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AN ANALYSIS OF THE MARINE CORPS AVIATION TRAINING SYSTEM REQUIREMENTS LIFE CYCLE

September 2022

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ABSTRACT

This capstone applied project examines the suitability of the current requirements life cycle for Marine Corps aviation training systems, including new programs and upgrades. Methodology includes a comprehensive review of existing policies and processes as well as interviews with key stakeholders. Analysis has identified weaknesses in the areas of training-focused requirements generation as well as portfolio management across Marine Corps training system programs. Recommendations include integrating modeling and simulation (M&S) expertise into the Training Management Process (TMP) and full implementation of Training Systems Certification (TSC) and Systematic Team Assessment of Readiness Training (START) tools to improve requirement relevancy to training needs as well as improved portfolio management for Marine Corps training systems led by Marine Corps Training and Education Command (TECOM). This capstone applied project concludes with recommendations for further study related to these matters.

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LIST OF ACRONYMS AND ABBREVIATIONS

3F	form, fit, and function
ACV	Amphibious Combat Vehicle
AL	advisory level
AO	action officer
APW	aviation programs and weapons
ASB	Aviation Standards Branch
ASN RDA	Assistant Secretary of the Navy, Research, Development, and Acquisition
ATD	Aviation Training Division
ATS	Aviation Training System
AVN	aviation
AWF	acquisition workforce
AWS	air warfare systems
CDD	Capabilities Development Directorate
CG TECOM	Commanding General, Training and Education Command
COA	course of action
DC	deputy commandant
DC, CD&I	Deputy Commandant, Combat Development and Integration
DCA	Deputy Commandant, Aviation
DL	distance learning
DOD	Department of Defense
DOTMLPF	doctrine, organization, training, material, leadership and education, personnel, and facilities
EL	executive level
FMF	Fleet Marine Force
FRS	fleet replacement squadron
GS	general schedule
HA	human abilities
HITL	human in-the-loop
HQMC	Headquarters Marine Corps

IG	integration group
IL	integration level
IPT	integrated product team
ISD	instructional systems design
ITE	integrated training environment
ITEAM	Integrated Training Environment Assessment Methodology
CAP	capstone applied project
LVC	live, virtual, and constructive
LVC-TE	live, virtual, and constructive training environment
M&S	modeling and simulation
MAGTF	Marine air-ground task force
MARCORSYSCOM	Marine Corps Systems Command
MATSS	Marine Aviation Training System Site
MAWTS-1	Marine Aviation Weapons and Tactics Squadron One
MC	mission computer
MCCDC	Marine Corps Combat Development Command
MCISD	Marine Corps Instructional Systems Design
MCMSO	Marine Corps Modeling and Simulation Office
MCTE	Marine Corps Training Environment
MCTEMP	Marine Corps Training Environment Modernization Plan
MCWL	Marine Corps Warfighting Laboratory
MET	mission essential task
MOS	military occupational specialty
MOVES	Modeling, Virtual Environments, and Simulation
NAVAIR	Naval Air Systems Command
NAWCAD	Naval Air Warfare Center, Aircraft Division
NAWC-TSD	Naval Air Warfare Center, Training Systems Division
OEM	original equipment manufacturer
OPEVAL	operational evaluation
PEO	program executive office
PM	program manager
PMA	program management activity

PMOS	primary military occupational specialty
PMTRASYS	Program Manager Training Systems
POM	program objective memorandum
PSD	Policy and Standards Division
RO	requirements officer
ROI	return on investment
ROM	rough order of magnitude
SAT	Systems Approach to Training
SATE	Systems Approach to Training and Education
SME	subject matter expert
START	Systematic Team Assessment of Readiness Training
STIMB	Synthetic Training Integration and Management Branch
T&R	training and readiness
T/M/S	aircraft type, model, and series
TECOM	Training and Education Command
TMP	Training Management Process
TMT	training management team
TSC	Training Systems Certification
TSP	Technical Standards Profile
VMX-1	Marine Operational Test and Evaluation Squadron One
VV&A	verification, validation, and accreditation
VV&C	verification, validation, and certification
WG	working group

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I. INTRODUCTION

Acquisitions of aviation training systems pose additional unique challenges compared to conventional weapon systems. Simulators are inherently partial aircraft representations, requiring countless suitability determinations to control cost and schedule while preserving training utility. Furthermore, their role as a training tool versus a weapons system requires additional expertise in modeling and simulation (M&S) that is not resident in the end-user or acquisition workforce (AWF) populations, resulting in poor requirements generation and decomposition.

While this dilemma is not new, simulator acquisition activities are increasingly pursuing partial-task and deployable trainers with innovative form, fit, and function (3F) to drive down cost while improving portability and accessibility. Virtual reality, mixed-reality, control actuators miniaturization, touchscreens, and simulation of mission computers present opportunities for the Department of Defense (DOD) simulation enterprise to acquire more effective trainers at lower costs. Now more than ever, the AWF needs clearly articulated, informed requirements to navigate 3F tradeoffs, capitalizing on emerging technologies while preserving key characteristics needed to train aircrew.

This capstone applied project (CAP) surveys and analyzes the requirements life cycle for Marine Corps aviation training systems. First, the background provides a baseline understanding of the stakeholder landscape as well as the requirements policies, and processes that are currently in effect. Next, an analysis is conducted on the two primary shortfalls of the current system: 1) lack of a systemic process for decomposing training needs into training system requirements and 2) lack of portfolio management across the Marine Corps training system enterprise. Included in the analysis section are recommendations to remedy the identified weaknesses. The CAP concludes with recommendations for further research.

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II. BACKGROUND

To achieve a baseline understanding of the Marine Corps aviation training systems requirements life cycle, a thorough background is provided. This background will include a landscape of stakeholders broken into several functional groups across the Marine Corps and Naval Service. Then, a detailed description of the current requirements generation process, the Training Management Process (TMP), will be provided.

A. STAKEHOLDER LANDSCAPE

One of the more challenging tasks in understanding the requirements generation process was gaining a holistic perspective of the stakeholder landscape and the complex inter-relations between overlapping agencies. This section will describe the stakeholder landscape by outlining chains of command in the following functional areas: aviation advocacy, training, acquisitions, and M&S. Figure 1 is a graphical representation of this stakeholder landscape, and will assist the reader in maintaining orientation through the identification of the various agencies and their missions. The organizational charts of the various commands, activities, and agencies depicted in Figure 1 have been heavily edited to only display the elements relevant to Marine Corps aviation training systems.

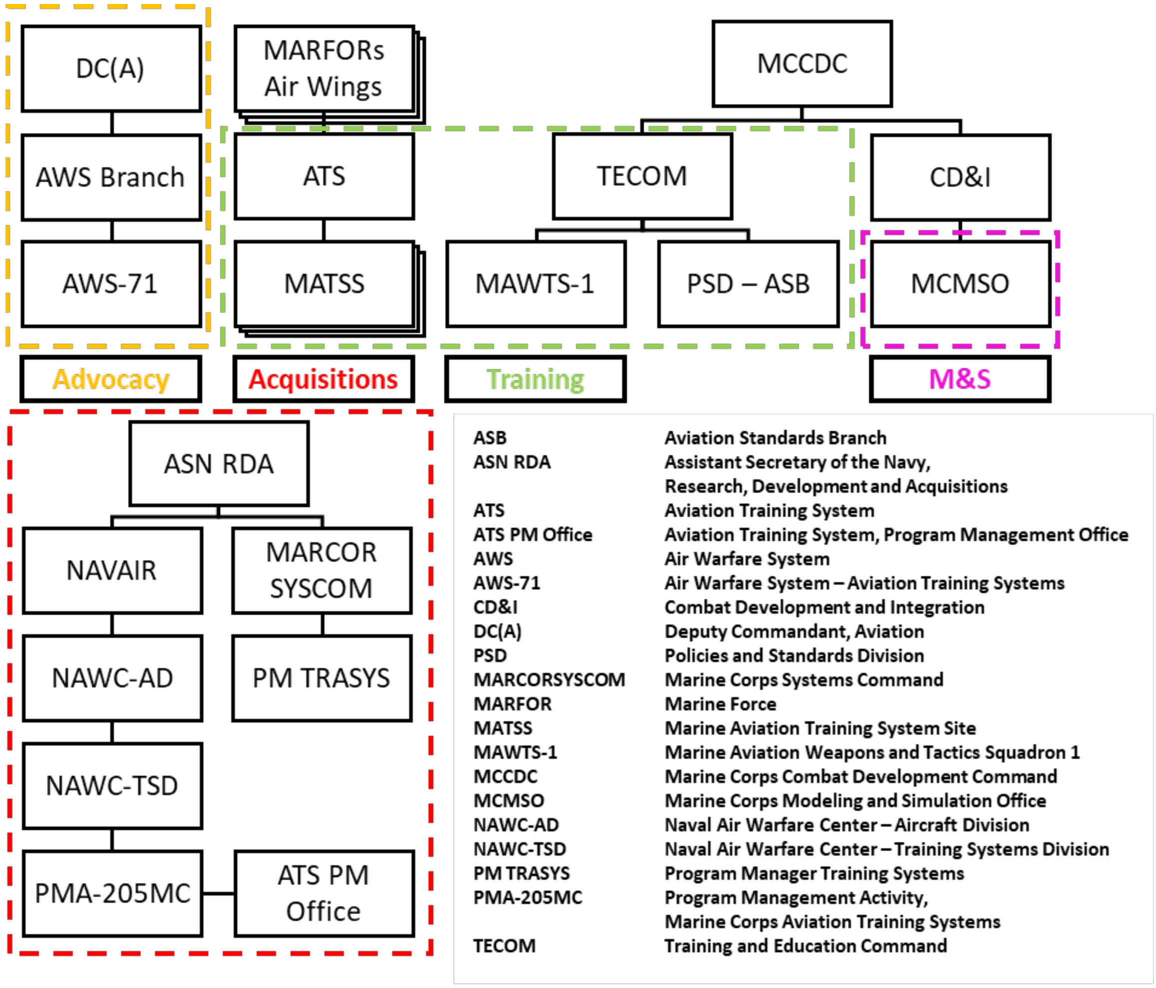

Figure 1. Marine Corps Aviation Training Systems Stakeholder Landscape

1. Aviation Advocacy

Marine Corps aviation advocacy resides at Headquarters Marine Corps (HQMC) Aviation under the leadership of the Deputy Commandant for Aviation (DCA). The DCA "serves as the principal advisor to the Commandant [of the Marine Corps] on all aviation matters" and serves as the primary spokesperson of Marine Corps aviation programs, requirements, and strategy throughout the Department of the Navy and the Department of Defense (Headquarters Marine Corps [HQMC], n.d.b). Figure 2 shows the organizational structure of HQMC aviation.

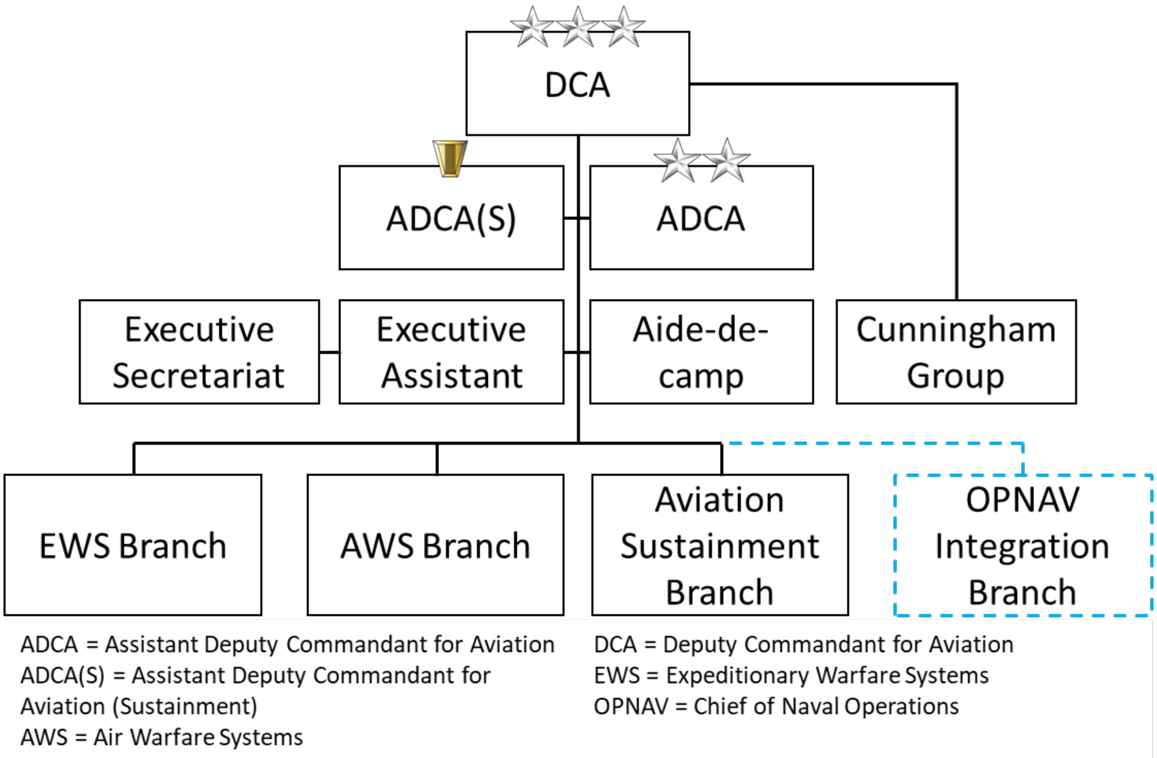

Figure 2. HQMC Aviation Organizational Structure.
Adapted from HQMC (2022a).

Under the DCA are warfare systems branches headed by Marine Colonels or civilian equivalents who "provide life cycle management of capabilities for Assault Support, TACAIR, Unmanned and Expeditionary Enabler systems and programs" (HQMC, 2022). Under these branches are individual offices led by action officers (AO) for each community. Most of these AOs are active-duty O-4 or O-5 officers from the primary military occupational specialty (PMOS) they represent. They typically have strong operational backgrounds serving in their PMOS and do not have acquisitions experience. They are responsible for fielding needs from fleet end-users that ultimately become requirements for acquisitions activities.

One office that differs, and is the focus of this paper, is the Air Warfare Systems 71 (AWS-71) led by a senior GS civilian with extensive experience and credentials in program management and M&S. AWS-71 is responsible for all Marine Corps Aviation Training Systems. With few exceptions, like the joint strike fighter, AWS-71 serves as the action officer (AO) for all Marine Corps aviation simulators. Incidentally, the officer who leads AWS-71 concurrently serves as the lead for Program Management Activity 205 Marine Corps (PMA-205MC), the activity responsible for all Marine Corps aviation training systems. More details on PMA-205MC and training systems acquisitions will be provided in Section 3 of this chapter.

While these action officers interface directly with fleet squadrons and HQMC to determine needs, they do not compose or certify requirements themselves. Marine Corps Combat Development Command (MCCDC) serves as the requirements certification authority for all Marine Corps systems, centralizing requirements generation expertise in a single location and ensuring requirements are not duplicated across the Marine Corps. This includes standard aviation training systems that are part of the larger aircraft programs of record.

It is important to note that changes and upgrades to currently fielded training systems are not certified at MCCDC. According to Mr. Gustavo Gierber, director of PMA-205MC, these requirements fall below that certification threshold, being generated and certified by individual program offices without the cognizance of MCCDC (interview with author, April 28, 2021). As a result, the integrating actions of MCCDC are not utilized by individual program offices generating divergent requirements that lack consideration for interoperability, economy of effort, and technical standardization.

2. Training

The command responsible for training and educating the Marine Corps is Training and Education Command (TECOM). TECOM's mission is to lead

> the Marine Corps Training and Education continuum from individual entry-level training, professional military education and continuous professional development, through unit, collective, and service-level training in order to produce warfighters and enhance warfighting organizations that enable the Fleet Marine Force (FMF) to build and sustain the combat readiness required to fight and win today and in the future. (HQMC, 2022c)

For decades, TECOM was a subordinate command under MCCDC, but in August 2020, TECOM was elevated to a three-star level command and separated from MCCDC.

MCCDC is responsible for designing and resourcing the future Marine Corps and TECOM is responsible for training and educating the Marines who will execute that vision.

One of the many divisions of TECOM, the Policy and Standards Division (PSD) is responsible for developing doctrine and executing policy, standards, and assessments that provide the framework for Marine Corps training and education. PSD manages the review, update, and revision of Training and Readiness standards, supporting emerging training requirements as necessary. Training and Education Officers, Military Occupational Specialty (MOS) 8802, act as subject matter experts in adult learning theory, curriculum development, instructional development and design, assessment, and instructional technique. These officers oversee the systems approach to training (SAT) and Instructional Systems Development (ISD) specialists who work on various training and education programs. Lastly, the Aviation Standards Branch of PSD is responsible for developing, reviewing, updating, and revising Training & Readiness (T&R) standards in accordance with the SAT, as well as ensuring that individual community T&R manuals comply with governing policies.

Regarding the development of training syllabi, there are two additional stakeholders. Marine Aviation Weapons and Training Squadron One (MAWTS-1) is a subordinate unit of TECOM and is responsible for developing training syllabi for each aviation community, defining training tasks, environment (i.e., aircraft versus simulator versus academic instruction), and performance standards that must be achieved to provide ready forces. The other stakeholder is the Aviation Training System (ATS), which is assigned to each Marine Air Wing. ATS integrates and coordinates policy, manpower, equipment, facilities, and fiscal requirements for training Marine Aviation officers and enlisted personnel in the FMF. ATS works closely with MAWTS-1, TECOM, and HQMC to oversee the Training Management Process (TMP). The TMP is Marine Corps Aviation's need-based requirements generation process and will be discussed in detail in the requirements generation section of the background. Under the ATS structure are numerous Marine Aviation Training System Sites (MATSS), which are responsible for providing access to aviation simulators for fleet units. ATS is staffed by highly qualified, second-tour officers and enlisted instructors who act as SMEs for their communities in developing requirements for training systems.

The process of generating a T&R manual is a decomposition of high-level mission essential tasks (METs) into individual skills required in combat and subsequently designing a syllabus of events to fulfill the training requirements of those individual skills, complete with performance standards to demonstrate proficiency. MCCDC assigns each community several METs they are responsible for accomplishing. The Aviation Standards Branch (ASB) within PSD provides a standardized framework for the individual skills that collectively accomplish the METs assigned to that unit. This framework is governed by NAVMC 1553.1A Marine Corps Instructional Systems Design/Systems Approach to Training and Education (MCISD/SATE) Handbook and NAVMC 3500.14E Marine Corps Aviation Training and Readiness Program Manual. These orders direct the application of ISD and SATE concepts and ensure standardization across diverse communities. MAWTS-1 instructor pilots serve as the T&R model managers for their specific platform, developing the training syllabi composed of multiple training events to build proficiency in each of these METs. These events range from prescribed readings to classroom instruction, simulator events, and flight events. These syllabi are then combined to comprise the T&R manual. While not trained in ISD or SATE, these instructors are among the very best in their communities, leveraging years of experience working within their specific T&R to inform iterative changes every two years.

3. Acquisitions

This section will provide an overview of the acquisitions chain of command for the Navy and the Marine Corps. While this capstone applied project focuses on the requirements life cycle and not the acquisition of systems to fulfill those requirements, it is important to appreciate how acquisitions for Marine Corps ground and aviation training systems are isolated from each other.

Common to both acquisitions commands is the Assistant Secretary of the Navy, Research, Development, and Acquisition (ASN RDA) who is “responsible for the development and acquisition of Navy and Marine Corps platforms and weapons systems”

(Department of the Navy [DON], 2022a). Below this node, Marine Corps aviation and ground training systems are split between Naval Air Warfare Systems Command (NAVAIR) and Marine Corps Systems Command (MARCORSYSCOM) respectively.

a. Naval Air Warfare Systems Command

NAVAIR provides "full life-cycle support of naval aviation aircraft, weapons, and systems operated by Sailors and Marines. This support includes research, design, development and systems engineering; acquisition; test and evaluation; training facilities and equipment; repair and modification; and in-service engineering and logistics support" (DON, 2022b). Marine aviation falls under this umbrella as do the accompanying training systems and facilities. Within NAVAIR are several divisions, one of which is the Naval Air Warfare Center Aircraft Division (NAWCAD) which houses the Naval Aviation Training Systems and Ranges program office (PMA-205). PMA-205 "provides full life cycle acquisition of naval aviation platform and general training systems, training range instrumentation systems, and distributed mission training centers to provide U.S. Navy and Marine Corps pilots, naval flight officers, aircrew, and maintainers with the training equipment required to provide lethal capability and operational readiness" (DON, 2022c). PMA-205 Marine Corps (PMA-205MC) is specifically responsible for Marine Corps systems, serving as the single point of program management for all aviation training systems.

b. Marine Corps Systems Command

Marine Corps Systems Command (MARCORSYSCOM) serves as "the acquisition command of the Marine Corps. MARCORSYSCOM exercises contracting and technical authority for all Marine Corps ground weapon and information technology programs." (HQMC, 2022d). Marine Corps specific programs ranging from the amphibious combat vehicle (ACV) to small arms fall under MARCORSYSCOM. Included within MARCORSYSCOM is program manager training systems (PM TRASYS), responsible for "providing training support, and developing and sustaining training systems and devices" (HQMC, 2022e). While PM TRASYS is only responsible for Marine Corps ground training systems, they coordinate with ATS via the Marine Corps ATS Program Manager (MC ATS

PM) and their deputies. This relationship is for coordination only and is non-authoritative in either direction.

4. Modeling and Simulation

Department of Defense Directive (DoDD) 5000.59 - DOD M&S Management directs the head of each DOD component to, "Implement management processes that provide visibility and access to component-level M&S programs and activities" (Department of Defense [DOD], 2018). This was done, among other things to, "Maximize the commonality, reuse, interoperability, efficiencies, and effectiveness of Component-specific M&S data, tools, and services" (DOD, 2018). To meet this requirement, the Marine Corps established the Marine Corps Modeling and Simulation Office (MCMSO) to better manage and coordinate diverse M&S activities across the Marine Corps. This section outlines the management structure for Marine Corps M&S as directed by Marine Corps Order 5200.28A. The Marine Corps M&S management structure is outlined in Figure 3.

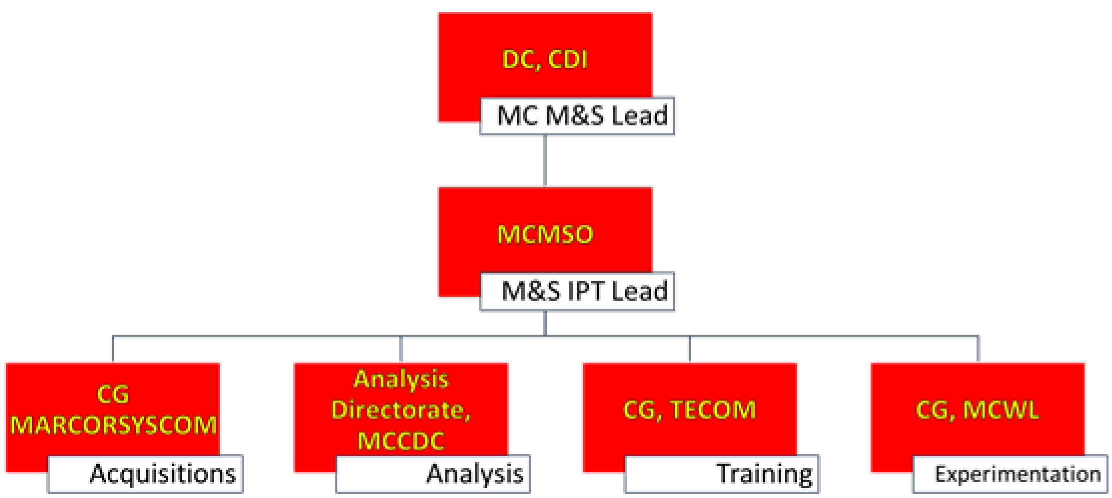

Figure 3. Marine Corps Modeling and Simulation Management Structure. Adapted from Commandant of the Marine Corps (2014)

a. Deputy Commandant, Combat Development and Integration

The Deputy Commandant for Combat Development and Integration (DC, CD&I) is designated as "the senior Marine Corps representative for DOD, Joint, and Navy M&S flag level forums" (Commandant of the Marine Corps [CMC], 2014). While overall responsibility for Marine Corps M&S lies with DC, CD&I, functional leadership falls to the Marine Corps Modeling and Simulation Office (MCMSO).

b. Marine Corps Modeling and Simulation Office

The MCMSO is designated by the DC, CD&I to head the Marine Corps M&S Integrated Process Team (IPT). Under the guidance of the MCMSO, the IPT works, "to promote interoperability, commonality, and reuse of Marine Corps M&S tools, data, and services" (CMC, 2014). In addition to these broad responsibilities, MCMSO serves as the occupational field sponsor for Marine Corps Modeling and Simulation Officers. These highly trained officers complete the Naval Postgraduate School Resident Modeling, Virtual Environment, and Simulation (MOVES) program, earning a Master of Science degree in MOVES and the additional military occupational specialty code of 8825. After completing the program, these officers serve in billets around the Marine Corps where their expertise drives M&S efforts. More details on the employment of M&S Officers will be provided after this section.

c. Marine Corps Modeling and Simulation Community Leads

MCO 5200.28A prescribes the four M&S communities shown in Figure 2 along with their respective leads. While the nature of M&S applications varies greatly across the communities, the responsibilities of the community leads remain the same. Among other tasks, they shall, "assign a representative to the Marine Corps M&S IPT. This representative shall coordinate all M&S requirements across their respective communities" (CMC, 2014). Additional tasking for the community lead includes, "work towards improving the interoperability, commonality, and reuse of Marine Corps M&S tools, data, and services" (CMC, 2014).

For the scope of this CAP, we will only look at the M&S training community led by the Commanding General of Training and Education Command (CG TECOM). The authority and responsibility for M&S training across all elements of the MAGTF lie with CG TECOM, but the day-to-day management is handled by Synthetic Training Integration and Management Branch (STIMB). However, TECOM has limited the scope STIMB's responsibility to non-standard ground systems, leaving the remainder of the Marine Corps M&S training community un-governed, including aviation training systems.

d. Modeling and Simulation Officers

Before closing this section on M&S, it is important to discuss how M&S Officers are employed, both in their initial utilization tour post-NPS graduation and later in their careers. The Marine Corps Military Occupational Specialty (MOS) manual describes M&S Officers as follows.

> Modeling and Simulation (M&S) Officers are the Marine Corps subject matter experts (SME) across the four pillars of USMC M&S: acquisition, analysis, experimentation, and training. As both managerial and technical SMEs, their recommendations to key decision makers can have Service level and national impacts. The M&S Officer is the *indispensable translator* of the commander's mission requirements and the details of the required critical technologies (CMC, 2019).

As stated above, M&S Officers are SMEs in all four M&S pillars (which mirror the M&S communities outlined by MCMSO) and serve in billets representing each. Table 1 displays the current Marine Corps billets where M&S officers are currently employed.

Table 1. FY22 Modeling and Simulation Officer Billet Laydown. Adapted from MCMSO, email to author, February 8, 2022.

Fiscal Year 2022 M&S Officer Billet Laydown

Billet	M&S Community	Location	Status
MCSC	Acquisitions	Quantico, VA	Filled
PM-TRASYS	Training / Acquisitions	Orlando, FL	Filled
TECOM RTPD	Training / Acquisitions	Quantico, VA	Filled
TECOM RTPD	Training / Acquisitions	Quantico, VA	Filled
TECOM G-5	Training	Quantico, VA	Filled
MSTP	Training	Quantico, VA	Filled
MAGTFTC	Training	29 Palms, CA	Filled
MCTOG	Training	29 Palms, CA	Filled
MCLOG	Training	29 Palms, CA	Filled
CE I MEF	Training	Camp Pendleton, CA	Vacant
CE II MEF	Training	Camp Lejeune, NC	Filled
EWTGLANT	Training	Virginia Beach, VA	Filled
EWTGPAC	Training	San Diego, CA	Filled
J7	Training / Analysis	Suffolk, VA	Vacant
OAD	Analysis	Quantico, VA	Filled
MCWL	Experimentation	Quantico, VA	Filled
ONR	Experimentation/ Acquisitions	Arlington, VA	Vacant

CE I MEF – Command Element 1st Marine Expeditionary Force
CE II MEF – Command Element 2nd Marine Expeditionary Force
EWTGLANT – Expeditionary Warfare Training Group Atlantic
EWTGPAC – Expeditionary Warfare Training Group Pacific G-5 – Future Plans
J7 – Directorate for Joint Force Development
MAGTFTC – Marine Air-Ground Task Force Training Command
MCLOG – Marine Corps Logistics Operations Group
MCSC – Marine Corps Systems Command
MCTOG – Marine Corps Tactics and Operations Group
MCWL – Marine Corps Warfighting Laboratory
MSTP – Marine Air-Ground Task Force Staff Training Program
ONR – Office of Naval Research
OAD – Operations Analysis Directorate
PM TRASYS – Program Manager Training Systems
RTPD – Range Training and Policies Division
TECOM – Training and Education Command

While all four M&S communities are present, M&S training is the most highly represented, accounting for 13 of the 17 M&S Officer billets. What is harder to break out from the billet list is the division within the training community between ground and air training systems. *All 17 of the M&S Officer billets for training serve ground training systems, leaving zero M&S Officers to serve aviation training systems requirements development and acquisition activities.* Regarding utilization tours, there is only a requirement to perform one three-year utilization tour after earning the 8825 MOS. While

M&S Officers may request to serve another tour in an M&S billet, this is not a requirement or a guarantee, leaving these highly impactful skills under-utilized later in their career.

B. REQUIREMENTS GENERATION

The Marine Corps' needs-based requirements generation process for aviation training systems is the Training Management Process (TMP) and is governed by MCO 3710.6A "Aviation Training Systems." This process is overseen by TECOM, a 3-star command that reports directly to the Commandant of the Marine Corps. The TMP is multi-tiered with a wide range of stakeholders and will be explored in detail in this section.

MCO 3710.6A describes the TMP as follows.

> The TMP is intended to identify specific training issues, derive common training issues among platforms/communities, explore common solutions to these issues, identify funding resources for high-priority issues, and resolve those issues determined to be requirements. The TMP is executed by military members and government civilians, with responsibility for validation, prioritization, and impact assessment of training system issues. (CMC, 2011)

The composition of the TMP is displayed in Figure 4. The TMP starts with end-user SMEs generating a prioritized list of needs. These community-specific lists are ultimately integrated with other communities to form a common list of prioritized issues. These issues are then matched with doctrine, organization, training, material, leadership and education, personnel, and facilities (DOTMLPF) solutions and sent to an executive level who prioritizes and obtains funds. In the following section, we will explore the individual elements that comprise the greater TMP.

Figure 4. Training Management Process. Adapted from CMC (2011).

1. Training Management Teams

The first step of the TMP involves military and civilian SMEs generating prioritized lists of needs as part of a group known as the Training Management Team (TMT). The TMT is a tiered process, with individual communities executing a TMT that then feeds into the overarching ATS TMT.

The goal of the community TMT is to identify and prioritize community-specific training issues across the DOTMLPF spectrum. The community TMT consists of several voting members. First, the syllabus sponsor (typically MAWTS-1) advocates for training resources in the context of the current training syllabus defined by the community T&R manual. Second, the community model manager advocates for resources needed to train post-accession pilots in their newly-assigned platform. Typically, these are representatives from the community's fleet replacement squadron (FRS). Lastly, fleet representatives from operational wings advocate for training resources needed to train pilots in operational flying squadrons after their initial training in the FRS. Non-voting members from TECOM Aviation Training Division (ATD), Marine Aviation Training System Site (MATSS), and a Community Procurement Agent (acquisition professional) help guide the TMT, provide updates on previous TMT outputs, and consolidate outputs. The typical output from the TMT is a "top ten" list of requirements.

Outputs from the community TMTs are forwarded to the ATS TMT, a senior TMT that bridges the community TMTs to the ATS Integration Group. "The ATS TMT identifies

ATS-specific issues, consolidates all community/platform-specific TMT issues, and derives potential common issues for further vetting" (CMC, 2011). Members of the ATS TMT are the TECOM ATD, Training Management Branch Head (chair), as well as representatives from NAVAIR PMA-205MC, MARCORSYSCOM PM TRASYS, PEO Land Systems, MAW ATS Directors, HQMC AVN, and NAWC-TSD. Issues identified as common proceed from the ATS TMT to the next level of the TMP, the Integration Group (IG).

It is important to note that community TMT items that are not identified as common undergo no further staffing within the construct of the TMP. These community-specific TMT items feed into the requirements processes of that individual community's NAWC-TSD office. There are no prescribed processes for these offices to analyze prospective solutions against T&R gains to determine a relative return on investment, leaving the acquisitions activities to select options with no further end-user coordination.

2. Integration Group

The ATS Integration Group is comprised of three levels: integration level (IL), advisory level (AL), and executive level (EL) which has an upper and lower tier.

The IL "conducts feasibility analysis, validates solutions, and forwards recommendations to the AL to support issue refinement, cost estimates, and POM submissions" (CMC, 2011). At the IL, engineering leads across differing functional areas (visual, software, logistics, etc.) along with ISD personnel conduct this analysis including a rough order of magnitude cost estimate, and deliver it to the AL. This difficult task is conducted by engineers and ISD personnel without any further coordination with the end-user and without uniformed M&S expertise to advise.

At the AL, issues are further refined, cost estimates are completed, and POM submissions are made. The Advisory level serves as the coordination effort between action officers and the O-6 level and acts as the advocate for all TMT issues to the Executive Level. Additionally, the AL is explicitly tasked with coordinating requirements definition, a daunting task for complex aviation training systems, especially without the aid of end-users or M&S officers participating.

The Executive Level is divided into two tiers, a lower tier comprised of TECOM and HQMC Aviation branch heads, and an upper tier consisting of the DCA and CG, TECOM. The most critical among the EL's responsibilities is to validate or establish requirements for aviation training systems.

Once approved at the TMT Executive Level, a list of approved specific TMT issues is released via naval message. This tiered approach is intended to bring common issues together and develop common solutions across the greater ATS community to maximize benefits to the warfighter. These common and individual issues are funded through various streams that were identified by the AL during the TMP and the acquisitions of those systems are turned over to various program management activities. Most common issues are managed by PMA-205MC and their subordinate activities NAWC-TSD with many involving considerable coordination with the platform PMA (H-1, MV-22, etc.) for integration.

The TMP is a bottom-up process that facilitates the flow of validated needs from end-users to HQMC, who ultimately provides funding for those requirements. Community-specific TMTs generate prioritized lists of requirements that feed into the greater ATS TMT, where opportunities for cross-community solutions are explored. Validated and prioritized requirements are then pushed to a multi-tiered integration group, where technical solutions are explored, selected, and resourced. The TMP employs not only acquisition professionals and decision-makers, but highly qualified end users that ultimately have a large voice in the requirements generation process.

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III. ANALYSIS AND RECOMMENDATIONS

In this section, an analysis of the requirements life cycle will be provided focusing on the two primary areas for improvement: training-focused requirements generation and portfolio management. Each topic will include a description of the problem, an analysis of root causes, and recommendations to address each shortfall.

A. TRAINING-FOCUSED REQUIREMENTS GENERATION

1. Problem Description

The Marine Corps' current needs-based requirements generation process produces under-informed requirements in a haphazard manner that fails to capitalize on training opportunities afforded by modern training systems. Community T&R manuals are adapting to match the capabilities of fielded training systems when the opposite should be true. T&R manuals articulate the training needs of a community and should be the driving force behind the development and upgrades of supporting training systems.

2. Analysis

Deficiencies in the current needs-based requirements generation process fall generally into two categories. First, is a shortfall in uniformed M&S expertise. The second is an absence of an empirical process to derive requirements from a community T&R manual for new training systems with continuing assessments for upgrades. Both of these deficiencies and their impacts will be discussed in detail.

First, while stakeholder representation is present for end-users and program management activities, there is a critical shortfall in M&S expertise to bridge the two. As outlined in the TMP, M&S Officers and MCMSO are not involved at any point. For issues identified as common in the TMP, this absence is felt most intensely at the IL of the TMP where engineers and ISD personnel must select candidate solutions for feasibility analysis without uniformed M&S expertise. Because of this, feasibility analysis may be conducted using solutions that are not suitable for the end-user needs, or conversely, suitable solutions may be excluded due to similar misunderstandings. This M&S expertise gap is experienced again at the AL where requirements coordination is conducted. The AL is comprised of AWS-71, PMA-205MC, and the TECOM ATD branch head. These offices are far removed from the needs of the end-user and unable to navigate the nuances of suitability and effectiveness needed to clearly articulate requirements. M&S Officers involved in the process from the outset would have both the expertise and the background knowledge on these issues to fill this gap.

Second, the TMP lacks an empirical process used to analyze training needs objectively, resulting in scattershot requirements that are generally suboptimal in terms of return on investment. Community TMTs incorrectly focus on incrementally improving fielded training systems, prescribing technical solutions they want rather than defining the training capabilities they need, trusting the program management activities to deliver. These prescriptive solution requests are delivered from the community TMT to the program management activities without clearly defined needs or purposes, leaving program managers, ISD personnel, and engineers to "reverse-engineer" the training requirement they are tasked to support. This role reversal with end-users defining solutions and program management activities defining requirements yields training systems that are unfocused on the actual training needs of that community. Insidiously, the opportunity costs of superior solutions are unknown because end-users are ignorant of the training opportunities the M&S industry has to offer. Because the opportunity cost is unknown, the incentive to change the current needs-based requirements generation process goes unrealized.

3. Recommendations

Recommendations fall into two general lines of effort. The first is to incorporate M&S expertise in the TMP. The second is to incorporate empirical processes to ensure requirements are derived from training needs.

a. Integrate M&S Expertise into the TMP

M&S expertise should be integrated into the TMP via three mechanisms: MATSS staff members earning M&S certificates from NPS, allocating an 8825 billet to the ATS

PM office, and integrating MCMSO with the AL of the TMP. The three mechanisms will be discussed in greater detail.

MATSS staff members should complete an M&S certificate program through NPS distance learning (DL). Both authors of this CAP have served as operations officers at MATSS Camp Pendleton and can state with authority the billet offers the time and flexibility needed to complete a one-year certificate program. The education would deliver immediate value to the TMP process, enabling the MATSS staff members to serve as better informed SMEs during the individual TMT. By selecting a one-year DL certificate program specifically, MATSS staff members will apply their education in stride with classes and still have one to two years remaining in the MATSS billet. Currently, the Modeling, Virtual Environments, and Simulation (MOVES) Institute at NPS does not offer an M&S certificate program via the DL format. A focused certificate program will capitalize on the "left side of the learning curve" in this discipline while preserving the limited capacity for M&S Officer production for more highly specialized 8825 billets.

An additional 8825 M&S Officer billet should be added to the structure of the ATS PM office. This 8825 should be a Marine Aviator to capitalize on a natural understanding of the end-user and would participate in all levels of the TMP, including the community TMTs. Having 8825 expertise in the room during the community TMTs would enable end-users to compose informed need statements that capitalize on current and emerging technologies. The 8825 would not drive requirements generation but would shape needs statements into definable requirements for which solutions exist. Additionally, by having the same 8825 attend all community TMTs, that individual gains a genuine awareness of the common themes across the community TMTs. This awareness as the *indispensable translator* is a critical enabler during the ATS TMT where common issues are derived for solution vetting. As pointed out in the TMP Background section, the only agency that participates in both the Community TMTs and the ATS TMT is TECOM ATD, so having this other source of continuity, as well as cross-functional expertise, is essential.

As the TMP transitions from the ATS TMT level into the IG at the IL, the 8825 continues to add value. The IL is where need statements are initially matched with technical solutions for suitability analysis. Failure to curate a list of suitable and effective solutions for later selection at higher levels of the TMP poses a significant risk to end-user outcomes. As pointed out in the background section for the TMP, engineering and ISD expertise is heavily represented, but M&S expertise is absent. Because 8825s are both managerial and technical SMEs, their advice during this "editing" phase ensures that the technical solutions best match the end-user need while engineering and PM SMEs provide realistic estimates for feasibility and cost.

Another source of M&S expertise to integrate into the TMP is the MCMSO itself, including a representative from MCMSO at the AL of the TMP IG. At the AL of the TMP, the MCMSO mission "to promote interoperability, commonality, and reuse of Marine Corps M&S tools, data, and services" aligns well with the AL task of requirements definition (CMC, 2014). MCMSO's expertise and awareness of adjacent Marine Corps M&S communities, in addition to Naval and Joint M&S communities, ensure the TMP produces well-informed requirements.

b. Incorporate Empirical Processes into Requirements Generation

Training Systems Certification (TSC) and the Systematic Team Assessment of Readiness Training (START) tool are two inter-related, empirical processes that will improve requirements generation for Marine Corps aviation training systems. TSC is the overarching process for evaluating and certifying a training system and the START tool is how TSC is accomplished. Both TSC and START will be described in detail.

Training System Certification (TSC) is mandated by MCO 3710.6A, Marine Corps Aviation Training System. The order states, "to ensure fielded training systems are capable of delivering relevant training, the TSC process will ensure not only that the systems work as designed, but also that they support T&R event execution through an Operational Evaluation (OPEVAL)" (CMC, 2011). To this end, the TSC process was developed by the ATS PM office as a means for accomplishing the TSC task as directed above. In the context of our recommendation, START fulfills the OPEVAL requirement. The ATS PM office is ideally suited to be the lead for TSC, with their expertise in training system acquisitions and their close working relationship with NAWC-TSD. Figure 5 is a visual depiction of the TSC process.

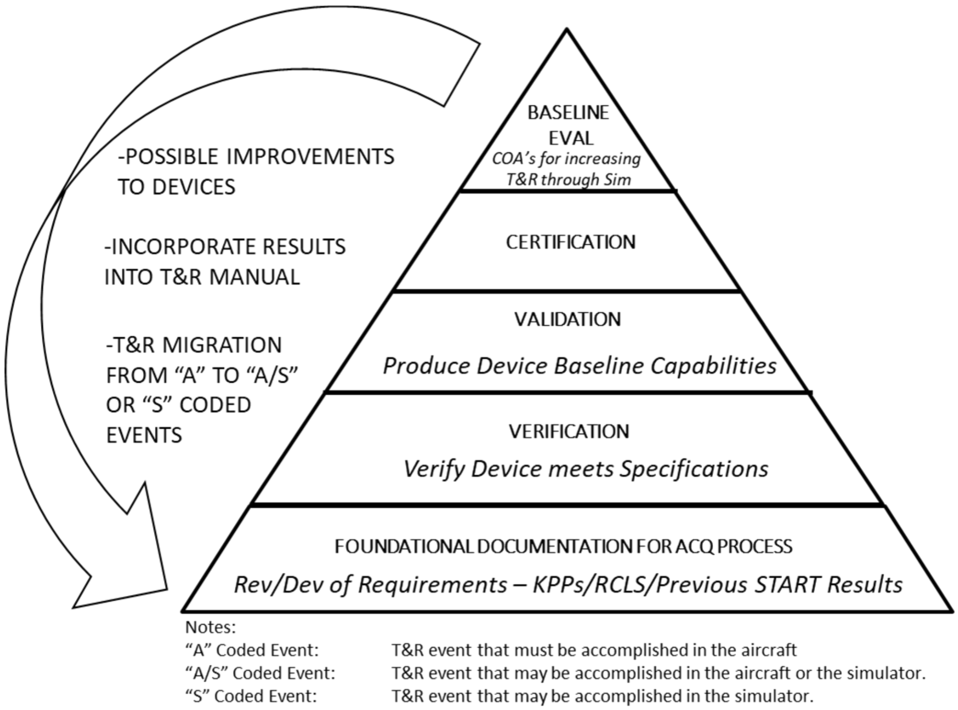

Figure 5. TSC Process. Adapted from K. Stark, email to author, March 5, 2020.

To execute TSC, "tiger teams" consisting of Marines and civilians from the MC ATS PM office and NAWC-TSD would travel to device locations to evaluate individual simulators. A proposed tiger team composition is outlined in Figure 6. These teams would consist of ISD leads and ISD analysts from the ATS PM office and systems engineers from NAWC-TSD.

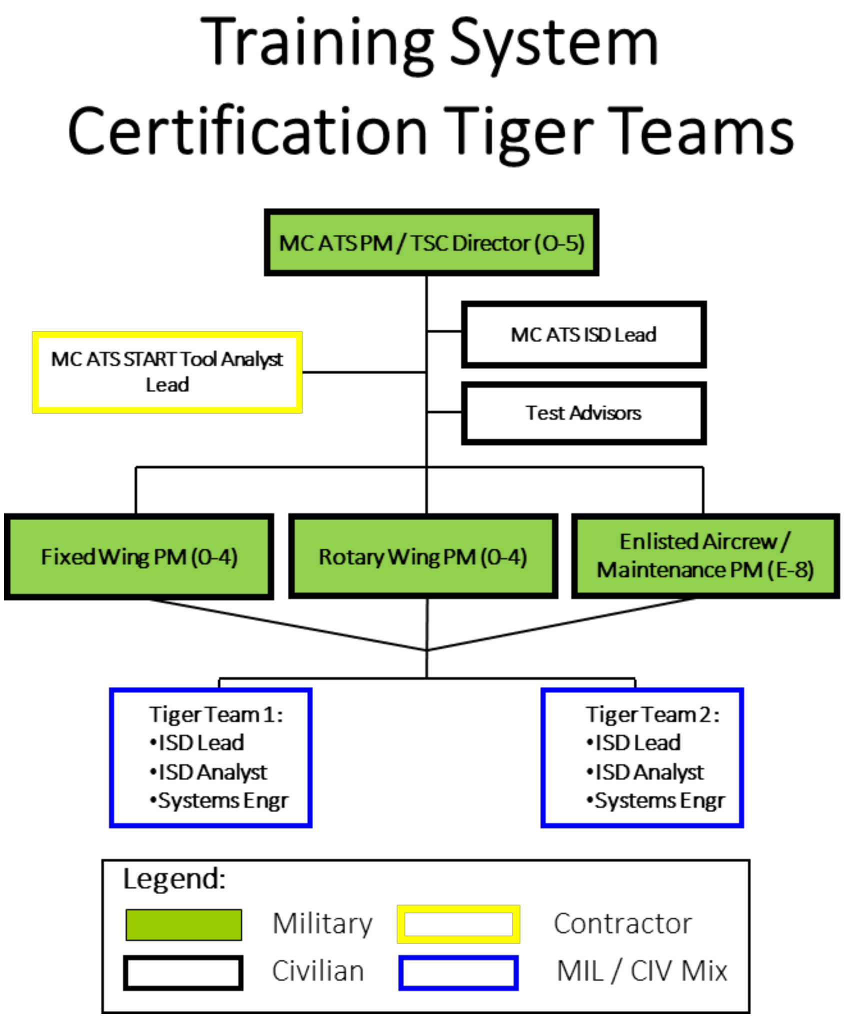

Figure 6. Proposed Training System Certification Tiger Team. Adapted from K. Stark, email to author, March 5, 2020.

On-site, these tiger teams would join forces with experienced pilots who would assist in TSC execution. The nominal candidates would be MATSS staff who possess both the expertise in their aircraft and as well as the simulator. Together, the tiger teams and their T/M/S SMEs would use the START tool to conduct a baseline analysis to prepare data for a three-step process of verification, validation, and certification (VV&C). Verification ensures that the device meets the specifications during acquisitions delivery. Validation ensures that the device satisfies its intended purpose. Certification is then conducted by an authoritative body, confirming the system can be used for its intended purpose. It is important to note that VV&C is a Marine Corps specific and training-oriented process that seeks to confirm that a device is capable of delivering the required training value to its end-users and should not be confused with verification, validation, and accreditation (VV&A) which is a separate M&S process designed to ensure that an M&S tool can be employed across the DOD. With the TSC process and tiger teams described, a detailed description of how START is implemented will be provided.

START was developed in 2011 by Aviation Programs and Weapons 71 (APW-71, now AWS-71) in coordination with efforts to upgrade the Marine Corps' CH-53E simulators across multiple MATSS locations. The goals of the START process are 1) to assess a simulator's current ability to support T&R events, and 2) to provide the PM with quantitative data to inform objective decision-making on simulator requirements, acquisitions, and upgrades. START is also an iterative process, developing recommendations for simulator upgrades after the initial START baseline is established.

This paragraph will describe the START process by describing the six steps outlined in Figure 7. START begins with step one, decomposing T&R events of a T&R manual into individual tasks that must be accomplished. With a master task list generated in step one, individual tasks are "mapped by criticality" in step two. To map by criticality, individual tasks are analyzed to quantify how many T&R events are impacted by the completion of each one, with the tasks that impact the greatest number of T&R events being designated as most critical. It is important to note that all T&R events are analyzed in this step, not just events that are designated for completion in the simulator. By including "aircraft" designated T&R events, opportunities to expand simulator usage to additional T&R events can be analyzed as well.

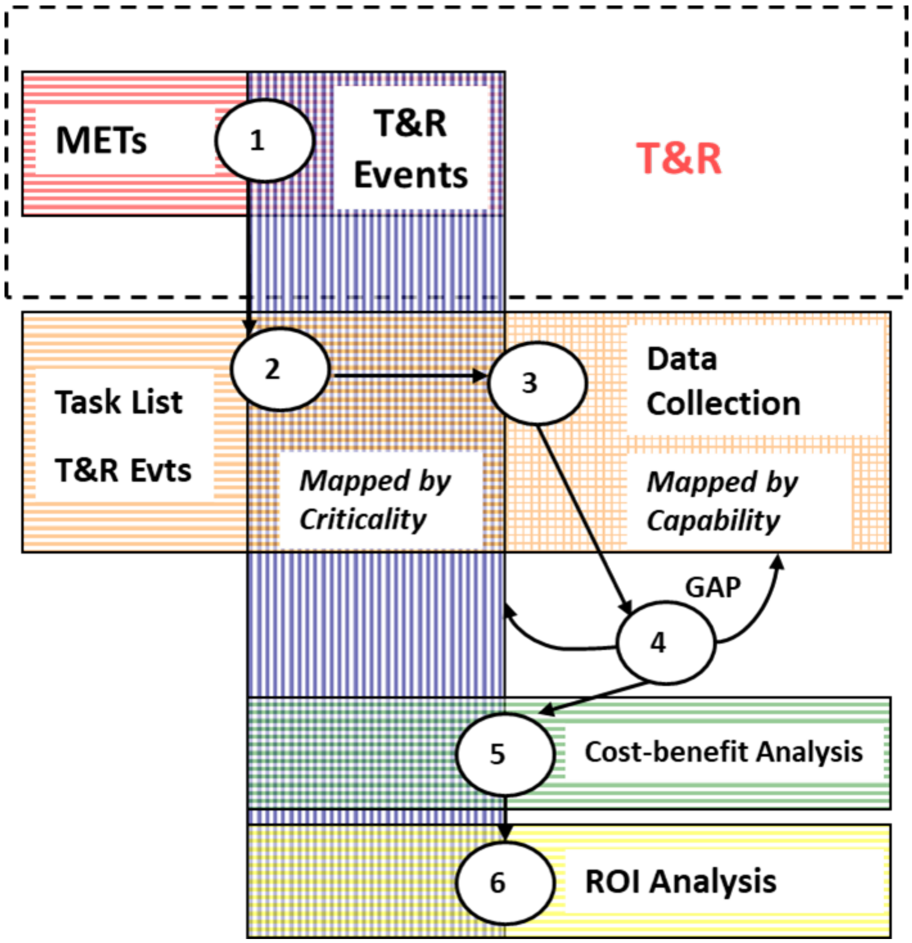

Figure 7. START Tool. Adapted from K. Stark, email to author, March 5, 2020.

Step three is the data collection phase where the simulator's ability to fulfill the training needs for each training task is analyzed. This step is time-intensive, requiring dozens of hours in the simulator to analyze the suitability and effectiveness of the training device against each task. The outputs, however, are exhaustive and yield quantitative data needed in step four.

Step four is gap analysis where shortfalls in simulator capabilities are correlated with task criticality to identify root causes for shortfalls in training utility, enabling step five. Step five is course of action (COA) development, where root causes can be matched with technical solutions. During this step, technical risk and rough order of magnitude (ROM) cost-estimates are calculated. Most importantly, because root causes have been cross-linked against task criticality, training benefits can be quantified and associated with each of these COAs. Empowered with a comprehensive understanding of each COA (cost, technical risk, and training benefit), a quantitative return on investment (ROI) analysis is conducted in step six. Ultimately, the outputs produced by START are a list of recommended upgrades (existing simulators) or capabilities (new devices) that the PM should focus their budget and efforts on to maximize return on investment.

Figures 8 and 9 show example outputs from the START tool utilized during the CH-53E simulator upgrade effort in 2011. Figure 8 shows the current status of the device as it relates to its ability to accomplish specific tasks from the CH-53E T&R manual. The "Code" column specifies a single training event, "Event Platform" denotes whether it is accomplished in a simulator ("S") or an aircraft, and the "Number Tasks" states how many individual tasks are associated with that event. Columns to the right are associated with specific training devices ("APT" and "WST") at different training sites. Boxes beneath communicate the percentage of tasks a device can support for a given training code. Green boxes show a device that is capable of completing most (>75%) of a required task list for a given event, while boxes that are orange or red can accomplish few (<25%) or none of the tasks. These tasks are analyzed for the root cause of their specific shortfall and recommendations are made for upgrades (such as functionality, aero model, visuals, etc.) that result in a maximization of simulator capabilities for the lowest cost. Figure 9 displays predicted increases in performance resulting from upgrade implementation, with notable increases in device training utility across every single task category and T&R event.

CH-53E START ANALYSIS BASELNE - NO UPGRADES							
Percentage of Codes Supported			100%	>75%	>50%	≥25%	<25%
		Sites	MCAS New River		MCAS Miramar		MCAS Futenma
Code	Event Platform	Number Tasks	APT	WST	APT	WST	APT
100	S	3	67%	33%	33%	33%	67%
101	S	11	45%	54%	9%	54%	36%
102	S	15	40%	47%	7%	47%	27%
103	S	18	34%	40%	6%	40%	23%
104	S	19	38%	43%	11%	43%	27%
105	S	23	32%	44%	9%	44%	23%
106	S	23	32%	44%	9%	44%	23%
107	S	9	13%	54%	13%	54%	13%
110		9	56%	56%	22%	56%	33%
111		13	46%	54%	16%	54%	39%
112		17	47%	53%	12%	53%	36%
113		20	41%	46%	11%	46%	31%
114		22	38%	46%	10%	46%	29%
115		22	38%	46%	10%	46%	29%
116		22	38%	46%	10%	46%	29%
117		22	38%	46%	10%	46%	29%
118		22	38%	46%	10%	46%	29%
119		22	38%	46%	10%	46%	29%
120		15	42%	53%	14%	53%	28%
121		19	36%	61%	12%	61%	30%
122		17	38%	59%	13%	59%	25%
130	S	15	68%	74%	49%	74%	63%
131	S	13	71%	70%	49%	70%	57%
132	S	16	70%	75%	46%	75%	65%
133	S	15	67%	74%	43%	74%	62%
134	S	19	70%	80%	55%	80%	66%
135		16	58%	64%	40%	64%	54%
136		14	64%	69%	41%	69%	50%
137		14	66%	72%	46%	72%	53%
138		20	72%	76%	58%	76%	63%

Figure 8. Example START Analysis – Original Baseline Capability. Adapted from K. Stark, email to author, March 5, 2020.

CH-53E START ANALYSIS Upgrade Functionality, Aero Model, Auditory, Visual, & Physical Look and Feel (A4, A5, A6, A20, A14, 15, A16, A7, A8, A9, A10, A11, A1, A2, & A3)							
Percentage of Codes Supported			100%	>75%	>50%	≥25%	<25%
		Sites	MCAS New River		MCAS Miramar		MCAS Futenma
Code	Event Platform	Number Tasks	APT	WST	APT	WST	APT
100	S	3	100%	100%	100%	100%	100%
101	S	11	82%	82%	72%	82%	72%
102	S	15	80%	80%	67%	80%	67%
103	S	18	72%	72%	61%	72%	61%
104	S	19	74%	74%	63%	74%	63%
105	S	23	70%	74%	61%	74%	61%
106	S	23	70%	74%	61%	74%	61%
107	S	9	68%	90%	68%	78%	68%
110		9	89%	89%	78%	89%	78%
111		13	84%	84%	76%	84%	76%
112		17	82%	82%	70%	82%	70%
113		20	80%	80%	70%	80%	70%
114		22	73%	77%	64%	77%	64%
115		22	73%	77%	64%	77%	64%
116		22	73%	77%	64%	77%	64%
117		22	73%	77%	64%	77%	64%
118		22	73%	77%	64%	77%	64%
119		22	73%	77%	64%	77%	64%
120		15	82%	94%	75%	87%	75%
121		19	85%	90%	79%	90%	79%
122		17	84%	89%	78%	89%	78%
130	S	15	87%	87%	82%	87%	82%
131	S	13	85%	85%	79%	85%	79%
132	S	16	88%	88%	83%	88%	83%
133	S	15	87%	87%	82%	87%	82%
134	S	19	90%	90%	86%	90%	86%
135		16	93%	93%	88%	93%	88%
136		14	85%	85%	79%	85%	79%
137		14	92%	92%	86%	92%	86%
138		20	90%	90%	86%	90%	86%

Figure 9. Example START Analysis – Implementation of All Upgrades. Adapted from K. Stark, email to author, March 5, 2020.

It is important to emphasize that there is a broad range of use-cases for START analysis. The example above evaluated a currently fielded simulator as part of its TSC and was also used to predict the effectiveness of potential upgrades. START would also be used to confirm the effectiveness of the upgrades after they are fielded, being nested in another iteration of the TSC process. An additional use-case where START analysis would be useful is generating requirements for a new-build simulator based on a baseline from an existing one. A good example would be the CH-53K (the latest variant of the CH-53E). While the CH-53K aircraft will have different user interfaces, the METs remain unchanged from the CH-53E, meaning many of the training requirements will remain the same. Therefore, a baseline of the currently fielded CH-53E simulators would serve to inform requirements generation for the CH-53K simulator.

At the time of the writing of this paper, no consistent efforts have been made or funded across the Marine Corps to resource and execute these data-driven processes. Baseline assessments of all currently fielded simulators should be conducted before upgrading or fielding new devices. TSC tiger teams implementing the START tool can provide objective recommendations for upgrades that provide the highest return on investment, as well as inform community T&R conferences on recommended migrations of T&R events to the simulator as new capabilities are added. As a final justification, MCO 3710.6A mandates that TSC be completed for Marine Corps aviation training systems, which is not currently being accomplished.

B. PORTFOLIO MANAGEMENT

1. Problem Description

In a fiscal environment of flattening budgets, it is critical for military services to become more efficient and pursue alternative, less expensive means of training our forces. For the M&S training community, training system requirements must be synchronized across MAGTF to ensure the portfolio of training systems can share resources where possible. Additionally, the M&S training community needs to replace expensive live training evolutions that are confined to a finite number of ranges, aircraft and ordnance availability, and other limitations with collective simulation training. Collective training offers increased availability at a decreased cost once interoperability of training systems can be achieved.

The current hierarchy of stakeholders and their associated authorities do not support sufficient portfolio management to ensure efficient use of resources and training system interoperability. An analysis conducted by MCMSO describes the problem as follows.

> In the absence of a well-defined enterprise policy or M&S portfolio, the structure of the Marine Corps lends itself for each Deputy Commandant (DC) to establish policy within their span of control. An unfortunate side-effect of being a Service that is centered on a well-integrated Marine Air Ground Task Force (MAGTF) is those DC's spans of control overlap in key areas that directly affect M&S within the Marine Corps. Without a unified vision and consistent collaboration on M&S activities and capabilities, the Marine Corps risks well-meaning disparate efforts competing for limited resources, developing divergent capabilities, and creating obstacles to integration and interoperability. (Telford & Whittington, email to author, May 5, 2021)

2. Analysis

This problem is not new and there are several initiatives in various stages of implementation seeking to resolve this issue. Their characteristics and specific shortfalls will be discussed in detail.

a. Marine Corps Training Environment Master Plan

TECOM's Synthetic Training Management & Integration Branch (STIMB) has taken steps to achieve interoperability in publishing the Marine Corps Training Environment Modernization Plan (MCTEMP). Published in June 2020, the MCTEMP aims to, "integrate, Live, Virtual, and Constructive (LVC) training domains through modern technology supporting an immersive, realistic, all-domain training environment that supports all warfighting functions of the Active and Reserve components" (A. Lang, email to author, May 11, 2021). The MCTEMP is clear-eyed about the current state of Marine Corps training systems, stating, "Traditional systems only support a limited number of training events and the sporadic, opportunistic federation of these systems is expensive, inefficient, less than optimally effective and may result in negative training" (A. Lang, email to author, May 11, 2021). To resolve the interoperability issue, the MCTEMP aptly describes three lines of effort: Manage the Marine Corps Training Environment, Integrate LVC Training Capabilities, and Provide, Sustain, and Modernize Training Capabilities.

Where the MCTEMP falls short is scope. STIMB under TECOM is currently only exercising authority over the Marine Corps' ground, non-standard family of systems, leaving a majority of Marine Corps training systems without authoritative guidance or vision. The MCTEMP acknowledges this, stating its intent to, "establish the required support and governance of the Deputy Commandants to realize the vision" (A. Lang, email to author, May 11, 2021), but it does not exercise institutional authority to implement its vision. The MCTEMP makes this explicit, stating, "The MCTE will leverage existing policy in an integrated manner, but will not aim to override policy specific to an occupational field/community" (A. Lang, email to author, May 11, 2021). *Bottom line,* w*ithout the institutional authority to transition the MCTEMP into action, the Marine Corps will fail in realizing this vision.*

b. Marine Corps M&S Technical Standards Profile

In April 2021, MCMSO under MC DC CD&I published the Marine Corps M&S Technical Standards Profile (TSP). In its own words, the Marine Corps M&S TSP is characterized as follows.

> The United States Marine Corps (USMC) Modeling and Simulation (M&S) Technical Standards Profile (TSP) identifies the preferred M&S standards and recommended practices for standards development across the Enterprise, establishes the governance structure and life cycle process for updating and evolving the TSP, and provides guidance on the governance processes of the acquisition, development, and utilization of models and simulations." (Marine Corps Modeling and Simulation Office, email to author, April 26, 2021)

This unifying document enables the enterprise to reduce duplicative efforts and risk during development while facilitating networkability, interoperability, and upgradeability. The TSP Life cycle shown in Figure 10 achieves consensus on standards via the Marine Corps M&S IPT, representing the needs of all the Marine Corps M&S stakeholders.

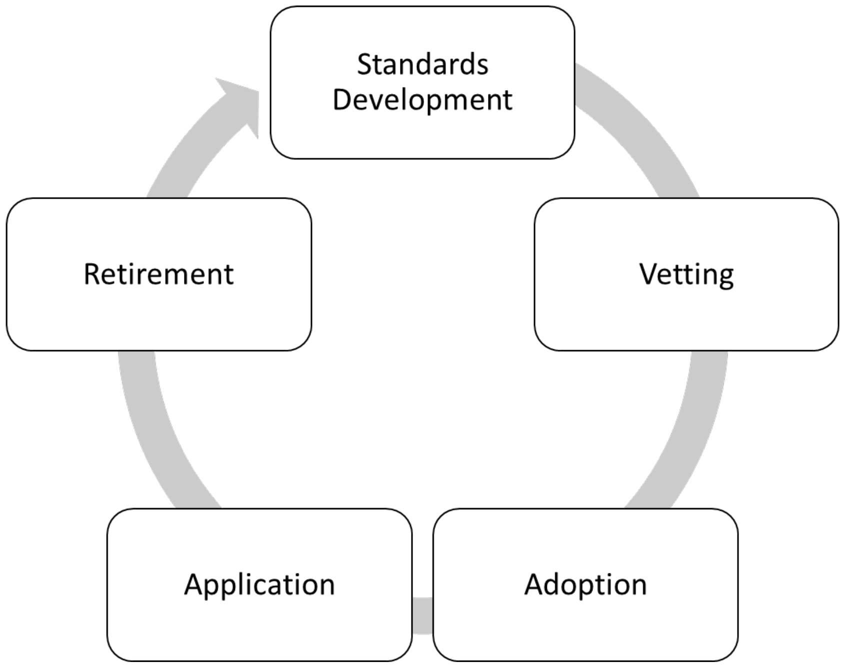

Figure 10. Technical Standards Profile Life Cycle. Adapted from MCMSO, email to author, April 26, 2021.

c. *Live, Virtual, and Constructive Training Environment*

Live Virtual Constructive Training Environment (LVC-TE) is the latest in a line of efforts and programs of record seeking to achieve interoperability solutions between simulation communities in the MAGTF. LVC-TE in its current form strives to accomplish this in two increments. Increment 1 will establish a dedicated training network integrating currently fielded training systems. Increment 2 will expand on increment 1, replacing the legacy network with a modern network purpose-built for interoperability while adding live ranges for force-on-force exercises and augmented reality (Donaldson, 2021). While these efforts and programs have varied in name, they have all pursued a strategy of achieving interoperability for separately developed programs after they have been fielded. These systems, having been built to differing technical standards, have only been able to achieve sporadic interoperability of limited duration and utility at a prohibitively high investment of effort. This statement is corroborated by recent Fleet Marine Force Trends from Third Marine Aircraft Wing, stating, “The barrier to entry is prohibitively high for linking simulators between communities, requiring heavy coordination and testing to support every evolution" (TECOM, email to author, July 26, 2021). Through the use of technical and operational experts, LVC-TE has brute-forced connections between differing systems but has rarely achieved durable and repeatable success. In any case, LVC-TE has been unable to achieve the persistent and reliable interoperability described in the MCTEMP.

3. Recommendations

Three recommendations will be discussed individually but should be executed concurrently, with each action reinforcing and informing the others.

a. Empower Synthetic Training Integration and Management Branch

STIMB, with TECOM's authority as the community lead for training M&S, should lead the Marine Corps M&S training enterprise, inclusive of aviation training systems. As stated before, STIMB is only exercising authority over non-standard ground training systems, leaving the vast majority of Marine Corps training systems ungoverned. As outlined in the stakeholder landscape, MCCDC is the requirements certification authority for all Marine Corps systems and has the power to direct requirements standardization across all Marine Corps communities. DC CD&I should publish a policy letter directing that all future training systems requirements comply with the policies and directives composed by STIMB that are built upon stakeholder consensus from across the Marine Corps M&S training community.

To effectively lead the M&S training community, STIMB would follow through on executing the MCTE Working Group (MCTE WG) as outlined in the MCTEMP, but expand the scope to include stakeholders from Marine Corps ground, C2, and aviation training systems to achieve the purpose of the MCTEMP, "to unite the training community, exercise design professionals, capability developers, acquisition professionals, and functional experts in building a MCTE capable of supporting operational readiness for tomorrow's fight optimized for today" (A. Lang, email to author, May 11, 2021). STIMB as the current manager of ground, non-standard training systems would serve as the lead for ground and C2 systems. ATS PM would serve as the lead for Marine Corps aviation training systems. Supporting acquisitions activities would attend, including PM TRASYS and PMA-205MC to inform discussion, as well as MCMSO and LVC-TE personnel.

While the MCTEMP framework serves as an excellent overall agenda for the working group, there are a few additional recommended actions. First, the MCTEMP seeks to, "unite companion documents and direct the necessary service-level policy and standards across warfighting function" but will stop short of overriding existing policy. (A. Lang, email to author, May 11, 2021). We recommend the working group identify conflicts between communities that prohibit MCTEMP realization, staff solutions that will preserve training utility while enabling interoperability and change occupational field/community-specific policies when necessary. This process will identify and rectify roadblocks to interoperability while preserving the training needs of individual communities. Second, the MCTE WG should strive to define the minimum required elements for the MCTE for meeting the collective training needs of communities conducting integrated training. Examples include gaming areas, a virtual and constructive characters list, environmental controls, and a list of radio and datalinks to simulate. These requirements would serve as a common "game board" for individual programs to build their systems to. Community needs will vary widely, and individual programs should pursue additional capabilities above and beyond these established minimums, but by including these characteristics from the outset, they'll ensure the interoperability needed for collective training.

b. Enforce Technical Standards Profile

The Technical Standards Profile (TSP) should be enforced across the Marine Corps M&S enterprise. While institutional uptake will be more easily enforceable for Marine Corps ground and C3 training systems, special attention should be paid to Marine Corps aviation training systems. As discussed in our first recommendation, MCCDC serves as the requirements certification authority for all Marine Corps acquisitions with the power to direct technical standards for all Marine Corps systems, including Marine aviation.

Regarding a timeline for implementation, TSP should be incorporated into all future training systems immediately. For legacy systems and systems currently under contract, TSP implementation should be incorporated on a case-by-case basis. Acquisitions activities for those systems should present cost estimates for implementation and cost-benefit analyses regarding community and collective training capabilities to the applicable

Capabilities Development Directorate (CDD) at MCCDC who will decide whether to approve a TSP deviation waiver. With TSP eventually incorporated into all Marine Corps training systems, interoperability will be achievable by LVC-TE.

c. Continue LVC-TE

While the LVC-TE program will not yield the push-button interoperability described in the MCTEMP by itself, it will succeed if combined with the two previous recommendations. The efforts of LVC-TE increment one will function as a learning campaign with several audiences. First, while it will be extremely challenging to stand up a network capable of hosting training systems built by different vendors to differing technical standards, it will yield the technical knowledge needed to inform the design of LVC-TE increment two. Second, the successes achieved in increment one, while sporadic and limited in nature, will serve as examples to community leaders regarding the value of collective training. This will shape future T&R design to capitalize on collective training value as LVC-TE increment two is fielded. While the CPG directs the use of collective training, achieving genuine demand signal from the trainers and instructors in the Fleet will drive future acquisitions of collective training systems.

With the knowledge gained during LVC-TE increment one in combination with the policy synchronization and technical standards adoption from our first two recommendations, LVC-TE increment two outcomes will be achievable, realizing the vision outlined in the MCTEMP supporting a more lethal Marine Corps.

IV. RECOMMENDATIONS FOR FURTHER STUDY

A. START ANALYSIS FOR ALL MARINE CORPS TRAINING SYSTEMS

The current landscape of Marine Corps training simulators is a mosaic of capabilities, protocols, vendors, and networks that each require individualized efforts to maintain and upgrade. The benefits of implementing START as described in our recommendation likely apply all training systems. PM TRASYS should consider employing tiger teams to conduct START analyses on a couple of the training systems in their portfolio to assess the feasibility and value of implementing START for their full portfolio of training systems.

B. REFINE TSC AND START PROCESSES

Implementing TSC using START in its current form is our current recommendation as it can deliver immediate value to the warfighter within the current construct of ATS. As it is implemented, it is critical to conduct ongoing assessments on TSC and START effectiveness to inform improvements going forward. The ATS PM office should pay particular attention to ways of reducing the burden placed on the SMEs who are conducting the assessments on site with the tiger teams.

In addition to inwardly oriented evaluations of START, the ATS PM office should evaluate the effectiveness and applicability of other assessment systems used across the DOD and M&S industry. While fully changing from START to another assessment system would disrupt the value stream afforded by regular START assessments, incorporating the best practices of other systems would offer an incremental improvement over time. One such system that should be considered for integration is the Integrated Training Environment Assessment Methodology (ITEAM) developed by Dr. Glenn Hodges at NPS. ITEAM is similar to START as it is, "an analytical assessment methodology to support the evaluation of human in-the-loop (HITL) simulations also known as Integrated Training Environments (ITE)" (Hodges, 2014). As seen in Figure 11, the overall workflow of ITEAM closely mirrors steps one through four of START. One strength unique to ITEAM is the categorization of tasks into human abilities (HA). "HA, were developed by Fleishman

& Quaintance (1984) as part of a taxonomic effort to define human performance and work. HA provide a way to look at the ITE in human terms (e.g., physical, sensory, psychomotor or cognitive abilities) instead of technical terms." (Hodges, 2014). This aspect of ITEAM could be integrated into step two of START (Map by Criticality). By further categorizing tasks into HA terms, START assessments would not only target tasks by impact to training utility (criticality) but would tie groups of tasks to specific attributes of the simulator which need improvement. For example, if tasks categorized into the psychomotor HA are frequently unsupported, START results would drive the pursuit of COAs for improving the look and feel of flight controls during step five of START (COA Development).

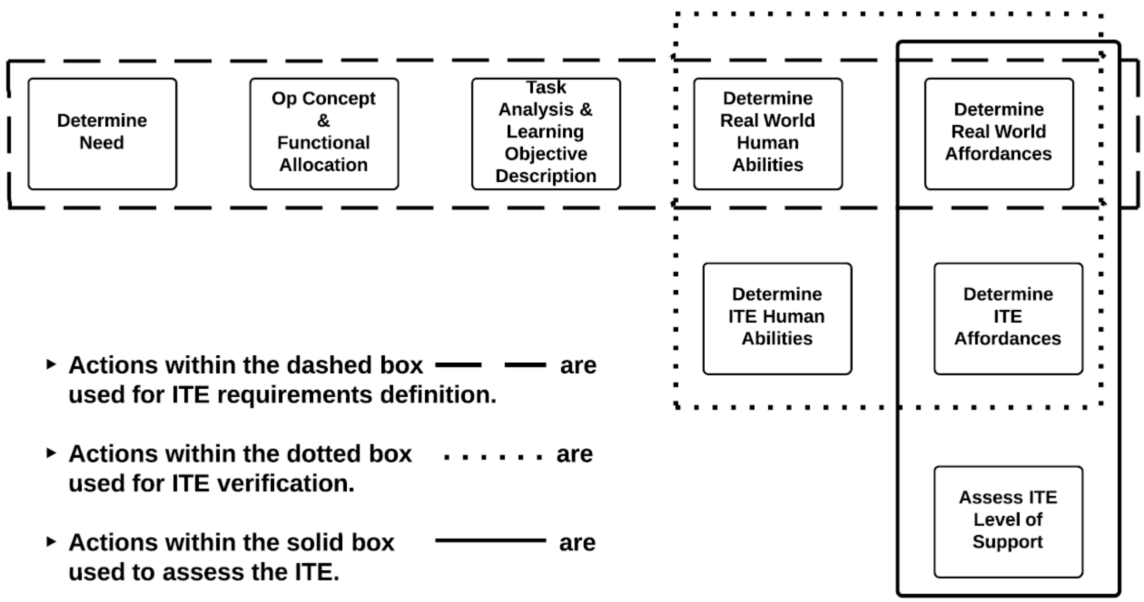

Figure 11. Integrated Training Environment Assessment Methodology. Source: Hodges (2014).

Above is just one example from one assessment tool that would incrementally improve START. The ATS PM office should investigate the utility of other ITEAM features as well as other systems. Dr. Hodges and other staff members at the NPS MOVES Institute as well as Brett Telford at MCMSO would be excellent resources for other assessment tools used by DOD and M&S industry.

C. INTEGRATE REQUIREMENTS FOR M&S COMMUNITIES FOR TRAINING, EXPERIMENTATION, AND ACQUISITION

In general, simulators and other M&S tools tend to serve one M&S community's needs and are optimized for those purposes. This largely makes sense with the differing natures of M&S community missions and the varying physical locations of each agency. There are instances however where two or more of the M&S community missions and physical locations overlap, presenting an opportunity to share simulators if the needs of each community can be incorporated into a common device. Currently, there are no mechanisms to integrate M&S requirements for the four M&S communities into common devices.

A specific example of this type of opportunity exists at Marine Corps Air Station Yuma (MCAS Yuma), where M&S stakeholders from the training, experimentation, and acquisition M&S communities are co-located for the aviation platforms of the AH-1Z, UH-1Y, MV-22B, and F-35B. Currently, there are only F-35B simulators available at MCAS Yuma and only used in a training context. At this location, a single simulator for each of the platforms could fulfill the needs of the three M&S communities if designed correctly. For the training M&S community in Yuma, MAWTS-1, Marine Operational Test and Evaluation Squadron 1 (VMX-1), as well as several local F-35B squadrons have aircrew with recurring training requirements to remain proficient in their platform that can be partially met by a simulator. For the experimentation M&S community, MAWTS-1 and VMX-1 have a shared mission of tactic, technique, and procedure (TTP) development and would use the simulator as a tool in that endeavor. Lastly, the acquisition M&S community in MCAS Yuma is represented by VMX-1 as the primary OT&E organization for the four aircraft listed above. VMX-1 could use a simulator if designed correctly to conduct some of their OT&E events.

While a training simulator for each of the platforms would provide immediate value across all three M&S communities, it would not be a device that balances the three optimally. For example, several Marine Corps Aviation training simulators are transitioning away from original equipment manufacturer (OEM) mission computers (MCs) towards personal computer (PC) based simulations of the same. This reduces the lifetime costs of the simulator because they do not have to buy the more expensive MCs that go in the aircraft. The drawback of this from an OT&E perspective is that the simulator can no longer be used to test new software loads, as the PC-based device can no longer accept the same code that the OEM MCs can.

The recommendation for further study would be for MCMSO to assess opportunities like the one described in MCAS Yuma where single locations can serve the needs of multiple M&S communities. Each case would vary, but there are likely opportunities to integrate the requirements of co-located stakeholders to ensure a balanced solution can serve the needs of all with fewer devices. After candidates are identified by MCMSO, the Marine Corps M&S IPT would be a suitable venue to further vet these candidates and staff a means for requirements to be integrated into devices at those locations.

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FOR FURTHER READING

Additional ITEAM readings include the following:

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