic attack, decoys, and other capabilities of the joint force.

These concepts and capabilities provide a look to the Marine Corps future. The *Marine Corps Vision and Strategy 2025* requires "a plan to provide a tailored, persistently engaged, contingency-capable MAGTF."[31] This vision includes all missions across the spectrum of military operations from forcible entry in A2AD environment to Theater Security and Cooperation exercises. These strategic visions filter down to the

operational and tactical level, these requirements result in a 5th generation fighter aircraft, with modern technology with sensor fusion and stealth capabilities, capable of any contingency.[32] The F-35 provides the Marine Corps the technology and capabilities to operate in the A2AD environment and specifically the F-35B provides the Marine Corps the opportunity to operate from a multitude of operational sites, including forward operating bases and sea platforms inherent in the dispersal of forces concepts in JOAC, similar to the dispersal of concepts that the original VSTOL visions of the Cold War or the Sea Control ships of Admiral Zumwalt in the 1970s. All these technological advances complete the "Material" factor in the DOTMLPF force development model described within the *Joint Operating Concepts* and the *Joint Vision Implementation Master Plan (JIMP).* The two missing elements now are a modification to current MEU doctrine and most importantly, the organization to maximize capabilities.

Time for Innovation

In the late 1980s, in a redefinition of the post-Vietnam policies, the USMC solidified its own version of revolutionary change by forward-deploying small combined arm teams, which were known as the Marine Amphibious Unit (MAU). Today, the name has changed but the concept remains the same. The Marine Corps' vision of a combined armed force at the lowest level became the Marine Expeditionary Unit (MEU). This organizational evolved around the Ground Combat Element (GCE), Aviation Combat Element (ACE), and the Logistics Combat Element (LCE). When forward deployed at-sea on naval amphibious shipping, the fixed-wing aviation combat power is generated by

a detachment of six (6) AV-8B Harriers**.** The MEUs forward deployed presence and spectrum of capabilities led to popular opinion for the Marine Corps as "America's 911 Force" and "First to Fight." The current force structure within in the ACE has not changed since the mid-1980s, except for the direct replacement of CH-46s with MV-22s. The introduction of the F-35B provides the opportunity to correct the current operating structure constraints as well as expand the fixed-wing capabilities of the deployed MEU. Without a hard discussion of requirements and capabilities assignment, the new aircraft will be locked into the dogma of the past without the innovation sought in the CDO or JOAC.

This ingrained concept of the past and "the how we have always done it" attitude must be overcome. A complete generation of military leaders has executed their 20+ year career since six-plane AV-8B detachments began operating in support of MEUs in the mid-1980s. An entire generation of proud Harrier pilots with histories of operations in Iraq, Afghanistan, and other contingency operations around the globe provided the Marine Corps the fixed-wing CAS requirements when called upon. In 1991, eighty-six (86) AV-8Bs from five separate squadrons or detachments flew a total of 9,353 sorties and 11,120 hours from King Abdul Azis Airfield, a forward operating site at Tanajib, and amphibious shipping, USS Nassau and USS Tarawa.[33] More recently, AV-8B detachments have been supporting operations in the Global War on Terror (GWOT), including OIF and OEF. Proof of concept of expeditionary operations occurred most recently in 2011 when six AV-8Bs of the 26th MEU operating off the USS Kearsarge participated in Operation Odyssey Dawn eliminating the U.S. requirement of providing a conventional aircraft carrier on station.[34] This successful operation again proved the

concept of VSTOL or STOVL operations in times with a big-deck carrier are not available. These proud traditions need to be seen as proof of concept and not defining doctrine. Six is not a magic or rigid number that it has become in fixed-wing detachments. The MEU operating structure must be flexible enough to achieve a balance between required force projection and operating cost in terms of people and assets.

Proposed Solution

Requirements versus Capabilities

With past prejudices aside, the problem must first be approached from the aspect of assigning the appropriate requirements of MEU fixed-wing operations. What does the MEU Commander or the combatant commander require from fixed-wing operations from the MEU? Does the detachment need to be capable of providing 24-hour operations? In today's operating environment, with the necessity of conducting MIR, striking High Value Targets (HVTs), or Time-Sensitive Targeting (TST) problems in any environment providing A2AD penetration or increased sensor ranges that the F-35B, the answer would lean to "yes." However, this is a decision for the commander. As previously discussed, what is the number of sorties does the commander need to provide in the environment? Is it a single section or does the commander need the capability to sortie two sections to extend a vulnerability window with MIR or Offensive Air Support (OAS) coverage? Again, the answer is for the commander would lend itself to two sections or four total aircraft. Does the problem require the capability to operate over two separate geographic locations, a very large geographic area, or the need for forces to operate in a distributed manner? The correct answer, presents itself as the defined requirement to sustain four

aircraft sorties at one time. This requirement is difficult to maintain by today's aircraft readiness rates and structure.

These answers push the problem to the current and predicted operational models for fixed wing units in the Marine Corps. Appendix A presents a compilation of each fixed-wing aircraft's structure as depicted in their T&R manuals today. The relevant columns to first analyze are similarity between the AV-8B detachment and the F-35 detachment. The only change is the number of pilots that will correct a portion of the crew day limitations previously discussed. However, more importantly are the sortie generation models, which are identical. Therefore, if the requirement is indeed the capability to sortie four aircraft at one time then the Squadron (-) column for the AV-8B becomes the preferred model.

This new preferred model advocates an eight-plane, 13-pilot unit or detachment. This model also falls in line with proposed capabilities when compared with the six-plane detachment's shortfalls in terms of sortie generation in regards to pilot and aircraft utilization. The model itself is more efficient, as that it averages 1.5 sorties per aircraft vice 1.3 sorties generated in the six-plane model, and provides maintenance redundancy to maintain the four-plane schedule. The model also fits nicely into the concept of a 16-plane squadron, which underlies the current force structure from which the F-35 acquisition process purchased the aircraft. This solution avoids the complexity of a ten-plane element or squadron (-) in the present proposal for F-35 organizational structure. The additional capabilities or efficiencies of a ten-plane over an eight-plane is difficult to visualize. Assuming again a 70% readiness rate or slightly worse as seen in today's

Harrier, the unit may have difficulty flying a six-jet schedule and will more than likely fall back to a four-plane model that a more efficient eight-plane model can provide.

Flight Deck Constraint Argument

The next step in the creation of an optimal organizational model would be to analyze its constraints. The number one constraint for the ACE onboard ship is flight deck space. The amount of space available for aircraft is listed in Figure 1 and the ratio used in calculating the comparative space between the CH-46 and the AV-8B or F-35B are listed in Figure 2.

	LHA-1	**LHD-1**	**LHA(R)-6**
H-46 Equivalent	43	55	64
H-60 Equivalent	56	72	84

Figure 1 - H-46/H-60 Equivalents by Amphibious Ship Class[35]

AV-8B	**F-35B**	**MV-22**
1.53	2.05	2.22

Figure 2 - Size comparison in CH-46 equivalent[36]

The ACE embarked on amphibious shipping is increasing as a whole in terms of pure deck space required. Utilizing the LHD as the most prevalent ship in the inventory, an analysis of the detachment sizes can be done. Leaving the aircraft structure assignments within the ACE at current levels, and simply replacing the AV-8B with the F-35B reveals

a difference in over three CH-46s on board. This is a reduction of 5.7% in deck space available on a LHD.

6 F-35Bs × 2.05 = **12.30** *CH*-46 Equivalents

6 AV-8Bs × 1.53 = **9.18** *CH*-46 Equivalents

3.12 *CH*-46 Equivalents ÷ 55 *CH*-46 Equivalents = .057

This is a significant reduction when done in conjunction with the MV-22 replacement of the CH-46 that the USMC completed in recent years. MEU deployments have been split in recent years with some units deploying with ten or twelve Ospreys.

10 MV-22s × 2.22 = **22.22** *CH*-46 Equivalents

12 MV-22s × 2.22 = **26.64** *CH*-46 Equivalents

Again the math reveals an increase from 12 CH-46s of 10.22 and 14.64 increase.

12.22 *CH*-46 Equivalents ÷ 55 *CH*-46 Equivalents = .222

14.64 *CH*-46 Equivalents ÷ 55 *CH*-46 Equivalents = .266

These calculations reveal a 22.2% or 26.6% reduction in deck space available over the 12 CH-46s previously deployed within a MEU ACE. The flight deck space is also complicated with the expansion of the H-60's role within the Amphibious Ready Group (ARG) and the discussions of making the total three (3) vice two (2) H-60s onboard the LHA or LHD. This overall reduction has resulted in the majority of recent composite ACE squadrons operate with a significant number of aircraft on the LPD-class ships even before the introduction of the F-35B.

An analysis of our preferred model of eight F-35Bs to cover the mission results in another large reduction in flight deck space.

8 F-35s × 2.02 = **16.40** *CH*-46 Equivalents

This is a loss of 7.22 CH-46 Equivalents when compared with the original six-plane Harrier detachment. This would seem insurmountable in the face of the previous increases in requirements for the MV-22 and possible addition of the extra H-60.

Perhaps the answer lies in a smaller F-35B force detached to a land base as in current practice for the F-18 and working much like cross-decking a detachment to the LPD. This concept would require splitting the F-35B detachment into two "modules" of 4 aircraft each.

4 F-35s × 2.02 = **8.20** *CH*-46 Equivalents

These would result in the (4) F-35s having a footprint similar to 89.3% of the previous six (6) AV-8Bs solving, not only the increased size of the F-35B versus the AV-8B but the increasing size of the MV-22 over the CH-46. This modular force structure provides options for the commander to employ a four-plane F-35B "module" or eight-plane detachment if the AH/UH detachment or combination detachment is placed on the LPD vice the LHA or LHD. These 4-plane "modules" could then be structured to operate as a single unit or limited capability as individual units. These four-plane module requirements would have to be carefully defined but provide opportunity to operate in a distributed operation construct.

Independent Modules Capability

Keeping in line with the sortie projection models to generate similar level capabilities would appear in a four-plane and six or seven pilot module. Without exponentially increasing the maintenance teams required, the module maintenance capabilities would have to be strictly defined to not include any large scale maintenance action such as aircraft phases or multi-system/cross-shop actions. Separate modules would inherently only be single shift capable both from a maintainer and pilot viewpoint and would have to be correctly defined with capabilities that could be added or subtracted as required during the pre-deployment force generation planning.

	Squadron	Detachment	“Module”
Airplanes	16	8	4
Pilots	27	13	6
Max Sorties	***	12 (4T4T4)	6 (2T2T2)
Sorties per jet	***	1.5	1.5
Sorties per Pilot	***	0.92	1

Figure 3 - Proposed "modular" construction

The module concept immediately creates great flexibility for the commander in terms of operations and the evolving doctrines of future warfare and could have a synergistic effect on such operations. On naval shipping, this modular approach creates opportunities for the squadron to distribute operations. One module could easily be based ashore with coalition or partner militaries while still maintaining a capability ashore. The concept would only increase the “persistence presence” as defined by the Marine Corps Vision or simply gain training opportunities while deployed on a MEU instead of conflicting with the rotary wing assets on the boat. If available, modules could utilize the

tethered C-130 aircraft or theater-level CFACC available refueling tankers for flight operations, greatly increasing the area of influence of the MEU. The displaced "module" could correspondingly provide support outside the Navy flight deck window when required to provide a 24-hour presence missions. This distributed operations in an A2AD environment is key to the doctrinal construct. Operations against enemy IADs infrastructure from two separate locations complicates the enemy's defense assets and limits their capabilities as well as protecting friendly assets from a single catastrophic attack on a centralized location which unfortunately occurred at Camp Bastion in 2012. Incidents such as this attack can be minimized during Phase Two of the operation (Build-up of Forces) using distributed operations or a multiple detachment or "module" structure. This model provides deterrence against enemy attack by operating in a distributed manner, with multiple small detachments and operating basis to provide a greater problem for the enemy and generate options in a crisis situation.

In overseas presence missions such as the 31st MEU in Japan or during theater security and cooperation exercises, this modular construct rapidly has great implications. Distributed operations with partners and allies allow a greater range of the theater to be influenced by the asset. Small modules could operate independently for short durations at great distances increasing the overall presence.

Financial Responsibility Argument

Looking at the argument from a financial aspect, the current price projections of a Lower Initial Rate of Production – Stage 4 (LRIP-4) F-35B costs the USMC roughly $150 million.[37] The replacement cost of an AV-8B is around $30 million in today's

dollars, revealing the F-35 costing roughly fives times more expensive. Navy estimates of combined operating costs for the F-18 and AV-8B at around $19,000 per flight hour while the F-35 is estimated to be about $31,000.[38,39] What additional capabilities is the USMC receiving with the F-35B? The capabilities must be fully utilized if the airplane costs five times the replacement cost and operating costs are 160% of the original aircraft.

The argument does not lie in the capabilities of the airplane. It is clear that the ability to operate in an A2AD environment, weapons lethality, and sensor fusion are key to the USMC and nation's vision of future warfare. The argument comes into being when the $150 million aircraft are forward deployed on a sea-based MEU on an enduring presence mission, not involved in conflict. From the previous shortfalls identified with six-plane Harrier detachments, these problems would befall the F-35B. The aircraft would be locked aboard ship, with little opportunity to train and limitations and operations severely limited by be constrained to the ship. The cost increase of the F-35B, only to have its operation limited by the six-plane AV-8B model, does not justify the expenditure.

Skill Progression Argument

An eight-plane detachment, consisting of two modules, allows the detachment to utilize one module to maintain the required shipboard presence, training, and integration with the USMC-NAVY team while allowing the other module to continue training. The skill and career progression argument the F-35 DRAFT T&R manual shows a similar structure to the current AV-8B manual and the career progression of the F-35B pilot will

befall the same difficulties of the AV-8B pilot. Appendix D reveals the career progression, starting at the 2000-phase, with the 1000-phase still is developed. The December 15, 2011 F-35B T&R Manual does include a "Conversion Syllabus" for Attack pilots that consists of 30 weeks[40], so it can reasonable argued that a complete 1000-phase syllabus will be in similar length, if not longer than the current AV-8B Fleet Replenishment Squadron (FRS) syllabus. With this assumption, it can be seen that the completion of the 3000-phase, the Mission Skill sets are approximately the same as the AV-8B, of around 24 months. However, an analysis of the mission sets reveals a larger number due to the increased capabilities of the airplane. This equates to a larger number of sorties and requirements to both attain the qualifications and maintain currency and proficiency.

The draft version of the F-35B 3000-level phase incorporates fourteen sorties to attain 3000-level skill set and nine sorties to maintain proficiency. Of these sorties, four of them do not require air-to-ground ordnance deliveries or air-to-ground ranges (OAAW, AAD, and EXP). These indicate numbers that are nearly identical except that the syllabus adds three simulators to the "maintain" syllabus that would have to be moved to the aircraft, ignored, or "chained" while deployed due to lack of a simulator while deployed. In essence, the same problem will exist with the F-35B pilots that exist today in the AV-8B.

The introduction of the module concept provides an opportunity for pilots to deploy to maintain or attain proficiency in the skill set for limited amounts of time while still maintaining a shipboard presence with the other module. Creative training evolutions and short land-based detachments would permit the F-35B fleet to continue

progression in the pilot's mission skill sets vice atrophying onboard ship due to the capabilities inherent within the module. This concept in conjunction with the increased financial burden of the F-35B operating costs creates shows more fiscal responsibility as the detachments are still progressing in their proficiencies vice declining over the time duration of the deployment.

The modular construction concept allows permits more mission-focused detachments to be utilized for the mission. The training difficulties described above often result in pilots being only qualified in certain skills. In fact, the deployment requirements are structured such that not every pilot must be qualified in every skill. A more modular force creates flexibility inherent in the structure to place pilots where the skill sets are most appropriate. If the detachment or module are deploying in support of a no-fly zone" in an anti-air capacity or to conduct Offensive Air Support with no anti-air threat, pilot qualifications can be easily tailored to fit the operating environment. For example, the concept would allow diversified basing for the anti-air assets/pilots at different locations along a specific threat axis and the attack pilots based in a location forward near the conflict area where ordnance is being employed. Regardless of the situation, the construct provides rapid flexibility that the organizational constructs and scalability are predefined vice the ad hoc manner in which the same scenario would be developed with today's structure.

In the end, the smaller modular structure, with the ability to build and compile the module differently presents flexibility and options for the commander. This is the underlying structure required in the visions of future warfare and the necessity to provide the most fiscally advantageous solution to force creation and maintenance within the

operating force. The modular construct allows the ability for the detachment to continue progressing while maintaining its requirements to the MEU. The structure also allows quick combination of both modules in order to mass structure and enable a robust sortie generation capability that is lacking in the six-plane model today.

Conclusion

The introduction of the F-35 to the operating forces creates an opportunity for the Marine Corps to reexamine its fixed-wing deployment structure, specifically in regards to the ACE of the MEU. Evolving concepts of JOAC, A2AD, distributed operations, continuing forward presence requirements, and declining operating budgets and resources greatly complicate the current issues today. Simply replacing airplanes with newer, technologically advanced airplanes is not the correct answer. A specific review of requirements, along with analysis of new operating concepts and projected capabilities must be scrutinized in order to provide the right force, at the right time.

The article proposes a modular flexible four-plane structure, easily scalable, as one solution to the problem, providing flexibility across multiple operating areas in real world operations with the added capability for training opportunities while maintaining presence missions during peacetime. More importantly, the concept would create permanent structure on which capabilities and requirements for commanders can be easily defined, rather than the current ad-hoc “what-if” situation that exists today. The VSTOL concept excelled with the military ingenuity and foresight of planners beginning in the 1960s and the requirement for heavy firepower with rapid response times has not

changed since and will never change due to the advances in technology. The F-35B provides this opportunity to fully integrate the concepts provided by a VSTOL force if allocated with the proper size and responsive force structure, maximizing its capabilities both operationally in wartime and during training in peacetime.

END NOTES

[1] Headquarters, United States Marine Corps, "*A Concept for Distributed Operations*," April 25, 2005, 1, https://www.mccdc.usmc.mil/FeatureTopics/DO/A%20Concept%20for%20Distributed%20Operations%20%20Final%20CMC%20signed%20co.pdf.

[2] DOTMLPF is defined in the Joint Vision Implementation Master Plan (JIMP) published in 2001. The acronym stands for doctrine, organization, training, material, leadership, personnel, and facilities.

[3] Stephen Peter Rosen, "*Winning the Next War: Innovation and the Modern Military,"* (Ithaca, NY: Cornell University Press, 1991), 7-20.

[4] Office of the Secretary of Defense, *Joint Operations Concepts*, (Washington, DC: Office of the Secretary of Defense, 2003), 21.

[5] Francis K. Mason, *Harrier*, (Annapolis, MD: Naval Institute Press, 1981), 117.

[6] Bruce Myles, *Jump Jet: The Revolutionary V/STOL Fighter*, 2nd Edition. (Elmsford, NY: Oergamon Press Inc, 1986), 254-258.

[7] 3T3T2 is defined as three aircraft flying a sortie, returning to be turned by maintenance, flying three more sorties, returning and fly two more sorties.

[8] Headquarters U.S. Marine Corps, *AV-8B T&R Manual* NAVMC 3500.51A, (Washington, DC: Headquarters U.S. Marine Corps, August 8, 2011), 1-10.

[9] Karen Walker, "VSTOL Comes of Age." *Flight International*, July 19, 1986: 22-25.

[10] Lon O. Nordeen, *Harrier II: Validating V/STOL*, (Annapolis, MD: Naval Institute Press, 2006), 84.

[11] Defense Industry Daily, "AV-8B Harrier Finding Success in Iraq," March 30, 2005, http://www.defenseindustrydaily.com/av8b-harrier-finding-success-in-iraq-0256/.

[12] RFT provides a better analysis of squadron sortie capabilities than FMC. RFT utilizes partial mission capable (PMC) aircraft to be utilized in mission sets in which the components, which are "down" for maintenance, are not needed. Therefore a PMC aircraft is RFT, and more importantly, available for sortie generation. However, RFT does not include aircraft that are FMC but still require a post-maintenance or functional

check flight (FCF) to ensure aircraft systems are fully operational. (The aircraft is not RFT until all checks are complete.)

[13] F-35 Joint Strike Fighter Program Office, *LRIP I Performance Based Agreement (PBA) Between the Joint Strike Fighter Program Office and the United States Air Forc*,. F-35 Joint Strike Fighter Program, September 9, 2005), 4-5. https://acc.dau.mil/adl/en-US/46566/file/13859/JSFSDD-%2383167-v11-LRIP_1_PBA_Final_V3-4.pdf.

[14] Defense Industry Daily Staff, *The F-22 Raptor: Program & Events*, Dec 19, 2012. http://www.defenseindustrydaily.com/f22-raptor-procurement-events-updated-02908/.

[15] Jeremiah Gertler, *V-22 Osprey Tilt Rotor Aircraft: Background and Issues for Congress*, CRS Report for Congress RL31384. (Washington, DC: Congressional Research Service, March 10, 2011), 11. http://www.fas.org/sgp/crs/weapons/RL31384.pdf.

[16] A three-plain "light" division may occasionally be flown but an argument can be made that with the increase in accuracy and lethality of modern weapons, with aircraft capable of ordnance loads of more than single weapons, the necessity to fly 3-aircraft in a single mission is not the most efficient model.

[17] A limited capability does exist for a limited capability of EW operations with attached pods to the aircraft that has been utilized in OEF but not employed yet on the MEU.

[18] FOD is an acronym for "Foreign Object Damage." In the text, a FOD walk is pre-flight function of the entire air department/squadron in which all members proceed in an on-line formation to clear the operating surface (taxiways, runways, etc) of any object which may be ingested by the engine or thrown into the air and cause damage to the aircraft or its surroundings.

[19] The Maintenance "Turn" encapsulates all the required maintenance action to turnaround the aircraft for another flight. This encompasses post-flight checks, refueling, and rearming or reconfiguring the aircraft's ordnance configuration. It does not include any maintenance action or repair.

[20] Pilot crew days are defined by local unit SOPs and typically 12 hours during the day and 10 hours at night.

[21] Department of the Navy, *NATOPS General Flight and Operating Limitations*, OPNAVINST 3710.7U. (Washington DC: Office of the Chief of Naval Operations: November 23, 2009), OPNAV 8-16.

[22] Headquarters U.S. Marine Corps, *AV-8B T&R Manual*, 2-3.

[23] All arguments in regards to Mission Skill Progression in the document are made utilizing the 3000-Phase of Training. The reasoning behind this simplification is to preclude the complexity and interpretation of codes that "chain" to the 2000-phase events. The same arguments exist for these 2000-phase events, ordnance is required to be expended during the training but a simple assumption is made that pilots would be 2000-level complete prior to deployment (which is not always true) and that each unit would be capable of maintaining currency in these events through chaining events from the 3000-phase. Clearly, as currency is lost in the chaining of 3000-level events, the loss of skill currency will be expounded into the 2000-level events creating an even larger deficit in sortie generation. In regards to 4000-level events and qualification/designation the problem again gains complexity due to the capabilities of each individual pilot. Although the argument applies in the 3000-level phase, the 4000-level phase and designation/qualification sorties will progress as the pilot meets the standards in each skill. It is less and less a check in the block as phases progress.

[24] Headquarters U.S. Marine Corps, *AV-8B T&R Manual*, 2-94 – 2-102

[25] "We are strengthening our military to ensure that it can prevail in today's wars; to prevent and deter threats against the United States, its interests, and our allies and partners; and prepare to defend the United States in a wide range of contingencies against state and nonstate actors. We will continue to rebalance our military capabilities to excel at counterterrorism, counterinsurgency, stability operations, and meeting increasingly sophisticated security threats, while ensuring our force is ready to address the full range of military operations. This includes preparing for increasingly sophisticated adversaries, deterring and defeating aggression in anti-access environments, and defending the United States and supporting civil authorities at home." (*National Security Strategy*, 2010)

[26] Philip Dupree, "*Air-Sea Battle: Clearing the fog*," *Armed Forces Journal*, June 2012, 2.

[27] Director for Strategic Plans and Policy, J5; Strategy Division, *Joint Vision 2020*, (Washington DC: US Government Printing Office, June 2000), 15-21.

[28] Director for Strategic Plans and Policy, J5; Strategy Division, 20.

[29] Van Tol, et al, *AirSea Battle: A Point of Departure Operational Concept*, Center for Strategic and Budgetary Assessments, May 18, 2010, xiv.

[30] Van Tol, et al, 42.

[31] Headquarters U.S. Marine Corps, *USMC Vision and Strategy 2025*, (Washington DC: Headquarters U.S. Marine Corps) 15.

[32] The capability of "5th generation" fighters varies from various sources. Perhaps, the best definition included in 2011 budgetary documents to Congress offer an accurate layman's definition. "Fifth-generation fighters combine new developments such as thrust vectoring, composite materials, supercruise (the ability to cruise at supersonic speeds without using engine afterburners), stealth technology, advanced radar and sensors, and integrated avionics to greatly improve pilot situational awareness. (Gertler 2011)

[33] Nordeen, 72-86.

[34] Department of Defense, *Coalition First Strikes*, Briefing Slides, 2011. http://www.defense.gov/news/PAO_DJS_Slides_19Mar11_v3.pdf (accessed Dec 18, 2012).

[35] Amphibious shipping aircraft carrying capacity is defined by either the number of H-46s or H-60s can be carried by the ship. These numbers are taken specifically from April 2008 Report by CNA Corporation. (Robinson, et al. n.d.)

[36] Size comparisons between AV-8B and the F-35B based off a CH-46 equivalent. Values obtained from www.globalsecurity.org. CNA Corporation gives the same value in GATOR Multiple Tool gives a value of 2.96 H-60 equivalents for both the F-35B and the AV-8B. (A CH-46 is equivalent to a 1.32 on H-60 equivalence scale) (Robinson, et al. n.d.)

[37] "On November 19, 2010, DOD announced the award of a contract for the fourth lot of low rate initial production (LRIP) F-35s. This $3.9 billion contract for 31 aircraft is fixed-price-incentive (firm target), meaning that Lockheed Martin and the government "would equally share the burden of a cost overrun up to 40% over the fixed price. Any overage above 40% would be Lockheed's responsibility. Based on the per-unit price of roughly $126 million, the cost could go as high as about $176 million, but the price paid by the government would be capped at around $151 million." (Congressional Research Service, 12)

[38] Colin Clark, *NavAir Offers F-18 Ammo Amid JSF Woes.* Jan 12, 2012, http://www.dodbuzz.com/2010/01/12/navair-offers-f-18-ammo-amid-jsf-woes/.

[39] An argument of a "valid" cost per flight hour could be made based on biased source with the Navy attempting to "sell" the current F-18 E/F. However, these numbers are inline with GAO estimates placing F-35 CTOL variants cost per flight hour at $35,2000 versus the F-16 cost per flight hour at $22,500. (GAO, 2012, 11)

[40] F-35B Training and Readiness Manual, 2-4 – 2-7

Appendix A – Squadron / Detachment Structures

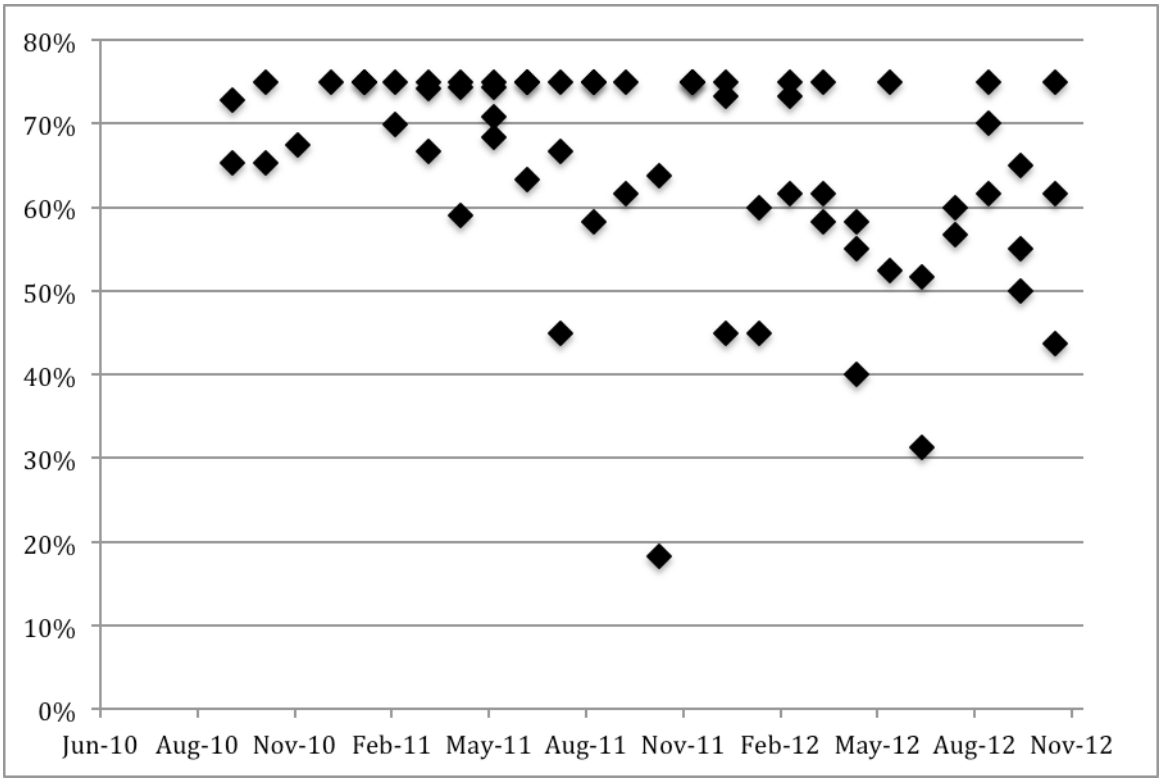
Current Legacy AV-8B and F-18 structure compared to proposed F-35B structure.

	AV-8B			F-18**	F-35		
	Squadron	Squad(-)	Detachment	Squadron	Squadron	Squadron	Detachment
Airplanes	14	8	6	12	16	10	6
Pilots	22	13	9	19	27	17	10
Max Sorties*	20 (6T6T4T4)	12 (4T4T4)	8 (3T3T2)	20		18	8
Sorties per Jet	1.43	1.50	1.33	1.67	***	1.80	1.33
Sorties per Pilot	0.91	0.92	0.89	1.05	***	1.06	0.80

* All TMS sorties are 1.3 hours in duration
** Numbers for F-18C and F-18D are same. WSO requirements mirror the pilot requirements but do not change numbers.
*** 16-plane squadron defined in current version of T&R but not in DRAFT revision.

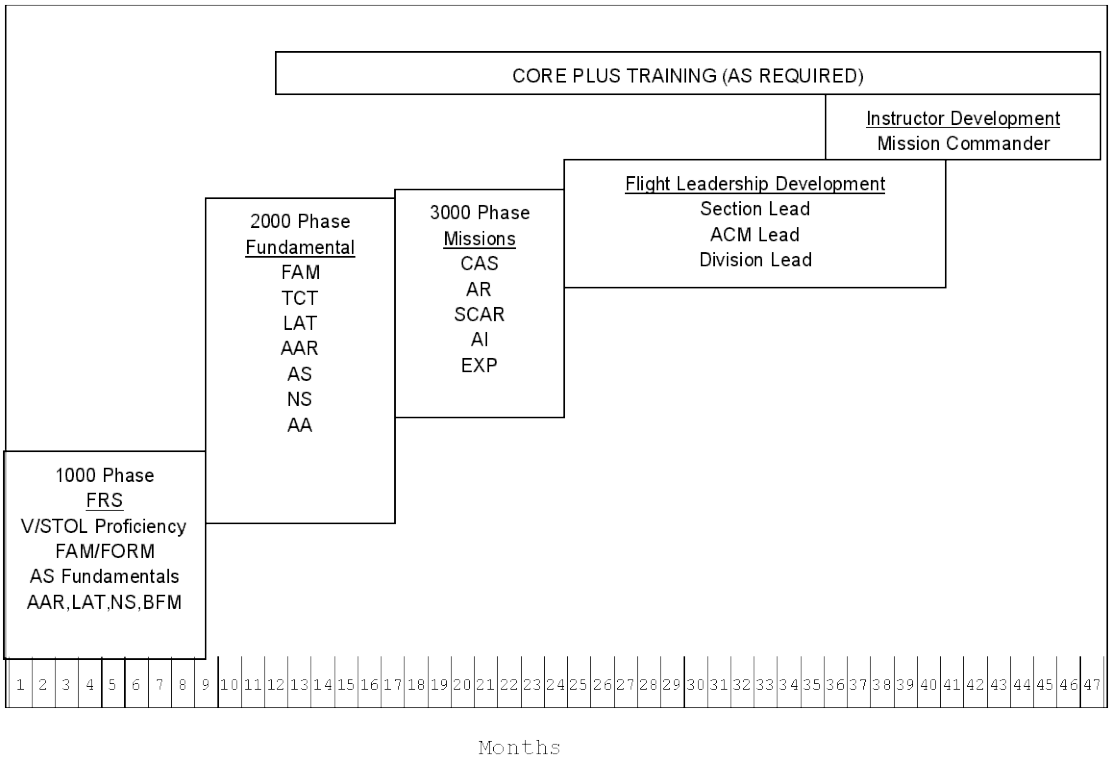
Note: Compilation of Data from all three aircraft T&R Manuals

Appendix B – AV-8B RFT Rates for FY11 and FY12



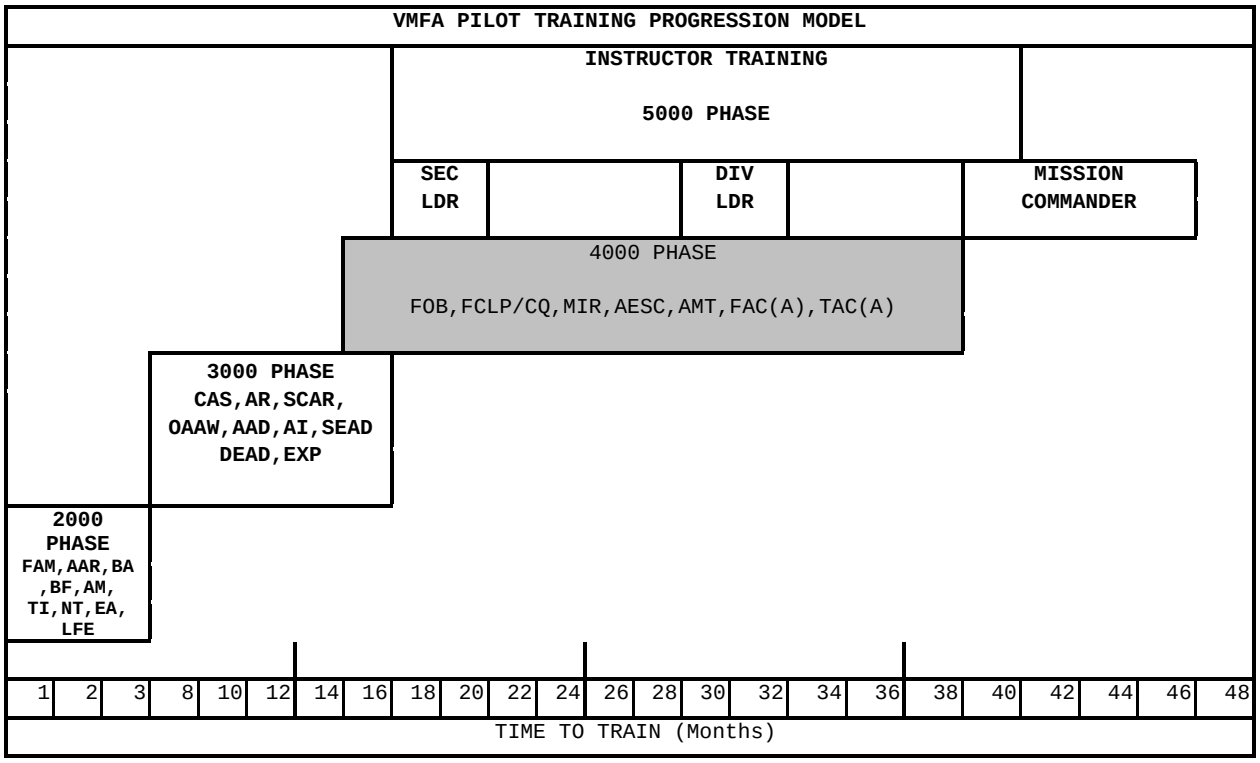
Note: Data obtained from AV-8B Readiness Office, MAG-13, December 2012.

Appendix C – Current AV-8B Carrier Progression Model



Source Table from AV-8B T&R Manual.

Appendix D - F-35B DRAFT Career Progression Model



Source Table from F-35B DRAFT T&R Manual

Appendix E – Mission Skill Proficiencies as defined by AV-8B T&R Manual

Individual Misison Skill Proficiency Attain Table					
Pilot	EXP	CAS	AR	SCAR	AI
T&R event requirements to attain MSP	3500R	S3100R S3101 S3102 3103R 3104 3105R 3106R 3107	S3200 3201 3202R 3203R	3300 3301R	S3400 3401R 3402R
R = Refresher POI Event S = Event Conducted in Simulator					

Individual Mission Skill Proficiency Maintain Table					
Pilot	EXP	CAS	AR	SCAR	AI
T&R event requirements to maintain CSP	3500R	3103R 3105R 3106R	3202R 3203R	3301R	3401R
R = Refresher POI Event S = Event Conducted in Simulator					

Appendix F – Core and Mission Skill Comparison between AV-8B and F-35B

103. VMA SKILLS ABBREVIATIONS. Shading indicates Core Plus/Mission Plus Skills.

CORE SKILLS	
AA	Air-to-Air
AAR	Air-to-Air Refueling
AS	Air-to-Surface
FAM	Familiarization
LAT	Low Altitude Tactics
NS	Night Systems
TCT	Threat Countertactics
MISSION SKILLS	
AI	Air Interdiction
AR	Armed Reconnaissance
CAS	Close Air Support
EXP	Shore-based Expeditionary
SCAR	Strike Coordination and Reconnaissance
CORE PLUS SKILLS	
ADLAT	Advanced Low Altitude Tactics
FCLP (D)	Field Carrier Landing Practice, Day
FCLP (N)	Field Carrier Landing Practice, Night
LFE	Large Force Exercise
LL AI	Low Level AI
LL CAS	Low Level CAS
MISSION PLUS SKILLS	
AAD	Active Air Defense
AE	Aerial Escort
CQ (D)	Carrier Qualification, Day
CQ (N)	Carrier Qualification, Night
FOB	Shore-based Restricted
MIR	Multi-sensor Imagery Reconnaissance
OAAW	Offensive Anti-air Warfare
FAC(A)	Forward Air Controller (Airborne)

VMFA	
CORE/MISSION/CORE PLUS SKILL ABBREVIATIONS	
CORE SKILLS (2000 Phase)	
FAM	Familiarization
AAR	Air-to-Air Refueling
BA	Basic Air-to-Surface
BF	Basic Fighter Maneuvering
AM	Air Combat Maneuvering
TI	Tactical Intercepts
NT	Non-Sanctuary Tactics
EA	Electronic Attack
LFE	Large Force Exercise
MISSION SKILLS (3000 Phase)	
CAS	Close Air Support
AR	Armed Reconnaissance
SCAR	Strike Coordination and Reconnaissance
OAAW	Offensive Anti-Air Warfare
AAD	Active Air Defense
AI	Air Interdiction
SE	Suppression/Destruction of Enemy Air Defense
EXP	Aviation Operations From Expeditionary Land-Based Sites
CORE PLUS (4000 Phase)	
CORE PLUS SKILLS	
FOB	Shore Base Restricted
FCLP	Field Carrier Landing Practice
CQ	Aviation Operations From Expeditionary Sea-Based Sites
MIR	Multi-Sensor Imagery Reconnaissance
MISSION PLUS SKILLS	
AESC	Aerial Escort
AMT	Attack Enemy Maritime Targets
TAC(A)	Tactical Air Coordination (Airborne)
FAC(A)	Forward Air Controller (Airborne)

List of Acronyms

A2AD	Anti-access/Area Denial
AAD	Active Air Defense
ACE	Aviation Combat Element
AH	Attack Helicopter
AMRAAM	Advanced Medium-Range Air-to-Air Missile
AR	Armed Reconnaissance
C2	Command and Control
CAS	Close Air Support
CATF	Commander, Amphibious Task Force
CDO	Concept for Distributed Operations
CLF	Commander, Landing Force
CTOL	Conventional Takeoff / Land
CFACC	Combined Forces Air Component Command
DATF	Defense of the Amphibious Task Force
DOTMLPF	Doctrine, Organization, Training, Material, Leadership, Personnel, Facilities
EXP	Expeditionary Shore Based Operations
EW	Electronic Warfare
FLIR	Forward Looking Infrared
FMC	Full Mission Capable
FOD	Foreign Object Damage
FRS	Fleet Replenishment Squadron
GCE	Ground Combat Element
GWOT	Global War on Terror
HVT	High-value Target
IADS	Integrated Air Defense Systems
ISR	Intelligence, Surveillance, Reconnaissance
JCIDS	Joint Capabilities and Development System
JOAC	Joint Operational Access Concept
JSF	Joint Strike Fighter
LCE	Logistics Combat Element
LRIP	Low Rate of Initial Production
GSE	Ground Support Equipment
GWOT	Global War on Terror
HVT	High Value Target
LAT	Low Altitude Tactics
LSO	Landing Signals Officer
MAGTF	Marine Air Ground Task Force
MAU	Marine Amphibious Unit (predecessor of the MEU)
MC	Mission Capable
MCTL	Marine Corps Task List
MET	Mission Essential Task
METL	Mission Essential Task List

MEU	Marine Expeditionary Unit
MIR	Multi-Sensor Image Reconnaissance
OAAW	Offensive Anti-air Warfare
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
OAS	Offensive Air Support
PMC	Partial Mission Capable
PLA	People's Liberation Army (China)
RBA	Ready Basic Aircraft
RFT	Ready For Tasking
SAM	Surface-to-Air Missile
SSSC	Surface Subsurface Search and Coordination
STOVL	Short Takeoff / Vertical Land
T&R	Training and Readiness
TST	Time Sensitive Target
TTP	Tactics, Techniques, and Procedures
UH	Utility Helicopter
VSTOL	Vertical / Short Takeoff / Land
VTOL	Vertical Takeoff and Land
T&R	Training and Readiness

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