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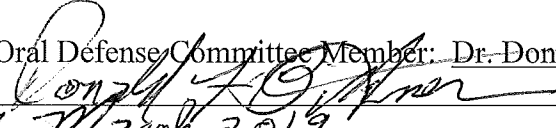
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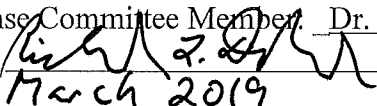
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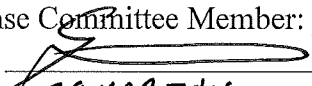
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Executive Summary

Title: Increased Dependence on Aviation Simulators in a Fiscally Constrained and Readiness Deficient Environment: A Balanced Approach for Marine Corps Aviation Training

Author: Major Patrick Flores, United States Marine Corps

Thesis: There are boundaries required for increased reliance on the aviation simulator and a comprehensive training curriculum cannot neglect the lessons learned from stressors associated with actual flight rather than simulation.

Discussion: The aviation simulator has developed through the trials and triumphs alongside the aircraft in aviation history. Organizational adaptations to technological advancements have been commonplace but are marked with suboptimal efficiency for endurance as technology continues to advance. The Tactical Environment Network (TEN) and digital interoperability to link simulators of various Type, Model and Series (T/M/S) platforms across the globe have garnered attention and increased the utility of aviation simulators for joint training. The dynamic nature and influence of annual budget cycles on the progression of the aviation simulator have impacted organizational forecasting to various degrees. A recent trend that raised concern is the increased use of simulators to compensate for deficient aircraft readiness. Aircraft readiness impacts each community differently, but the overall trends briefed by key officials in the Department of Defense (DoD) align with the current forecast of the future operating environment.

The existent organizational structure afforded by the Aviation Training System (ATS) has guidelines for the adoption of a sensible strategy with aviation simulator. The T&R Program manual and individual T/M/S T&R manuals can serve to best direct the changes required to achieve balance. A current environment that trends toward an unrestricted increase in simulator sorties instead of aircraft sorties warrants a period of pause and reflection. The Future Operating Environment (FOE) demands a multi-faceted approach for attacking the challenges before the aviation community.

Although aviation simulators are beneficial towards achieving limited training objectives in a fiscally constrained and readiness deficient environment, overreliance on simulator utility and forecast technology maturation will be problematic in the tactical environment. The many enduring simulator limitations combined with future challenges limit the potential readiness and proficiency that the aviation simulator offers. Insufficient audio and visual cues in the aviation simulators do not replicate the complexities of the real environment and lend towards negative training. Learned behavior from increased simulator sorties will inevitably translate into pilot tendencies in the aircraft as aviators fight the way they are trained. These negative returns are just as problematic if not more so than the fiscal concerns from conducting training in the actual aircraft.

Conclusion: During a period of increased attention on aircraft readiness and fiscal constraints, each aviation community should conduct a genuine audit of the Training and Readiness (T&R) objectives using current simulator capabilities to avoid trending toward overdependence on the technological promise of the future aviation simulator.

DISCLAIMER

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

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Preface

The aviation community is continually evolving under external pressures such as fiscal constraints, aircraft readiness deficiencies, and technological modernization. The aviation simulator has acted as both a catalyst and a product of this evolutionary process. When harnessed in conjunction with the aircraft, the simulator has proven instrumental in the training and development of perspective and winged aviators alike. This combined approach has enabled the nation's pilots and aircrew to meet ever-growing aviation challenges. The technological advances of the aviation simulator toward virtual reality and digital interoperability have presented further opportunities for unprecedented tactical training in simulators. However, an increased emphasis on aviation simulators for tactical training can be problematic. During a period of increased attention on aircraft readiness and fiscal constraints, each aviation community should conduct a genuine audit of the Training and Readiness (T&R) objectives using current simulator capabilities to avoid trending toward overdependence on the technological promise of the future aviation simulator.

This paper will briefly review the historical benefits that aviation simulators have afforded civilian and military communities. The enduring challenges associated with simulator improvements and implementation will be generally addressed from the authors perspective as a Weapons and Tactics Instructor (WTI) Pilot and school certified Experimental Test Pilot. This paper will also provide an overview of the Aviation Training System (ATS) for the United States Marine Corps (USMC) Aviation Communities to highlight established conduits for change. A case study of the Training and Readiness (T&R) manual of the AH-1 Cobra attack helicopter, reveals a trend toward increased reliance on Tactical Environment Network (TEN) simulators to meet training and readiness requirements. A description of simulator and aircraft sorties

described in the Training and Readiness (T&R) manual of the AH-1 will be reviewed. Finally, this paper will suggest a balanced strategic approach to harnessing the benefits of the aviation simulator in the Future Operating Environment (FOE).

Although there are many details regarding fiscal budgeting for aviation simulators, the resource aspect of procurement, maintenance, and operations costs will not be thoroughly addressed. Additionally, while simulator shortcomings such as visual display inconsistencies, unrepresentative aircraft performance modeling and unrealistic simulator handling qualities are addressed in general terms, specific deficiencies of individual USMC aviation communities are beyond the scope of this paper. A detailed review of the T&R trends towards simulator dependency of each Type/Model/Series (T/M/S) community is warranted but will be left up to the Subject Matter Experts (SMEs).

I want to thank my wife Marissa and our three children Damian, Arissa and Roman for their support and patience throughout this research process. Additionally, this paper would not have been possible without the dedicated guidance and mentorship of Dr. Donald F. Bittner Ph.D., Professor of History (Emeritus).

Relevant Highlights of Aviation Simulator History

The aviation simulator developed alongside aircraft throughout the rich and illustrious history that defines aviation. Aviation professionals who embarked on the high-risk evolution of flight were sustained by the safety and technical proficiency that the aviation simulator afforded. Early simulator designs such as the Link Trainer of 1929 were primarily undertaken by civilian industry, but their application to military flight inevitably followed.¹ The initial Link Trainer consisted of a scaled down fuselage affixed atop four pneumatic bellows to replicate the motion of banking, pitching and turning.² Great strides in simulator development were often coupled with the urgency of the period, as evidenced leading up to World War II. During World War II, pilots were trained extensively in an upgraded variant of the Link Trainer, known as the AN-T-18 which incorporated a pilot's track over the ground to aid in simulated instrument training.³ In 1960, the Naval Training Device and Equipment Center (NAVTRAEQUIPCEN) developed what was believed to be the first general purpose, all-digital computing simulator, known as the Universal Digital Operational Flight Trainer (UDOFT).⁴ The UDOFTs digital computation bridged a significant gap that existed between the aircraft and simulator. Digital computation made simulator design size much more manageable. This development shifted the military's perspective on the benefit of simulators in the aviation community. This paradigm shift influenced the military and civilian aviation communities who increased investment into this aspect of aviation training during the 1980s.⁵

Like many aviation improvements, advances in rotary wing (RW) simulator development lagged the fixed wing (FW) community. Helicopter designs presented simulator developers with a more complicated challenge as the method of generating lift varied substantially from that of traditional FW communities. These complications, combined with general control

mechanization differences between FW and RW platforms, provided additional justification for developmental delays of the RW community. As the FW simulator developed and gained early success, military and civilian aviation communities eventually invested in RW simulator development. This delay took over fifty years from the early Link Trainer of 1929. From that perspective, helicopter simulators are a relatively recent and nascent innovation. Not until 1986 did the Federal Aviation Administration (FAA) certify the first helicopter simulator by Bell Helicopter in Hurst, Texas.⁶

The FAA recognized the need to standardize the categorization and naming convention of the many training devices in existence for aviation training and certification development. Those early cockpit replications, which did not include motion, were categorized as Flight Training Devices (FTDs) and included various numeric levels based on ground and flight condition fidelity.⁷ The overall computer processing required to synchronize motion and visual displays developed in parallel with changes in models for the visual representation of the environment. As such, the Full Flight Simulators (FFSs) were given the designation of level A, B, C, and D based on the FAA Qualification Performance Standard.⁸ Each higher level, from A to D, includes more stringent tolerances for the modeling associated with aspects such as helicopter performance, handling characteristics, visual displays, and motion replication.

Historically, industry and commercial airline companies found various justifications for increasing the use of aviation simulators in pilot training. Recognizing the need for quality assurance and standardization amidst this increased utilization, the FAA reaffirmed its legal role as the endorsement authority for simulator development and training.⁹ On February 2nd, 1970 the FAA permitted the expanded use of approved simulators for the training of airline crews.¹⁰ An often-cited justification for the increased use of the aviation simulator was the inherent safety of

conducting training on the ground rather than in the air. Another justification asserted that simulator training would alleviate congested airspace.¹¹ However, natural resource consumption was never far from the aviation simulator justification discussion. In the wake of the Arab Petroleum embargo of 1973, a seven-point jet *fuel conservation plan* was implemented by the United States; this policy endorsed increased airline training and check flights in the simulator rather than the aircraft.¹² Airspace congestion and resource conservation served as convenient justifications for commercial industry to recognize the principal benefit of the aviation simulator: cost savings in dollar amounts. The primary motivator for commercial airlines to dedicate increased emphasis on simulator training was the forecast cost savings that the simulator promised.¹³

Since early adoption, commercial airlines and military aviation communities have devoted a greater distribution of initial pilot training to the aviation simulator. The FAA fostered this environment through an increased number of Federal Aviation Regulations (FARs) regarding approved simulator certifications and training.¹⁴ Most airlines conduct a majority of initial pilot training and annual requirements in the aviation simulator specific to the type rating desired. The military's adoption of simulator training was most notable amongst the fixed-wing communities that closely mirrored commercial airplanes, as they were able to leverage the similar technological advantages. In 2002, the Marine Corps Aviation Simulator Master Plan (MCASMP) included extensive investment in Aircraft Procedural Trainers (APTs) for basic training and advanced tactics training.¹⁵ While acknowledging that the simulator will never be a substitute for actual flight, then Deputy Commandant for Aviation (DCA), Lieutenant General William L. Nyland wrote in the *Marine Corps Gazette* in 2002; "Our drive to increase simulator use reflects the worldwide trend in both defense and industry for this type of training."¹⁶ Early

adoption of the aviation simulator is remarkably similar to the current trends characterizing increased reliance beyond the demonstrated benefits that the simulator can have on training. During a period of increased attention on aircraft readiness and fiscal constraints, each aviation community should conduct a genuine audit of the Training and Readiness (T&R) objectives using current simulator capabilities to avoid trending toward overdependence on the technological promise of the future aviation simulator.

Basic Aircraft Familiarization and Instrument Training

The naval aviation flight school curriculum provides an example of how most aviation communities conduct initial flight training. Working knowledge of initial aviation training is needed to understand where the aviation simulator fits within that architecture. Student naval aviators experience Introductory Flight School (IFS), which consists of early exposure to aviation through a single-engine civilian aircraft, e.g., the Cessna 172A. Once in Florida, the Aviation Pre-flight Indoctrination (API) academic period of instruction commences. Following API, students conduct Primary Flight Training followed by courses in Intermediate and Advanced phases before selecting their T/M/S for the fleet.¹⁷ Appendix A shows the current naval aviator training pipeline.

Early on in training, the simulator is used for cockpit replication to conduct basic familiarization of the controls and cockpit gauges as well as training in the instrument environment. Basic familiarization training of an aircraft entails memorizing the location of flight instruments, performance gauges, and mechanization of cockpit controls. Rudimentary training devices, such as a poster print out of the instrument and gauge relative locations in the cockpit assist in these basic memorization tasks. An example of the T-34B training aircraft

cockpit gauge poster used in the Primary phase of the naval aviation training course is included in Figure 1 below.

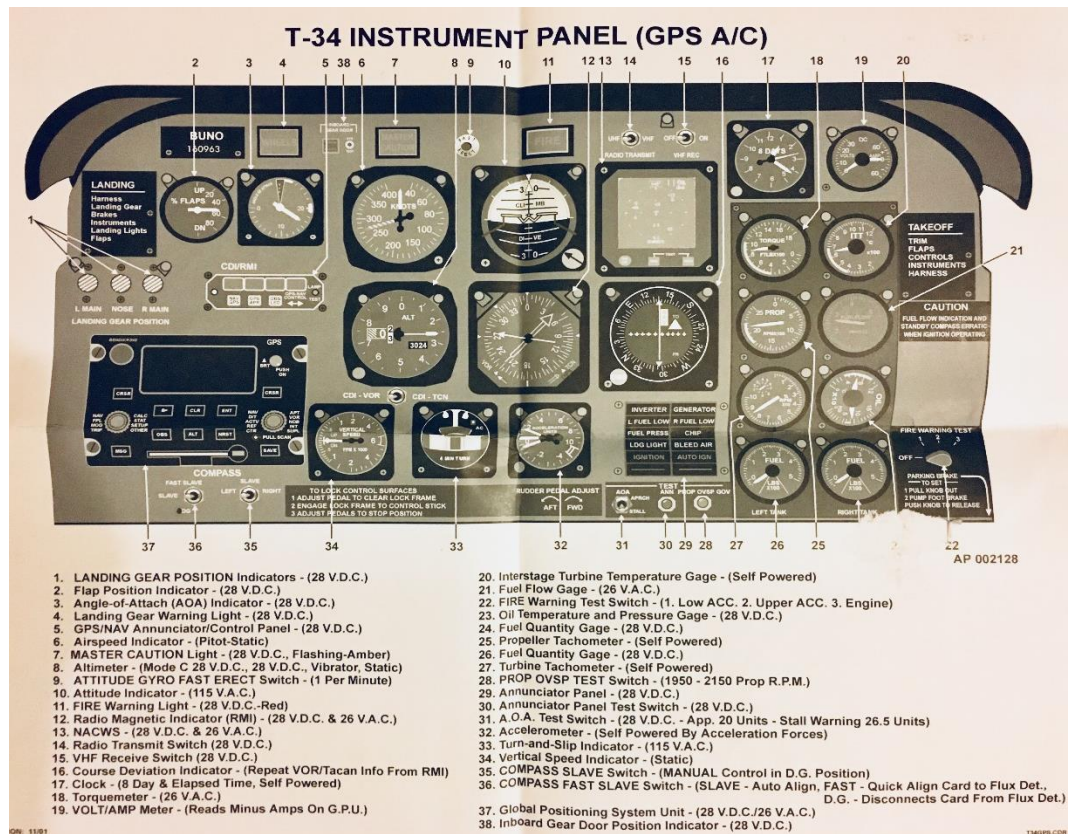


Figure 1: T-34B Training Aircraft Cockpit Layout¹⁸

These tools remain issued during the primary flight training phase in Pensacola, Florida. However, cockpit replications such as Flight Training Devices (FTDs) provide an immersive environment for this aspect of early flight training. FTDs present the aviator with a replica of the cockpit layout and relative switch locations to practice tactical reach while sitting in the cockpit mockup. The functioning indications and control mechanization reinforce cognitive and muscle memory through repetition.¹⁹ Basic cockpit familiarization sets the foundation for early flight familiarization training in each aircraft throughout the training curriculum. A rapid visual scan of the cockpit indications is critical when training for formation flight evolutions. During

formation flight, aircraft remain as close as fifty feet from one another, conditions under which a slow scan of the cockpit indications can result in a midair collision.

Instrument Meteorological Condition (IMC) training is another aspect of an aviator's progression where the aviation simulator has proven its merit. The Primary phase of Naval Flight school is heavily geared toward this type of training. IMC flight requires dependence on flight instrumentation rather than an outside the cockpit scan for aircraft attitude. These conditions include clouds or low visibility where a visual horizon is not available for reference. The aviator must rely on the attitude gyro, heading indicator, and altimeter represented in the cockpit for general aircraft orientation. The attitude gyro provides aircraft pitch and roll feedback to the aviator, while the heading indicator depicts yaw (the left and right rotation of the nose of the aircraft about the vertical axis). One of the chief functions of instrument flight training is to build a habit pattern for the scanning of these instrument and performance indications. The FFS accounts for up to 50% of annual instrument flight minimum requirements for maintaining an instrument rating in the military.²⁰ Using the simulator for annual instrument minimum requirements is common amongst fleet units and the Fleet Replacement Squadrons (FRS).

One of the Marine Corps aviation communities that benefit most from the aviation simulator is the KC-130J. Due to costs associated with the new J model in 2002, the Marine Aviation Board agreed to discontinue the Fleet Replacement Squadron (FRS) (VMGRT-253). This was done in order to maximize the number of aircraft in fleet units rather than at the training squadron.²¹ The KC-130J community began using Level D simulators in 2007 at their designated Auxiliary Training Units (ATUs) as a substitute for the FRS.²² It is important to note that the simulator sorties that replace flights at the FRS are Core Introduction Phase events. The

Training and Readiness (T&R) Program Manual defines the Core Introduction phase as "Fundamental system/equipment operation familiarization, initial individual or crew procedures, and initial exposure to future Core training."²³

The KC-130J community has made the best of the circumstances it has encountered, but the fiscal constraints and limited aircraft availability drove the community towards this fate. The extended procurement phase of the KC-130J is at the root of the aircraft availability issue and not expected to begin recovery until FY26.²⁴ As aviators learn the basic aircraft functions from a simulator, the disparity between the aircraft and the simulator becomes a foundational concern. The simulator does not perfectly replicate the aircraft, and the response to specific control inputs is noticeably different from the actual aircraft environment. The disparity encountered is also commonly referred to as "negative training," where the learned techniques in the simulator have an influence on aircraft control manipulation techniques. Within the KC-130J community, there are five sorties conducted in the aircraft during the Core Introduction phase to validate the effectiveness of the prior simulator training.²⁵ A check flight in the actual aircraft concludes this phase of training.

Crew Resource Management

In 1991, the Navy established Crew Resource Management (CRM) concepts through a research and development effort, wherein seven common behavioral skills related to mishaps were identified.²⁶ The goal of this tool was to minimize mishaps that resulted from crew preventable errors. CRM impacts each facet of aviation training, from ground instruction to actual aircraft sorties and in the simulator. Today, both industry and the military benefit from the crew resource management practice that the simulator affords. As the name implies, CRM focuses on recognition of the behavior and interactions between all members of the flight crew.

This aircrew interaction is routine with commercial airlines and multi-piloted aircraft in the military, and the simulator provides a controlled environment for such practice.

Multi-piloted aircraft simulator sorties include the entire crew preparing and executing a simulator event as though it were in the actual aircraft. This technique suffers from unrealistic cabin layouts for the aircrew or when some simulator designs neglect the cabin altogether. Aircrew become marginalized participants to the simulator event in these cases. Nonetheless, the promise of a simulator event carrying more weight than a simple round table discussion or ground event propagates its continued use and ultimately satisfies the annual CRM flight requirement.²⁷

Single seat or single-piloted aircraft, such as the F-35 and AH-1 respectively, benefit differently from CRM training in the aviation simulator. The simulator provides a controlled environment for instructors to introduce and demonstrate flight maneuvers that pilots might otherwise have to perform for the first time while alone in the aircraft. These simulators have instructor stations where a real-time observation post reinforces learning. The AH-1 simulator uses this instructor station for tasks such as threat identification and reaction training during the Simulated Threat Counter Tactics (STCT) simulator sortie.²⁸ Similarly, the F-35B uses an instructor station in the simulator for many training evolutions such as the introduction of Functional Check Flight (FCF) maneuvers.²⁹ Although these aviation communities differ significantly in the application of CRM, the lessons learned from CRM practice in the simulator carry forward into the aircraft.

A common CRM training deficiency that the simulator neglects is the very thing touted as a benefit: The controlled and safe environment removes personal harm from the equation. After a mistake in the simulator, everyone gets to step right outside and debrief the event rather

than dealing with the effect of gravity and the mishap that would have occurred in the aircraft. However, this increased safety measure diminishes the behavioral realism that CRM training seeks to replicate. Without the stress and fear of consequences, personal interactions and responses in the simulator will never be fully representative of the aircraft. The Prussian General and military thinker Carl von Clausewitz mentions this idea in his work *On War* where he postulates “Who could advise, or resolve upon a great battle, without feeling his mind more or less wrought up or perplexed by the danger and responsibility which such a great act of decision carries in itself!”³⁰ By this rationale, decision making in the aviation simulator does not carry the same burden or severe consequences that are inherent in the actual aircraft. The absence of real danger limits training effectiveness.

Enduring Aviation Simulator Challenges

Audio and Visual Displays

The visual displays for most USMC full motion simulators provide adequate feedback for most basic daytime operations, as the certification requirements for continued use mandate such performance. However, the Field of View (FOV) requirements (180 x 60 degree FOV) prescribed for a Level D FAA certification omit notable viewing aspects otherwise present in the aircraft.³¹ During formation flight training in the simulator, these rear aspect FOV restrictions eliminate realistic wingman checks, where the lead aircraft in the formation confirms the location of other aircraft in the formation. Additionally, poor resolution of ground obstacles for low altitude training and landing exist when conducting sensor operations.³² The observer optical height above ground does not provide an aircraft representative perspective due to the simulator floor obstructions. This misperception induces a negative training condition known as “feeling for the deck” where the pilot senses the ground earlier in the simulator than in the aircraft. The

visual inconsistencies described above drove the USMC to procure Weapon System Trainers (WSTs) with identical specifications and features to combat the issue of maintaining a common operating picture.³³ Identical WSTs formed the foundation of the common visual database concept.

A similar inconsistency is the unrepresentative acoustic signatures of the aviation simulator. Requirement documents and design specifications state that acoustic modeling is necessary. However, tracking the fidelity of that requirement does not occur. The sounds in the simulator are not nearly as loud as what would be present in the actual aircraft where double hearing protection is warranted. A quieter environment may present a better learning space and excite hearing conservation specialists; however, the unrealistic sounds are foreign to the aircrew, especially crew chiefs who have grown accustomed to overcoming aircraft noises for basic CRM tasks. Additionally, experience in the aircraft sharpens the acoustic inclinations of crew chiefs which enable them to hear aircraft performance malfunctions in the aircraft even before they manifest as indications on the display panels. This aptitude for acoustic signature is most evident during Functional Check Flight evolutions when the entire flight crew is increasingly sensitive to subtle aural cues.

Handling Qualities

One of the most common critiques of aviation simulators is that they do not accurately reproduce the response expected from the same control manipulation applied in the actual aircraft. Handling qualities and flying qualities are interchangeable terms which are defined as “those characteristics of an aircraft that govern the ease and precision with which a pilot is able to perform the tasks required in support of an aircraft role.”³⁴ Handling qualities are characterized in detail for every known aircraft in the aviation community as a part of the

developmental test period. During this testing, noticeable friction induced by the physical control linkages is often present. The simulator does not readily mirror those subtle differences in physical control link forces which manifest uniquely to each aircraft. External perturbations are another aspect of aircraft handling qualities that the simulator does not replicate well. Flying in a windy and turbulent environment is not felt in the simulator the same way it would feel in the aircraft. The hydraulic actuators commonly used for simulator motion present a less natural and more robotic sensation when simulating something like a gust of wind.

Performance Modeling

Performance modeling is another problematic aspect encountered when attempting to reproduce aircraft characteristics in the simulator. Modeling the simulator software for aircraft representative responses to control manipulation is complicated, as the performance gauges and visual displays need to be synchronized. Much of the simulator development requires feedback from an experienced aviator to describe whether the performance indicated is representative of the actual aircraft.³⁵ This process is impacted by environmental conditions much the same way as handling qualities. However, each aircraft engine generates subtle performance differences not reflected in the simulator. The simulator indications require fine-tuning to represent the aircraft performance model. A great deal of the performance modeling process involves experienced pilots providing feedback on the representative indications and response that the simulator demonstrates. Characterizing the aerodynamic performance modeling in this manner is problematic as consistent results are rarely gleaned from different experienced aviators.

External Influences on Aviation Simulator Advocacy

The aviation simulator develops with influences from an environment in a constant state of flux. This environment carries with it various restricting as well as enabling characteristics.

Technological advancements have increased the focus and promulgation of the aviation simulator but in certain circumstances have also stifled progress. These technological advancements are often manifest by growth in the organizational structure following predicted periods of development. However, the dynamic nature of technological developments, combined with annual budget cycles, convolute the solution for predicting when best to grow an organization and harness the promise of said developments. While these are not the only external influences impacting the progression of aviation simulators, they are demonstrative of recent trends. Another recent trend that is of concern is the increased use of simulators to compensate for deficient aircraft readiness. Aircraft readiness impacts each community differently, but the overall trends briefed by key officials in the Department of Defense (DoD) are of interest to this study.

Aircraft Readiness

The Navy and Marine Corps are experiencing deficient aircraft readiness across most aviation communities. In a 2016 hearing before the House Armed Services Committee, Rear Admiral Michael Manazir, then Deputy Chief of Naval Operations for Warfare Systems, asserted that the readiness deficit began as early as 2009 and that aircraft availability was the leading factor in the readiness challenge.³⁶ The current and former Marine Deputy Commandant's for Aviation (DCA) both similarly stressed the imperative of addressing aircraft readiness in the Marine Corps. Both have testified before Congress, acknowledging that there have been various influences that have the Corps to its current state of deficient aircraft readiness which is more substantial for some communities and aging platforms.³⁷ The long-lasting impact of not having aircraft available to fly presents an issue of safety. Marine aviation's ability to maintain

proficient and efficient flight leaders is of paramount importance in the threat environment of today and the future.

Amidst the readiness challenge, aviation leadership at the highest levels has re-emphasized the importance of having actual aircraft to fly in order to maintain pilot proficiency and prepare for the high-end fight. In an article to the *Marine Corps Gazette* in May 2017, the then DCA detailed “The Art of Readiness” across Marine Aviation and the impact that the Force would have to endure during the recovery efforts. One of the top concerns mentioned was the readiness deficiency contributing to the Marine Corps inability to fly and mature its pilots and aircrew.³⁸ Later in 2017, General Steven Rudder, the current DCA, quantified the issue of readiness concerning first tour pilots: They on average fly 20% fewer flight hours than their predecessors.³⁹ The remainder of the statement provides details on a majority of the most readiness deficient communities of Marine aviation and the progress toward readiness standards.⁴⁰ The Chairman of the Joint Chiefs of Staff (CJCS), General Joseph Dunford, USMC, was also quoted: “[T]he high-hour aviator is better-armed to make a split-second assessment and respond to an anomalous situation, correctly.⁴¹ The high hours referenced were actual flight hours and not simulator hours.

Throughout this readiness deficient era, many T/M/S specific Individual Readiness Reviews (IRRs) have been conducted only to report various solutions to a multi-faceted issue. As previously mentioned, leadership is on record as recognizing the need for actual aircraft to remedy the proficiency deficit that pilots are experiencing from readiness woes. However, there are also key leaders who have advocated using simulators to address the pilot proficiency aspect of readiness which has been created by unavailable aircraft. In 2004, Vice Admiral Charles Moore, then Deputy Chief of Naval Operations (CNO) for Fleet Readiness and Logistics (N4),

said "Up until a year ago, we did not accrue any readiness from those simulators.... We are investing more in simulators, and we have created policy to accrue readiness or build readiness with simulators."⁴² This statement represents a shift across the DoD that was very fiscally driven, but not a new tactic. The road to readiness recovery includes aircraft modernization, which is financially burdensome and leaves the simulator as a fiscally sensible and convenient alternative to actual flight proficiency.

Fiscal Constraints

Surges in aviation simulator interest have historically arisen due to budget concerns or technological advancements. In 1973, the comptroller general for the Department of Defense (DoD) presented a report to Congress detailing the cost savings that the flight simulator would generate while (in theory) increasing pilot proficiency in military pilot training.⁴³ The greatest reservation submitted with this recommendation to increase the use of simulators in military pilot training was the unknown efficiency of learning transfer from a simulator to the actual aircraft. This reservation remains a key argument against the increased use of aircraft simulators in place of actual flight hours. In a 2016 hearing before the subcommittee on readiness during the 2nd session of the 114th Congress, Major General Scott West, then Director of Current Operations for the U.S. Air Force, argued for live training over simulators, citing the inadequacy of exercising the entire performance of the system.⁴⁴

The potential cost, i.e., dollar savings, that simulation could add to the naval aviation enterprise was investigated in March of 2005, when the Chief of Naval Operations (CNO) directed the Navy to establish Task Force SIM. TF SIM's initial findings were promising and suggested that the fleet would see savings from the following: reduced fuel consumption, reduced system maintenance, and reduced consumable consumption.⁴⁵ It would appear evident

that the reduction in actual flight operations would, in turn, reduce consumption of all resources related to the flight operation itself. Nevertheless, findings such as this sparked the apparent readymade solution to the looming readiness issues facing aviation.

Again in 2011, then Major Ryan A. Pope, USMC, a Command and Staff College (CSC) student, argued for USMC aviation communities to replace the entire FRS training structure with a simulator-centric model to save money.⁴⁶ His argument centered around a comparison of the KC-130J and the MV-22 early training models, with calculable savings from increased dependence on simulators instead of aircraft. However, the paper only tangentially addressed the existential limitations of simulators. The studies he cited on the Cessna in 2004 and from the Army Research Institute (ARI) in 2008, found that a correlation between training effectiveness and simulator realism and fidelity was neither reliable nor supportable by empirical evidence.⁴⁷

Technological Advancements and Organizational Growth

The Tactical Environment Network (TEN) and digital interoperability to link simulators of various T/M/S platforms across the globe have garnered attention and increased the prospect of aviation simulators for joint training in a more complex and challenging operating environment. In 2011, the Commandant of the Marine Corps (CMC) issued a transformative order “to develop a completely integrated training system across Marine aviation that links training cost with readiness in order to provide the Marine Air Ground Task Force (MAGTF) commander with combat-ready units.”⁴⁸ The Aviation Training System (ATS) Manual followed and detailed the structure and procedures for Marine Corps aviation command relationships and funding channels behind the aviation training architecture. The manual reiterates the increased utilization of aviation simulators throughout its content. The following phrase best captures this

sentiment: “Marine Aviation **shall** continue to fund, develop, and build high fidelity trainers that support T&R requirements and are capable of being networked.” (Author’s emphasis) ⁴⁹

Operationalizing the ATS manual required a more in-depth look at the workforce structure of the aviation training system. The Marine Corps created positions within existent aviation units to leverage the structure and expedite the time to full operational capability (FOC). One such example is the establishment of Marine Aviation Training System Sites (MATSS) at every Marine Corps Air Station (MCAS). The MATSS coordinate closely with the respective Marine Aviation Groups (MAGs) but report to the Aviation Training System Director at the respective Marine Aviation Wing (MAW).⁵⁰ Figure 2 below depicts the structure that was designed to encompass every aspect of Marine aviation, from subject matter experts (SMEs) for each T/M/S to the training devices and aviation simulators for each community.

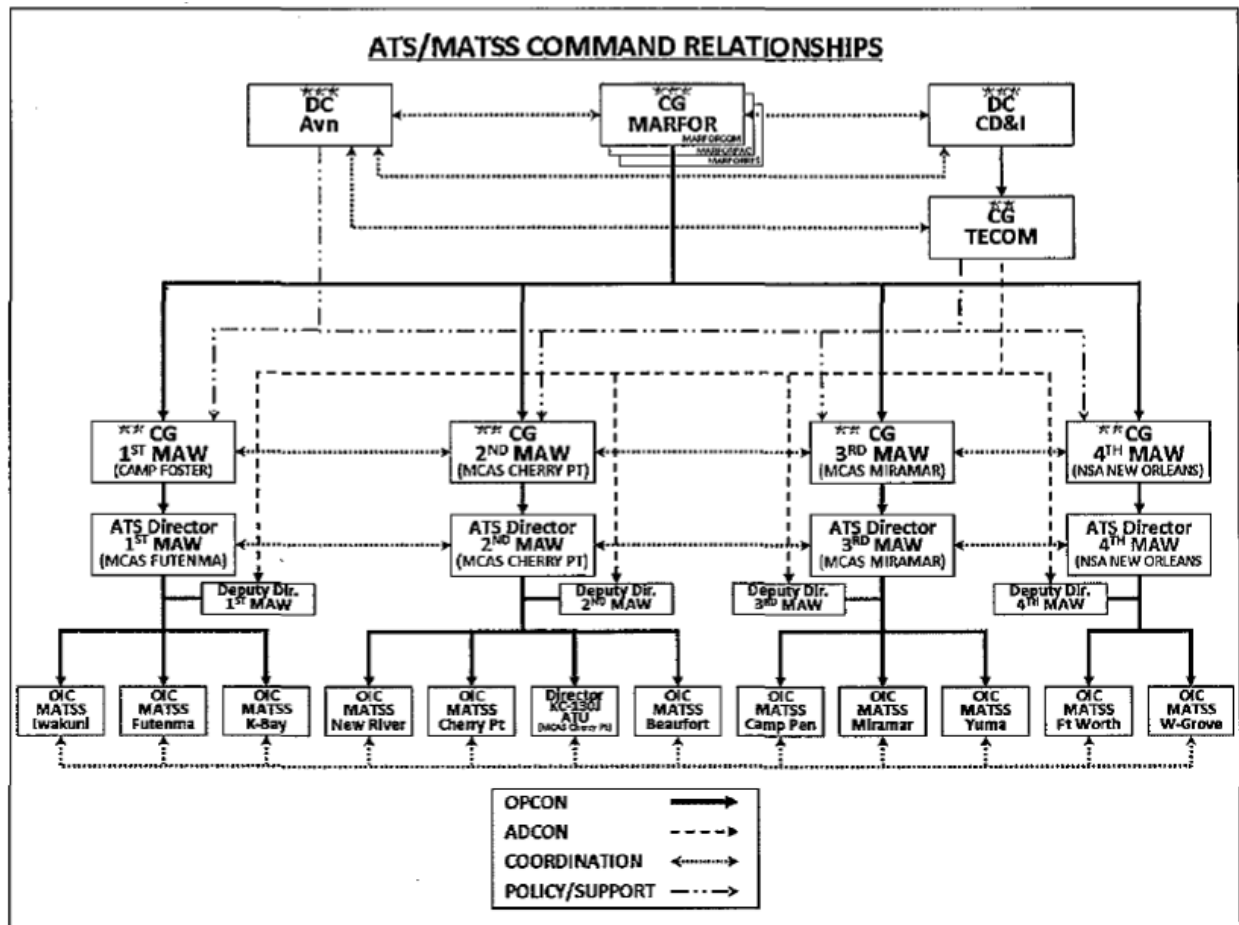


Figure 2: ATS/MATSS Command Relationships⁵¹

The ATS manual prescribes a very balanced process to curriculum development through the Systems Approach to Training (SAT) and is inclusive of subject matter experts through its Training System Certification (TSC) process.⁵² However, the manual does not prescribe a limit on the "increase" of aviation simulator utilization. Rather, the document encourages syllabus sponsors, model managers (MM), and program coordinators (PC) to optimize the use of simulation "to adjust the number of simulator-coded training events where training device capabilities match training requirements" in each respective T&R manual.⁵³

Case Study of the AH-1 Training Syllabus

General Overview of the Training and Readiness (T&R) Program Manual

While the FAA spearheaded the standardization for simulator qualification and designation, the military developed Standard Operating Procedures (SOPs) for the implementation of these training systems. The Aviation Training and Readiness (T&R) Program Manual, signed by the Commandant of the Marine Corps (CMC) for USMC aviation communities, contains the standards and regulations on aircrew training and planned system operation. This overarching USMC policy with regards to aviation training has evolved to include the increased use of simulators in the training curriculum. The initial comments regarding simulator use simply stated that “Annual instrument and NATOPS evaluations shall be completed in the simulator to the maximum extent possible.”⁵⁴ The most recent Aviation T&R Program Manual, dated 05 Feb 2016, now dedicates a brief section 2.12 entitled "Simulator Policy." This section opens with the following description encouraging maximum use of simulators:

All T&R manuals shall maximize the use of simulation in the T&R development/review process. Particular emphasis should be placed upon the capabilities and/or limitations of a community’s simulation capability in the selection of the device utilized to execute/complete an event. If the community possesses a simulator with the capability of executing the goal and requirement of an event as well as the means of evaluating the performance standard, then it shall be conducted in the simulator or, at a minimum, be listed as simulator preferred (see Chapter 6 for device coding). In order to exploit emerging capabilities, network training capabilities should be considered for inclusion in T&R manuals.⁵⁵

While the program manual suggests the exploitation of emerging simulator technologies, it does not provide a standardized policy restraining the use of aviation simulators in the T&R curriculum. Each T/M/S community develops their T&R manual to fit their unique capabilities and requirements.

Each USMC Aviation community uses working groups to develop its T&R manuals, guided by the principles described in the program manual. Chapter six of the T&R program manual provides the instructions for building T/M/S specific crewmember syllabi. The program manual defines the following:

The Core Skill (2000) Phase consists of the fundamental, environmental, or conditional capabilities required to perform basic functions. These basic functions serve as tactical enablers that allow crews to progress to the more complex Mission Skills. The Mission Skill (3000) Phase contains advanced skills training. It extends proficiency achieved in basic Core Skills and develops mission-level individuals and leaders that normally results in certifications, qualifications, and leadership designations. Individuals and crews proficient in this Phase of training should be capable of planning, managing, conducting mission essential tasks or leading crews / flights of numerous aircraft in a contingency operation.⁵⁶

Each phase is further broken down into stages for T/M/S unique Mission Essential Tasks (METs) and ultimately into syllabus events with specific performance requirements.

Current Trend Analysis of Aircraft Vs. Simulator Sorties

The T&R manual of the AH-1 community provides an opportune case study to analyze the trends associated with simulator use. The AH-1W is the legacy attack helicopter variant for the Marine Corps and provides a more conservative example than the digitally upgraded AH-1Z Viper which is replacing it. In order to maintain annual flight minimum requirements all naval aviators with less than twenty years of aviation service are to fly forty hours semi-annually and one hundred hours every fiscal year.⁵⁷ The simulator can account for up to fifty percent of these annual flight hour requirements.⁵⁸ In 2011, the AH-1W T&R manual included ten simulator sorties for a total of 15.0 hours as a part of the Core Skills and Mission Skills phase events. Since 2018, the AH-1W T&R manual has included fifteen simulator sorties for a total of 19.5 hours as a part of the Core Skills and Mission Skills phase events. This increase is parsed out in

table 1 below and depicts the marked increase over this period with the most significant increase in the Mission Skills phase.

Table 1: AH-1W T&R Simulator Sortie/Hour Trends AY 2011- AY 2018⁵⁹

T/M/S	<u>Core Skills Phase (2000)</u> <u>Sorties/Hours</u>		<u>Mission Skills Phase (3000)</u> <u>Sorties/Hours</u>		Core Phase Total	Mission Phase Total
	Simulator	Aircraft	Simulator	Aircraft		
AH-1W 2011	9/13.5	13/21.0	1/1.5	15/22.5	39% Simulator Hours	7% Simulator Hours
AH-1W 2018	10/15.0	15/23.0	3/4.5	20/24.0	39% Simulator Hours	16% Simulator Hours

The Core Skill (2000 level) and Mission Skill (3000 level) events permitted in the simulator increased in more than one way during this period. Previous events not considered suitable for the simulator are now permitted as simulator preferred over aircraft, designated as S/A. These events include a Threat Counter Tactics (TCT) sortie (2201X), an Assault Support Escort Sortie (3102X), and RW Control Forward Air Controller Airborne (3401X) sortie. The TCT sortie includes requirements for an Electronic Warfare (EW) and Laser safe range if flown in the aircraft, however those requirements are mitigated by conducting the sortie in the simulator.⁶⁰ Additionally, both the Assault Support Escort sortie and the Forward Air Controller Airborne (FAC(A)) sortie require additional external aircraft to meet training objectives in the actual aircraft. This requirement is once again mitigated by using the simulator, however the training realism and associated challenges with external asset coordination are training objectives that are lost.

In the current T&R manual for the AH-1W, there are an additional four sorties which are now designated as aircraft preferred but simulator optional (A/S) events where aircraft availability limitations may permit increased simulator use to obtain training objectives. Two of

these sorties were not in the 2011 T&R, while the other two were but did not permit execution in the simulator. The performance standards associated with these particular sorties stress the current limitations of the simulator tactical environment network (TEN). Table 2 describes the additional simulator optional (A/S) events from this period and suggests paired simulator limitations on the required performance standards.

Table 2: Simulator Limitations to Additional A/S Sorties AY 2011 – AY 2018.

<u>Phase</u>	<u>T&R Code</u>	<u>Event Title</u>	<u>Performance Description</u>	<u>Simulator Limitation</u>
Core	2610 ¹	Moving Target Gunnery	Proper 20mm and 2.75” Rocket Impact Detection and Adjustment	Visual Displays
Mission	3103	Surface Escort	Support Ground Combat Element (GCE) Scheme of Maneuver (SOM) (minimum of 3 vehicles)	Simulator Fidelity of GCE SOM
Mission	3304 ¹	Intro Urban CAS	Conduct Urban Targeting using a Gridded Reference Graphic (GRG)	Urban terrain relief and GRG representation
Mission	3307	SCAR	Validate using Video Tape Recorder (VTR) ² an effective Precision Guided Munition (PGM) engagement of a point target	DVR recordings not available/representative in the simulator

Notes:

1. These events were not in the 2011 T&R manual.
2. VTR replaced by Digital Video Recorder (DVR).

While the increased reliance on simulator use to obtain the training objectives of the Core and Mission Phases of the AH-1 syllabus is quantitatively apparent, the variation in quality of training between the aircraft and simulator is more challenging to define. The 2011 numbers suggest that the AH-1 community understood then the importance of conducting advanced mission skill events in the aircraft. While the simulator accounted for 39% of the Core Skills event hours, only 7% of the Mission Skills hours were designated as simulator events.⁶¹ On the surface, the recognition of this critical distinction remains in the 2018 T&R manual, where the

required simulator events comprise 16% of the overall hours for the Mission Skill Phase. However, upon further inspection, the additional A/S events increase the inclusive simulator sortie hours to roughly 43% of the overall Mission Skill Phase. The weighted increase marks a dramatic shift from the historical method for AH-1 training in this advanced stage. The Weapons and Tactics Instructor (WTI) Syllabus retains the importance of conducting AH-1 training in the aircraft as opposed to the simulator. The two-month WTI AH-1 Pilot Specific Evaluation Syllabus only prescribes one NATOPS/Emergency Procedure (EP) simulator event.⁶²

The additional events in the T&R requirements for the AH-1 community are indicative of a trend towards reliance on simulator technology. The training objectives for these events are softened in order to gain efficiencies in the planning and coordination phase. An obvious commonality with additional T&R events being designated as S/A is that external coordination for additional assets or range scheduling can be mitigated. However, the lessons learned from this coordination aspect are an example of the intangible training objectives that are lost when flight events are conducted in the simulator. Additionally, the various simulator limitations that are enduring due to technological and interoperability issues further hinder training objective realization. Increased reliance on simulator efficacy for training events is nearing the fifty percent limit imposed by overarching Naval Instruction on annual flight hour minimums. The danger in this calculation is that many of these training events are conducted first and sometimes only in the simulator. That does not translate to aircraft proficiency.

Aviation Simulators in the Future Operating Environment

USMC Guiding Concepts and Documents

The Marine Corps dedicates a substantial amount of time studying and forecasting operations in the future operating environment. In 2015, the Marine Corps Intelligence Activity (MCIA)

published Future Operating Environment (FOE) 2015-2025. This document provides the framework for decision-makers in the Marine Corps to anticipate how the force will adapt and overcome in conflict when confronted with adversaries who have ambiguous objectives and employ creative methods for accomplishing those objectives. As with any planning evolution, beginning with a common understanding of the environment is foundational. This document went as far as to identify five challenges to the Marine Corps, which drove the planning process for how to approach the problems of the future.

The Marine Corps Operating Concept (MOC) was written a year after the FOE, and it forecasts how the Marine Corps will operate, fight, and win in 2025 and beyond. An underlining purpose of the MOC is to "inform capability development and budget programming decisions."⁶³ The MOC identifies five drivers of change and then subsequently describes five critical tasks for the Marine Corps to attack to maintain the competitive edge as summarized in Table 3 below.

Table 3: Marine Corps Operating Concept (MOC) Five Drivers of Change and Critical Tasks⁶⁴

<u>Five Key Drivers of Change</u>	<u>Five Critical Tasks</u>
Complex Terrain	Integrate the Naval Force to Fight at and from the Sea
Technology Proliferation Battle of Signatures	Evolve the MAGTF
Information as a Weapon	Operate with Resilience in a Contested-Network Environment
Battle of Signatures	Enhance Our Ability to Maneuver
Increasingly Contested Maritime Domain	Exploit the Competence of the Individual Marine

Note: The Key Drivers do not correspond to the Critical Tasks aligned in the table.

As a concept document, it is intentionally general with the description of the environment, but it gets particularly descriptive with the critical task titled "exploit the competence of the individual

Marine.”⁶⁵ This task describes simulation in the future environment as a method to increase the number of looks Marines will achieve in training before actual execution. It proposes that the Live, Virtual, Constructive Training Environment (LVC-TE) is critical towards preparing the individual Marine for the complexity of the FOE and that the Marine Corps must continue to refine and exploit its use.

The 2018 Aviation Plan (AVPLAN) reflects the construct of the 2015 FOE and the 2016 MOC. The AVPLAN is an annual planning document for Marine Aviation that forecasts out on a ten-year perspective. It uses the results of IRRs from recent years to establish the current state of Marine aviation as a common baseline from which to move forward. The Marine Aviation Synthetic Training section closes out the final pages of this 192-page document. One of the recurring references in this section is the Marine Corps Aviation Simulator Master Plan (MCASMP). The MCASMP is the guiding program for networking all newly acquired aviation simulators into a common network when linked.⁶⁶ It also highlights a few enablers towards achieving the common network, namely a Common Synthetic Training Area (CSTA) through visual database fidelity and content correlation for interoperability.⁶⁷

These are current shortfalls that plague networked training of different T/M/S aircraft and challenge future integration of non-aviation training simulators. Amidst these challenges, the AVPLAN emphasizes the importance of aviation simulation for the future most directly through the following: “The Marine aviation simulator strategy outlines an increased reliance on simulation to augment flight training and provide improved readiness.”⁶⁸ This reliance is existential and enduring as USMC investment in simulator technology continues into the foreseeable future. The section on the MCASMP closes out with a few suggestive statements to this effect: “Fully integrated implementation of the MCASMP will foster a tipping point for

Marine aviation, whereby the aviation community accepts the full capacity and capability of networked, high fidelity training systems as the 'norm'. Its use is DEMANDED as part of complex, persistent, and scalable pre-deployment mission rehearsal training."⁶⁹

Live, Virtual, Constructive Training Development

The increased awareness and advocacy for a networked simulator centric training environment has influenced each of the branches of the United States military. The Air Force Agency for Modeling and Simulation (AFAMS) in Orlando's Central Florida Research Park leverages technological advantages from industry, DoD, and Joint organizations to foster growth in LVC concepts.⁷⁰ An example of investment in this concept is the Secure LVC Advanced Training Environment (SLATE) initiative that the Air Force Research Laboratory is currently developing. SLATE aims to provide pilots flying 5th Generation aircraft with a representative and detailed training environment cues to augment the live environment. A pilot in a live aircraft receives constructive injects for training purposes that would otherwise be a limit in the physical training environment. Some of the enduring challenges to this initiative are the security of the transmitted data and interoperability within the existent simulator architecture.⁷¹ In a 2016 hearing before the House Armed Services Committee (HASC), Major General Scott D. West, then Director of Current Operations for the USAF, was careful to articulate that it was imperative to strike a balance between the SLATE Advanced Technology Demonstration (ATD) and improvement in the range complexes and live training environment.⁷² Once again the imperative of live training remains a fundamental element of readiness amidst the desire to pursue technological advancements. The comment was a sobering reminder for those who vehemently advocate for simulators as the solution to a readiness deficient and fiscally constrained aviation community.

In that same hearing before the HASC in 2016, leaders representing the Navy and Marine Corps indicated interest in the development of the SLATE ATD but asserted that it was one of many initiatives to reach specific training capability requirements. The Marine Corps ATS is pursuing enhancements in the Aviation Distributed Virtual Training Environment (ADVTE), which reportedly links more than 40 Marine Corps aviation trainers from the East and West Coast MATSS.⁷³ A Program of Record (PoR) under the Marine Corps Synthetic Training Environment (MCSTE) is the Live Virtual Constructive Training Environment (LVC-TE). The LVC-TE is the Marine Corps main effort for future interoperability across the live, virtual and constructive simulation domains.⁷⁴ The Acquisition Milestone of Analysis of Alternatives (AoA) Decision Brief was expected in the first quarter of the fiscal year 2019 (FY19).⁷⁵ Once again, the key driver for this initiative is the repetitions that virtual and constructive training environments afford aviation communities to achieve, in theory, a more cost effective combat readiness than actual flight in the aircraft.

5th Generation Aircraft

As aircraft technological advancements occur, replications for training are pursued through simulator progression as well. This training trend is most evident in the training syllabus of the F-35B, a single seat Short Takeoff and Vertical Landing (STOVL) 5th generation stealth aircraft.⁷⁶ The aircraft boasts a state-of-the-art fly-by-wire flight control systems (FCS) and modular digital interfaces as some of its technological advantages that the simulator can replicate. The trend toward increased use of the simulator for training is evident in each phase of the T&R when compared with other T/M/S aircraft. The 2017 F-35B T&R manual details that 50% of the overall Core Skill Phase hours occur in the simulator.⁷⁷ Furthermore, 52% of the Mission Skills Phase occur in the simulator rather than in the aircraft.⁷⁸ However, because each

T/M/S is charged with training to specific Mission Essential Tasks (METs) this percentage increase suggests that FW aircraft, especially single seat designs, are more suited for increased simulator events. Additionally, although 5th Generation aircraft are the tip of the technological spear, the interoperability with visual displays of existing T/M/S simulator becomes problematic. During the FAC(A) training phase, simulator controls count toward TYPE 1 controls requirements, which requires visual acquisition and geometry evaluation of the aircraft conducting the terminal attack. The trend toward increased simulator reliance impacts aviation communities differently based on specific training objectives and the resources available to close the gaps of existent limitations.

The most recent and ongoing efforts to conduct LVC training with 5th Generation aircraft have encountered several technological challenges. In a 2018 paper titled “Advancing the State-of-the-Art in Airborne LVC training” from the Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC), many of the current challenges were addressed. The SLATE initiative was once again leveraged to test a 5th Generation Advanced Training Waveform (5G-ATW) against LVC integration challenges such as cyber security, latency, bandwidth, spectrum availability and aircraft integration.⁷⁹ The paper concluded that addressing these issues would be required prior to full LVC integration in mainstream training curricula.⁸⁰ Furthermore, a test of the Marine Corps LVC-TE in 29 Palms, California yielded results that pinpointed network inefficiencies as a barrier to LVC integrated training exercises. Large scale exercises across the live, virtual and constructive domains have proven unwieldy to manage as network traffic bombards existent enterprise capacities.⁸¹

Conclusion

As the aviation community navigates the dynamic operating environment of the future, it is essential to reflect upon the historical precedent set and develop a calculated and balanced approach for the continued use of the aviation simulator. Therefore, acknowledgment of the critical impact that the aviation simulator has had on the aviation community should not unduly generate a tendency toward increased dependence on the promise of future technology. The balance sought may naturally arise due to technological progression and limitations encountered; however, a retrospective victory is not as fulfilling or promising as one gleaned from a well developed and articulated plan.

The many enduring simulator limitations combined with future challenges discussed limit the potential readiness and proficiency that the aviation simulator offers. Insufficient audio and visual cues in the aviation simulators do not replicate the complexities of the real environment and lend towards negative training. Learned behavior from increased simulator sorties will inevitably translate into pilot tendencies in the aircraft as aviators fight the way they are trained. These negative returns are just as problematic if not more so than the fiscal concerns from conducting training in the actual aircraft. There are boundaries required for increased reliance on the aviation simulator and a comprehensive training curriculum cannot neglect the lessons learned from stressors associated with actual flight rather than simulation.

The rhetoric surrounding advocacy for increased simulator investment may serve to generate support and funding in a fiscally constrained system but cannot guide the operationalization of the technology. A dedicated study for each T/M/S is warranted to ascertain the degree to which the simulator can accomplish specific training objectives. Conceptual readiness and funding concerns cannot be the sole motives fueling this decision to promote

simulators above actual flight in the aircraft. Hence, the Training and Readiness Program Manual should include restrictions on the use of the simulator for training objectives. The aforementioned study must inform these restrictions and be specific to each aviation community. Each T/M/S T&R manual must also acknowledge and track the limitations of the simulator to support an interoperable solution that the ATS manual prescribes.

Appendix A: Referenced Aircraft Illustrations

AH-1W Super Cobra:



AH-1Z Viper Cobra:



T-34B Mentor:



T-6B Texan II:



KC-130J Hercules:



F-35B Lightning II:



Appendix B: Naval Aviator Training Pipeline



Source: <https://www.cnatra.navy.mil/training.asp>

The naval aviation training pipeline is diverse, and the length of training is dependent upon which phase is selected after the primary curriculum. The Chief of Naval Aviation Training (CNATRA) conducts six Student Naval Aviator training pipelines - Strike, Rotary, Maritime, Tilt-rotor, E-2/C-2, and E-6. Primary training is the foundation and conducted in the T-6B which replaced the T-34C Turbo Mentor as the primary training aircraft in April 2015. The T-6B cockpit and avionics suite is designed to better facilitate the transition to increasingly sophisticated follow-on training and fleet aircraft. Once complete with Advanced flight training, Student Naval Aviators receive their Aviator Designation, select their T/M/S aircraft and report to their respective Fleet Replacement Squadrons (FRSs).

Appendix C: AH-1Z T&R Syllabus Matrix Example

AH-1Z T&R SYLLABUS MATRIX																					
SKILL	PREFIX	T&R DESCRIPTION	EVENT NUMBER	ATTAIN			MAINTAIN	ACAD/GRND		SIM		FLIGHT		COND	SEAT	TYPE	# A/C or Sim	# REFLY	EOM	MIRROR (W→Z)	EVENT CONV
				B	R	SC		#	TIME	#	TIME	#	TIME								
ANSQ	SANSQ	NVD LLL EPs	2700	X							1.5			NS	OS	S	1	*			2700
	ANSQ	NVD LLL FAM/Nav	2701	X	X	X	X						2.0	NS	FS	A	1	180			2701
	ANSQ	NVD LLL TACFORM/TERF	2702	X	X		X						1.5	NS	OS	A	2	180			2702
	SANSQ	Intro NVD LLL Ord	2704	X							1.5			NS	OS	S	1	*			2704
	ANSQ	Rev NVD LLL Ord Del	2705	X	X	X	X						1.5	NS	OS	A	2	180			2705
ANSQ TOTAL								0	0.0	2	3.0	3	5.0								
FAM	FAM	FAM/INST Proficiency	2800	X	X	X	X						1.5	(NS)	OS	A	1	90			2800
	SFAM	EP Simulator	2801	X	X	X	X				1.5			(NS)	OS	S/A	1	90			2801
FAM TOTAL								0	0.0	1	1.5	1	1.5								
CORE PHASE TOTAL								0	0.0	10	15.0	15	23.0								
MISSION (3000 P-loads)																					
ACAD	ACAD	Intel Prep Battlefield	3000	X										(N)		G		*			3000
	ACAD	Problem Framing	3001	X					1.0					(N)		G		*			3001
	ACAD	ROE Planning	3002	X					1.0					(N)		G		*			3002
	ACAD	GCE RAID Planning	3003	X					1.0					(N)		G		*			3003
	ACAD	Execution Checklist	3004	X					1.0					(N)		G		*			3004
	ACAD	Objective Area Plan	3005	X	X		X		1.0					(N)		G		365			3005
	ACAD	NEO Execution	3006	X					1.0					(N)		G		*			3006
	ACAD	Rapid Response Plan	3007	X					1.0					(N)		G		*			3007
	ACAD	(S) RADAR Surface to Air Threat	3008	X					1.0					(N)		G		*			3008
	ACAD	(S) REC Threat to the MAGTF	3009	X					1.0					(N)		G		*			3009
	ACAD	(S) IR Threat to RW Aircraft	3010	X	X		X		1.0					(N)		G		365			3010
	ACAD	(S) ADA Threat to RW Aircraft	3011	X	X		X		1.0					(N)		G		365			3011
	ACAD	(S) Laser Threat	3012	X					1.0					(N)		G		*			3012
	ACAD	(S) Electronic Warfare	3013	X					1.0					(N)		G		*			3013
	ACAD	Assault Support Escort Tactics	3019	X	X		X		1.0					(N)		G		365			3019
	ACAD	RW OAS	3030	X	X		X		1.0					(N)		G		365			3030
	ACAD	Urban CAS	3031	X	X		X		1.0					(N)		G		365			3031
	ACAD	Close Air Support	3032	X					1.0					(N)		G		*			3032
	ACAD	CAS Standardization	3033	X	X		X		1.0					(N)		G		365			3033
	ACAD	Weaponizing	3034	X					1.0					(N)		G		*			3034
	ACAD	HM/LA AR and SCAR TTPs	3035	X					1.0					(N)		G		*			3035
	ACAD	(S) Personnel Recovery	3038	X					1.0					(N)		G		*			3038
	ACAD	(S) TRAP	3039	X					1.0					(N)		G		*			3039
	ACAD	JFAC(A) Courseware	3041	X	X		X		1.0					(N)		G		365			3041
	ACAD	FAC(A) TTPs	3042	X										(N)		G		*			3042
	ACAD	HM/LA FARP Ops	3045	X					1.0					(N)		G		*			3045
ACAD TOTAL								26	24.0	0	0.0	0	0.0								
ESC	ESC	ASPT ESC	3100	X									1.5	D	OS	A	2	*			3100
	ESC	NVD ASPT ESC	3101	X	X		X						1.5	NS	OS	A	2	365			3101
	SESC	SIM ASPT ESC	3102	X	X	X	X				1.5			(NS)	OS	S/A	2	365			3102
	ESC	Surface ESC	3103	X	X								1.5	(NS)	OS	A	2	*			3103
ESC TOTAL								0	0.0	1	1.5	1	4.5								

Source: AH-1Z Training and Readiness Manual, NAVMC 3500.104B, April 03, 2018

Appendix D: Acronyms

A/S	Aircraft Preferred but Simulator Optional
AoA	Analysis of Alternatives
ADVTE	Aviation Distributed Virtual Training Environment
AFAMS	Air Force Agency for Modeling and Simulation
API	Aviation Pre-flight Indoctrination
APT	Aircrew Procedure Trainer (Aircraft Procedural Trainer)
ARI	Army Research Institute
ATD	Advanced Technology Demonstrations
ATS	Aviation Training System
ATU	Auxiliary Training Unit
AVPLAN	Aviation Plan
CAS	Close Air Support
CFR	Code of Federal Regulations
CNO	Chief of Naval Operations
CMC	Commandant of the Marine Corps
CNATRA	Chief of Naval Air Training
CRM	Crew Resource Management (Cockpit Resource Management)
CSC	Command and Staff College
CSTA	Common Synthetic Training Area
DC/AVN (DCA)	Deputy Commandant for Aviation
DoD	Department of Defense
DoN	Department of Navy
DVR	Digital Video Recorder
EP	Emergency Procedure
EW	Electronic Warfare
FAA	Federal Aviation Administration
FAC(A)	Forward Air Controller (Airborne)
FAR	Federal Aviation Regulation
FCF	Functional Check Flight
FCS	Flight Control System
FOC	Full Operational Capability
FOE	Future Operating Environment
FFS	Full Flight Simulator
FTD	Flight Training Device
FRS	Fleet Replacement Squadron
FW	Fixed Wing
FY	Fiscal Year
GCE	Ground Combat Element
GRG	Gridded Reference Graphic

HASC	House Armed Service Committee
HMLA	Marine Light Attack Helicopter
HQMC	Headquarters Marine Corps
IFS	Introductory Flight School
IMC	Instrument Meteorological Conditions
IOC	Initial Operational Capability
IRR	Individual Readiness Review
LVC	Live Virtual Constructive
LVCTE	Live Virtual Constructive Training Environment
MAG	Marine Aircraft Group
MAGTF	Marine Air Ground Task Force
MATSS	Marine Aviation Training System Site
MAW	Marine Aircraft Wing
MCAS	Marine Corps Air Station
MCASMP	Marine Corps Aviation Simulator Master Plan
MCIA	Marine Corps Intelligence Activity
MCSTE	Marine Corps Synthetic Training Environment
MET	Mission Essential Task
MM	Model Manager
MOC	Marine Corps Operating Concept
NATOPS	Naval Air Training and Operating Procedures Standardization
NAVTRAEQUIPCEN	Naval Training and Equipment Center
PC	Program Coordinator
PGM	Precision Guided Munition
RW	Rotary Wing
S/A	Simulator Preferred Over Aircraft
SAT	Systems Approach to Training
SCAR	Strike Coordination and Reconnaissance
SLATE	Secure LVC Advanced Training Environment
SME	Subject Matter Expert
SOM	Scheme of Maneuver
SOP	Standard Operating Procedure
STCT	Simulated Threat Counter-Tactics
STOVL	Short Take-off/Vertical Landing
T&R	Training and Readiness
TCT	Threat Counter Tactics
TEN	Tactical Environment Network

T/M/S	Type, Model, and/or Series
TSC	Training System Certification
UDOFT	Universal Digital Operational Flight Trainer
VTR	Video Tape Recorder
WST	Weapon System Trainer
WTI	Weapons and Tactics Instructor

GLOSSARY OF TERMS

All Terms Defined Exactly as Found in Associated Sources

Aircraft: DOT, US Code 49, §40102, Mar 17

Any contrivance invented, used, or designed to navigate, or fly in, the air.

Aircrew Procedure Trainer: N88-NTSP-A-50-9602A/A, January 2002.

The cockpit assembly includes full-sized active indicators, controls, lights, panels, gauges, and instruments located in the same relative position as in the actual aircraft. Power supplies, host computers, a control loading system, aural cueing, intercom system, and associated peripherals are located in the cockpit assembly. The IOS includes an Instructor desk, two chairs, two monitors, two keyboard-mouse assemblies, and a printer with stand. The IOS monitors are for starting the simulator system, controlling student training sessions, and monitoring corresponding student actions. The IOS printer is provided to obtain student records, session printouts, IOS dumps, and diagnostics. A unique feature of the device is the capability to run and control the simulation without an Instructor. The device can be controlled from either of the Crew stations via a trackball assembly and the IOS information is projected onto the right OTW screen. The device possess all the capabilities of the AH-1W WST, except for motion and simulated threat, and performs all functional checklists, including the weapon systems and emergency procedures, both airborne and on the ground. It is also qualified as an Instrument Flight Training device.

Crew Resource Management: CNAF M-3710.7

The use of specifically defined behavioral skills as an integral part of every flight to improve mission effectiveness by minimizing crew preventable errors, maximizing crew coordination, and optimizing risk management.

Flight Training Device: 14 CFR 1.1

Flight training device (FTD) means a replica of aircraft instruments, equipment, panels, and controls in an open flight deck area or an enclosed aircraft cockpit replica. It includes the equipment and computer programs necessary to represent aircraft (or set of aircraft) operations in ground and flight conditions having the full range of capabilities of the systems installed in the device as described in part 60 of this chapter and the qualification performance standard (QPS) for a specific FTD qualification level.

Full Flight Simulator: 14 CFR 1.1

Full flight simulator (FFS) means a replica of a specific type; or make, model, and series aircraft cockpit. It includes the assemblage of equipment and computer programs necessary to represent aircraft operations in ground and flight conditions, a visual system providing an out-of-the-cockpit view, a system that provides cues at least equivalent to those of a three-degree-of-freedom motion system, and has the full range of capabilities of the systems installed in the device as described in part 60 of this chapter and the qualification performance standards (QPS) for a specific FFS qualification level.

Instrument Meteorological Conditions: CNAF M-3710.7

Meteorological conditions expressed in terms of visibility, distance from clouds, and ceiling less than the minimums specified for visual meteorological conditions. IMC conditions exist anytime a visible horizon is not distinguishable.

Multi-piloted Aircraft. CNAF M-3710.7

Any aircraft having two sets of flight controls and instruments and operated by two pilots, both of who meet the requirements of the NATOPS manual for that model aircraft.

Single-piloted Aircraft. CNAF M-3710.7

Any aircraft that has only one set of flight controls or a tandem cockpit, or any aircraft that has two sets of flight controls and instruments and is being operated by only one pilot who meets the requirements of the NATOPS manual for that model aircraft.

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This document provides clarity into the overarching policies that affect each USMC aviation community. The specific and permissive wording about aviation simulators is of particular interest to this writing.

Commandant of the Marine Corps. *AH-1W Training and Readiness Manual*, NAVMC 3500.49, March 08, 2011.

This document will serve as a baseline for the case study of the comparison of the simulator to aircraft sorties in the development of the tactical aviator. A comparison of this and the most recent AH-1W T&R will be useful in conveying the argument for a trend toward overdependence on simulators.

Commandant of the Marine Corps. *AH-1W Training and Readiness Manual*, NAVMC 3500.49B, April 03, 2018.

This document will serve as the most recent AH-1W T&R manual to compare against historical precedence. It provides a systematic description of the training requirements for each sortie in the AH-1W curriculum.

Commandant of the Marine Corps. *AH-1Z Training and Readiness Manual*, NAVMC 3500.104B, April 03, 2018.

This document will serve as the most recent AH-1Z T&R manual to compare against the AH-1W and other training documents. It provides a standard curriculum for the AH-1 community, even though the aircraft are remarkably different concerning technology. The trend analysis of the AH-1Z over time may provide a more dramatic example for this paper and is worthy of investigation.

Commandant of the Marine Corps. *F-35B Training and Readiness Manual*, NAVMC 3500.118A, June 13, 2017.

This document represents the training and readiness of a 5th Generation aircraft. The description of aircraft to simulator sorties is pertinent as a comparison and in developing any forecast of a future trend.

Commandant of the Marine Corps. *Marine Corps Aviation Training System*, MCO 3710.6A, September 30, 2011.

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[https://www.public.navy.mil/airfor/vaw120/Documents/CNAF%201542.7A%20\(CRM\).pdf](https://www.public.navy.mil/airfor/vaw120/Documents/CNAF%201542.7A%20(CRM).pdf)

The CRM program provides insight into the reach of the aviation simulator. The simulator facilitates many of the annual CRM flight requirements.

Commanding Officer United States Naval Test Pilot School. Flight Test Manual 107 Rotary Wing Stability and Control, 31 December 1995 with Errata.

This FTM describes the testing required to evaluate helicopter flying qualities. The terms and techniques are applicable to the aircraft and simulator alike.

Department of Defense. Report to the Congress: *Greater Use of Flight Simulators In Military Pilot Training can Lower Costs and Increase Pilot Proficiency*. Washington, DC: General Accounting Office, 1973.

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This document provides insight into the future aviation plan as of 2018. It will be useful as a reference when making an argument for simulator use in an unmanned capacity.

Headquarters United States Marine Corps. *Marine Corps Operating Concept: How an Expeditionary Force Operates in the 21st Century*. Quantico, VA: Marine Corps Combat Development Command, September, 2016. <http://www.mcwl.marines.mil/Portals/34/Images/MarineCorpsOperatingConceptSept2016.pdf?ver=2016-12-02-073359-207>.

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⁴⁷ *Ibid.*, 9.

⁴⁸ Commandant of the Marine Corps, *Marine Corps Aviation Training System*, MCO 3710.6A, September 30, 2011, 1.

⁴⁹ *Ibid.*, 2. Emphasis added by author. The quote goes on to state "By using these trainers, we will ensure greater standardization, readiness, and reduce operating cost."

⁵⁰ *Ibid.*, 9-2.

⁵¹ *Ibid.*, 3-4.

⁵² *Ibid.*, 1-2. "Training System Certification ensures aviation training system and devices are capable of providing the training to support platform/community T&R simulation events through a periodic review of training system capabilities. TSC will also be used to validate the CCM processes, ensuring the simulator's configuration supports the curriculum and is representative of the aircraft or operational system. T/M/S subject matter experts (SMEs) will be instrumental in TSC."

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⁶⁴ Headquarters United States Marine Corps, *Marine Corps Operating Concept: How an Expeditionary Force Operates in the 21st Century*. (Quantico, VA: Marine Corps Combat Development Command, September, 2016), 5, 10.

<http://www.mcwl.marines.mil/Portals/34/Images/MarineCorpsOperatingConceptSept2016.pdf?ver=2016-12-02-073359-207>.

⁶⁵ *Marine Corps Operating Concept*, 24.

⁶⁶ Headquarters United States Marine Corps, *2018 Marine Aviation Plan*, (Washington, DC: Deputy Commandant for Aviation, 2017), 191.

<https://www.aviation.marines.mil/Portals/11/2018%20AvPlan%20FINAL.pdf>.

⁶⁷ *2018 Marine Aviation Plan*, 191.

⁶⁸ *2018 Marine Aviation Plan*, 190.

⁶⁹ *2018 Marine Aviation Plan*, 190.

⁷⁰ Air Force Agency for Modeling and Simulation (AFAMS) homepage, published January 7, 2019. Available at

<https://www.afams.af.mil/DesktopModules/ArticleCS/Print.aspx?PortalId=81&ModuleId=14322&Article=429786>

⁷¹ Courtney Albion, "AFRL to begin key LVC demonstration later this month," *Inside Defense*, (June 14, 2018), <https://insidedefense-com.lomc.idm.oclc.org/daily-news/afrl-begin-key-lvc-technology-demonstration-later-month>

⁷² *Aviation Readiness: Hearing before the House Armed Services Subcommittee on Readiness*, 114th Cong., 19, (2016) (statement of Major General Scott West, USAF, Director of Current Operations).

⁷³ Naval Air Systems Command, Aviation Distributed Virtual Training Environment homepage. Available at

<http://www.navair.navy.mil/index.cfm?fuseaction=home.displayPlatform&key=52FD7C22-33DE-47E3-9EB5-AB01B907E722>

⁷⁴ The Official Website of the United States Marine Corps, “Live Virtual Constructive Training Environment” Available at <https://www.candp.marines.mil/Programs/Focus-Area-2-Training-Simulation/Collective-Training-Systems/LVCTE/>

⁷⁵ The Official Website of the United States Marine Corps, “Live Virtual Constructive Training Environment” Available at <https://www.candp.marines.mil/Programs/Focus-Area-2-Training-Simulation/Collective-Training-Systems/LVCTE/>

⁷⁶ Jeffrey Hood, “Defining the 5th Generation Fighter Jet”, 633rd Air Base Wing Public Affairs, March 14, 2017. <https://www.jble.af.mil/News/Commentaries/Display/Article/1112351/defining-the-5th-generation-fighter-jet/>. First generation fighter jets exploited technologies first generated during World War II, specifically the jet engine and swept wing technology. Second generation fighters incorporated advances in speed, weapons and sensors of their first generation counterparts. Third generation fighters integrated more advanced radars capable of tracking targets at longer ranges with semi-active radar-guided missiles that enabled beyond visual range engagements. As fourth-generation aircraft matured, they incorporated several incremental improvements including active electronically scanned array radars and helmet mounted cueing systems to facilitate greater off-boresight weapons engagement. Fifth-generation fighters truly fuse multiple on-board offensive and defense sensor systems with off-board information to present a smart, networked digital data-presentation to the pilot.

⁷⁷ Commandant of the Marine Corps, *F-35B Training and Readiness Manual*, NAVMC 3500.118A, June 13, 2017, 2-165. Percentages calculated by diving simulator hours by total hours per phase and multiplying by 100.

⁷⁸ *F-35B Training and Readiness Manual*, NAVMC 3500.118, Percentages calculated by diving simulator hours by total hours per phase and multiplying by 100.

⁷⁹ Lance R. Call and Rob Lechner, “Advancing the State-of-the-Art in Airborne LVC Training”, Interservice/Industry Training, Simulation, and Education Conference 2018, paper number 18249, 2.

⁸⁰ *Ibid*, 3.

⁸¹ Luis E. Velazquez, “Effective Deployment of LVC-TE on Wide Area Networks”, Interservice/Industry Training, Simulation, and Education Conference 2018, paper number 18092, 9.