Leveraging Simulation Against the F-16 Flying Training Gap

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CHAPTER 11
Leveraging Simulation Against the F-16 Flying Training Gap

Shaun R. McGrath

I. Introduction

> *The F-100 was a very simple airplane. It was an airframe wrapped around an engine and a cannon and that's about what it consisted of. That's not the case today. Our weapon systems are very complex. They involve very complex avionics, radars, and missile systems that reach out 20, 30, 40 miles. They come with a requirement to integrate off-board information from systems like Rivet Joint, AWACS, Joint Stars -- integrate that information into a weapon system to produce the situational awareness needed to work in concert with other forces…*
>
> --General Richard Hawley (COMACC, 1997)[1]

The United States Air Force (USAF) long ago retired the F-100s to the boneyard to make way for today's complex fighter aircraft like the F-16. Recently, rapid increases in computing power corresponding to Moore's Law translated into an almost over night exponential leap in the F-16's hardware and software complexity.[2] While most see the benefit to these rapid advances as enhanced combat power, the underlying challenge is to keep pace training the "man in the machine." Multiple current day constraints prevent meeting this challenge through a simple increase of flying hours. Rather, today's fighter community must leverage emerging simulation technology into combined flight training to counter mission employment complexity created by technology itself. General Hawley's remarks were a precursor to championing one such leveraged solution—utilizing high-tech simulators called distributed mission trainers (DMTs).

The USAF is currently proliferating hi-tech simulators in the F-16, F-15, E-3, and E-8 communities. Interconnectivity or networking of two or more of these stand-alone simulators creates a mission training center (MTC), which when further networked create distributed mission operations (DMO). Ultimately, the grand operational vision of DMO is to interconnect non-collocated users creating a "virtual" joint training environment across multiple platforms and disciplines. However, while the fully implemented long-term vision is years away, the near-term benefit of leveraging these high-tech simulators to close the growing gaps in flying training is real. Justification for DMO funding in some regard stems from continuing research that postulates “simulation, when properly applied and combined with flying training, can reduce the distance between the continuation training (CT) ramp and the proficiencies required in combat” (see Figure 1).[3] Continuation training is merely how we train for combat during peacetime and safety constraints create gaps in CT. The fighter aviation community has also encountered other training gaps in the past decade. These have stemmed from a systematic reduction in the average pilot’s flying hours coincident with massive increases in aviation technology.[4]

This increase in aviation technology brought the F-16 from its early beginnings in 1973 as a “day VFR” fighter to today’s multi-role, multi-sensor, and multi-weapons platform.[5] Since 1991 the USAF has added significant capabilities to the F-16 in the way of the low altitude navigation and targeting infrared for night (LANTIRN) system, the high-speed anti-radiation missile targeting system (HTS), and the advanced medium range air-to-air missile (AMRAAM). These capabilities have required the addition of qualification training tasks, some of which have been executed in simulators. Again, in the past two years, the F-16 community has realized a quantum leap in software and hardware technology under the Common Configuration Implementation Program (CCIP). Unfortunately, the resulting exponential jump in complexity on a single platform adds to the growing training dilemma and gap. The bottom line is that no matter how complicated the aircraft and its associated avionics become, all of the technological advances are useless without pilots having the available training to master new systems and their mission employment. The MTCs or DMO being emplaced likely provide the best means to bridge the gap, enabling the “virtual” simulation world to train inexperienced pilots into combat ready fighter pilots with superior operational awareness.

II. Training Shortfalls or “the Gap”

The Peacetime Training Gap

Researchers and trainers have struggled with the task of training pilots since the dawn of applied combat aviation technology. It is well documented and professed by the same that “without good simulation and computer-based training, teaching a pilot to fly a modern aircraft is going to require more and more hours in the airplane.”[6] Many peacetime limitations like training rules, resource shortfalls, technical constraints, and security restrictions further hamper training based solely on live flight. So simply throwing more flying hours at gaps in training is not a viable solution. Therefore, a significant challenge exists for military leaders to create CT programs able to produce combat mission ready (CMR) pilots. These factors, among others, led recent Air Combat Command (ACC) leadership to continue studies into the effectiveness of high-fidelity simulation. One particular analysis centers on mission essential competencies (MEC), which are a measure of combat readiness in terms of maximal aircrew performance standards under combat conditions. [7]

Taken from the analysis, Figure 11.1 illustrates that the available CT in a given fighter unit falls well short of achieving the required combat MEC proficiency. Safety is one of the key drivers, but there are others. The old adage of “train like you fight” only goes as far as safety permits. Live ordnance training is limited to featureless targets and the chance for any actual air-to-air weapons employment is infrequent at best. A general inability to train against “red” opposition ground or air threat simulators further limits the ability to train in an environment that replicates the conditions of combat. These limitations compound existing safety and resource constraints. Air combat training is becoming increasingly constrained by shrinking budgets, airspace limitations for countermeasures and supersonic employment, and operational taskings that limit CT opportunities.[8] Therefore, this myriad of constraints and restraints further hamstrings the peacetime MEC training gap driven in large part by concerns for personnel, equipment, and environmental safety. Finally, as if the challenge were not big enough, recent and rapid technology changes have exacerbated the problem, especially for the F-16 community.

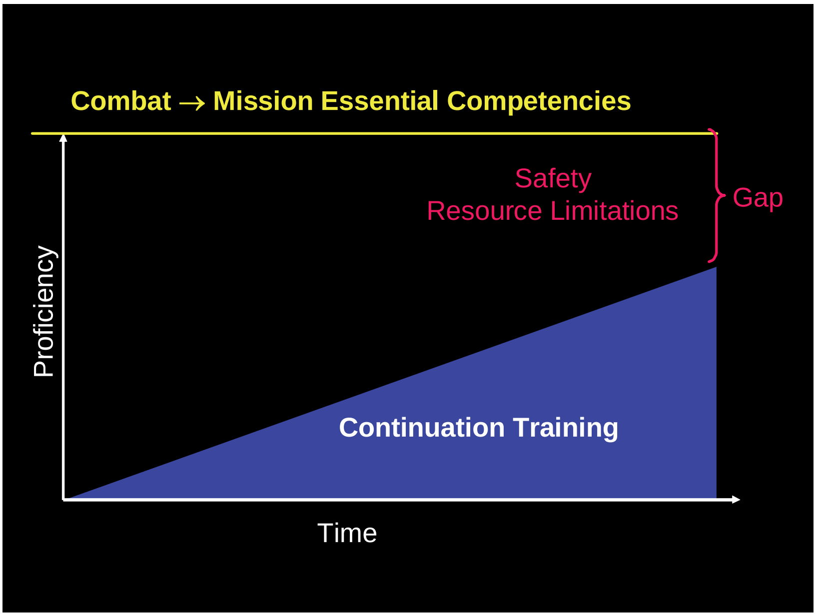

Figure 11.1 ACC Previous DMO Rationalized Gap[9]

Technology Created Gap by the F-16 Evolution

Rarely do you hear of a USAF leader asserting that technology hampers combat employment. Quite the contrary, most state that technology enabled combat aviation to progress rather rapidly over the past century. However, rapid advances in an airframe's hardware and software create a corresponding training gap until the pilot learns the new systems' employment.

Since the introduction of the Block 40 F-16 in 1988, the F-16 has transitioned from its original day-VFR fighter design to an all-weather, night capable combat platform. During the early 1990s multiple airframe upgrades occurred, corresponding to the addition of LANTIRN, HTS, and AMRAAM capabilities. These additions created training challenges, and specialized training programs followed. However, operational units in large part shouldered this burden by increasing mission qualification training (MQT) and tailoring CT upgrade programs. Over time, the inclusion of this training into the F-16's initial qualification training (IQT) and follow-on specific Block 40 or 50 courses taught at Luke AFB lessened the operational units' burden.

CCIP for the F-16 community again complicates training and creates a technology driven training gap. Figure 2 highlights the widened gap created, which all Block 50 units face. Unfortunately, the operational units will bear the burden for this additional training for some time. There is no current plan to execute the IQT syllabus in Block 50 CCIP airframes, and the first of the CCIP aircraft, albeit Block 42 models at Luke AFB, do not arrive until late 2005.[10]

The F-16 pilot is cynically referred to as the "jack of all trades, but master of none." Training for multi-role platforms requires calculated approaches to prevent the aforementioned stigma. CCIP in the Block 50 secures a spot in the USAF for the F-16 as a multi-role workhorse, but this requires correspondingly ingenious training approaches. CCIP provides the F-16 the ability to elevate its established air-to-air prowess through the addition of the joint helmet mounted cueing system (JHMCS) and an air-to-air interrogator (AAI); enhance suppression of enemy air defenses (SEAD) mission performance through the incorporation of Link-16; and enhance precision guided strike capabilities with the addition of the advanced targeting pod or SNIPER. Training the man in the loop remains the challenge.

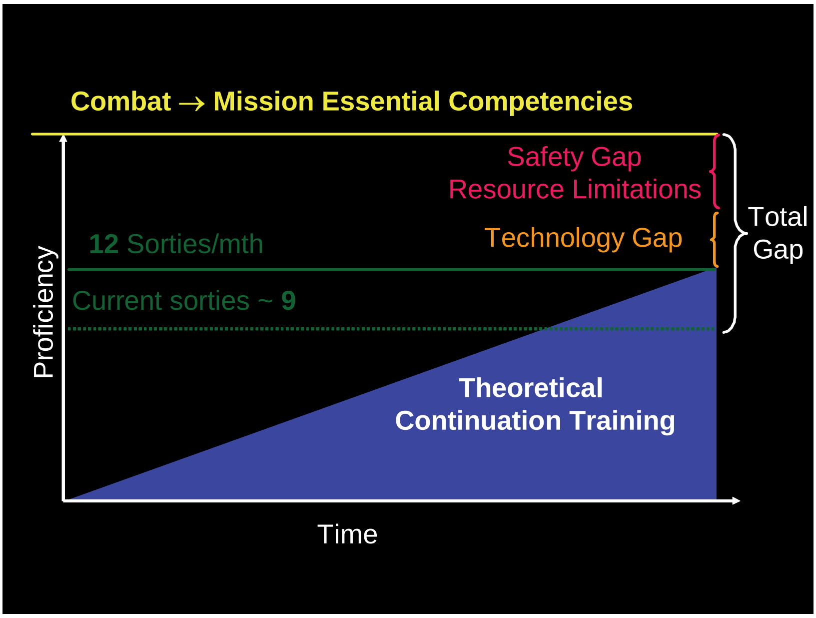

Figure 11.2 Total Current Training Gap

Whether or not the corporate USAF decides to task Block 50 squadrons with maintaining combat proficiency in all respective areas described is worthy of much debate but outside the scope of this research. The real challenge, regardless of the scope, is training to the required MECs and subordinate tasks with the new technology. Reaching the combat proficiency pinnacle of the CT ramp by overcoming the two depicted gaps in Figure 11.2 is challenging enough. One other significant difference between the mid-1990s' technology-training gap and the current one lies in the number of sorties available to pilots today. Some of the cuts in the flying hour program (FHP) over the past decade are directly linked to the proposed DMO solution.[11]

III. Flying Hour Reduction

Basic Flying Hour and Sortie Reduction

In the late 1990s the administration's shrinking defense budget certainly did not provide a great opportunity to maintain or increase the operations and maintenance (O&M) dollars spent on training pilots. This left USAF leadership at a previously traveled crossroad. Following Vietnam in 1973, the General Accounting Office conducted a study that ultimately proposed a replacement of 25% of flight hours by simulator hours to maintain combat proficiency and to evaluate pilot proficiency.[12] On a similar path, ACC leadership proposed cutting the FHP during 1998 and considered reductions of up to 30% more.[13] The timing of these thoughts corresponded with the timeframe of General Hawley's comments to the 19th Interservice/Industry Training Simulation and Education Conference concerning the desire to supplement training via simulation. However, other factors in play already created a declining trend for pilot hours and sorties throughout the 1990s that carried into the 21st century.

The PACAF staff presented a briefing in the fall of 1999 outlining "The Declining Fighter Sortie Trend." The trend highlighted a significant decline in fighter pilot sorties across the command compared to the early 1990s; that trend has been repeated in ACC over the past three years. The data compiled by the PACAF staff displayed this declining trend over a three year period from 1996-1999, taking the average sortie rate per month from a high of just above 11 to a low of 8.6. This trend did not just start in 1996, as it was already declining from rates of 12-13 monthly sorties per pilot in the early 1990s. [14] It is worth noting that these numbers may be a bit misleading when applied to the challenge of combat proficiency. Following Desert Storm and leading up to Operation Iraqi Freedom, Operations Northern and Southern Watch (ON/SW) accounted for some of those monthly sorties. One can argue that because of a plethora of flight limitations, those sorties do not factor into the equation of measuring CT proficiency.

The sortie data in ACC demonstrates a similar trend line. Observing the trend from the FY00-FY03 FHPs, the F-16 specifically went from a weighted average high of 12.3 to 9.1 sorties per month in

FY03.[15] The same comment applies to ON/SW sorties during this period, but the sortie rates did rise slightly in late FY03-04 to 10.8, corresponding to the increase from the War on Terrorism (WOT)-associated combat operations. While recent combat experience naturally heightens one's combat proficiency, limited combat airpower operations in the transition phase over Iraq today, returns the previous sortie challenges to the fighter community.

Declining fighter pilot sorties per month certainly presents a training challenge, but in the late 1990s the Air Force Safety Center researched its effect on mishaps. The conclusion of their studies determined that the average fighter pilot required 11 sorties per month to maintain an adequate level of proficiency.[16] The recent declining trends should again peak concern. However, the declining trend did not occur in a vacuum—several other factors are critical.

Operations Tempo, Manning, and Maintenance Induced Reduction

Three other critical areas have presented challenges to fighter sorties over the past decade. The 1999 PACAF brief highlighted all three, and all remain problematic today. Operations tempo supporting air expeditionary force (AEF) rotations to ON/SW previously impacted efforts to provide adequate continuation training. Any prediction of continued AEF rotations matching those of ON/SW is uncertain, but deployments to support the WOT likely will continue for some time. PACAF estimated that 300 continuation sorties per squadron were lost for each rotation due to deployment/redeployment sorties, pilot swap-out and recovery periods, lack of quality training opportunities while deployed, and limited opportunities for home station training due to split operations.[17] However, ops tempo is only one of the major factors.

The second relates to a well-documented declining mission capable (MC) rate for the fighter fleet. Some say there is an uncanny resemblance to the MC trend line that combat aircraft experienced shortly after the Vietnam conflict. PACAF graphically depicted the line on a time versus MC rate scale. The MC rate trend line post-Desert Storm peaked at 88.4% but then experienced a steady decline every year thereafter, plunging to 74% by FY98. The corresponding utilization (UTE) rate also dropped from 20.0 to 16.4 over the same period.[18] Data provided from ACC depicts a similar story for the most recent FY04, with an average UTE rate hovering near 16.5 for its F-16 units.[19] Multiple factors continue to plague the MC rate, including experienced enlisted technician manning shortages, spare parts shortages, and most importantly, a tripling since 1990 of the average age of the fighter fleet from 6 to 18 years.[20]

The third factor is the numeric composition of fighter squadrons, or the numbers of primary assigned aircraft (PAA). PAA drives an organization's ability to produce sorties from a maintenance perspective and to schedule sorties from the operations side. Tactical Air Command and PACAF leadership realized this when, between 1978 and 1984, they stopped rapidly declining MC rates by consolidating 18 PAA squadrons into 24 PAA squadrons. However, the recent post-Cold War falling MC rates appear to correlate with a leadership decision to reverse these actions. Converting 27 of the 38, 24 PAA squadrons back to 18 PAA squadrons had decisive, yet undesirable effects.[21] Significant operations and maintenance manning and airframe availability issues have compounded the negative effect on sortie generation. This factor alone is worthy of additional research but beyond this paper's scope. These factors, combined with other training gaps, should provide a clear picture of the "Total Gap" depicted by Figure 11.2 for deficient combat proficiency training.

Shift in Flying Hour Training Funds to DMO

The multi-faceted picture painted by this historical background illuminates the challenge at hand. The challenge is to recognize the "real" current problem and leverage common sense solutions with all available tools. Unfortunately, the solution currently proposed cuts deeper into the widening chasm of FHP reductions and threatens to precipitate a continued decline in fighter sorties. The advanced high-tech simulators linked in a MTC provide a capable tool, but as with all tools, it comes at a cost. "According to ACC, the Air Force has awarded large contracts to support DMO: Boeing (F-15C, $574 million over the life of the 15 year contract and F-15E, $280 million); Plexsys of Portland OR (AWACS, $75.6 million); and Lockheed Martin Corporation (F-16, $249 million)."[22] In the era of scrutinized budgets due to wartime considerations, something must give, and unfortunately that something is O&M dollars.

Prior to FY04, a good portion of the funding for the development of DMTs to MTCs, and finally to the DMO concept, rested within the Air Force Research Lab (AFRL) and test community. That changed in FY04, as funding for the DMO required a large capital investment. According to ACC, the Air Staff mandated a 5% across the board reduction in O&M FHP dollars to provide some capital.[23] With the limited number of operational MTC facilities, no true evaluation measure exits to determine whether or not these hours are truly being "replaced" by DMO hours. For those who cringed at General Hawley's suggestion to replace 30% of proficiency training with simulators, the day has arrived. That math is derived from the 25% reduction in the average monthly sortie rate (12 to 9) over the last decade, coupled with FY04's 5% additional reduction in the FHP. With all factors considered, it is now time for the "replacing," because up to this point just a 30% gap in combat training capability has existed.

Seemingly undaunted by the reductions, the USAF must continue to train and remains committed to the ultimate DMO vision. Recent comments from the USAF Chief of Staff reiterated this commitment. "DMO will be fully funded."[24] Currently, there is no indication of the resultant impact this statement will have. However, underscore that with yet another Air Staff directed 2% across the board reduction in O&M FHP dollars for FY06 and FY07 to offset costs incurred by the WOT.[25] Given all these realities, the challenge remains to bridge the gap in combat proficiency training. Based on the depicted picture, the only realistic solution is to leverage high-tech simulation in the combat training environment. By no means is this the first time that aviators have relied on simulation for training assistance.

IV. Why Simulation

Historical Beginnings and the Evolution of Realism

Simulation is no new concept to aviation training or to the USAF. Flight simulation saw its early beginnings with the Wright Flyer, and as evidenced by DMO, kept a steady pace of improvement and technological advancement right along with those of modern aircraft. Throughout the history of simulation, two key elements have played a significant role in its development and acceptance by aviators. The first is realism, and the second is training effectiveness (or transfer of training). Both are required for aviator acceptance as substitutes for "real time" in the aircraft. Indeed, the gap to close already stands at 30% of flying time lost.

Even in the early days of simulation, realism of the model, at least its dimension and appearance, was a primary concern. Arguably, some of the first simulators were wooden barrels mocked up to be horses and ridden by soldiers of the cavalry to practice mounted riding and fighting. Flying simulation began along with the Wright brothers' first flight. They built a mock up of the Wright Flyer without canvas coverings to practice the basic taxiing and flight control drills. However, realism soon took less of a literal design approach in the era of Edwin Link.[26]

Ground simulators introduced as early as 1929 were scaled-down replicas of actual aircraft and were pivotal to flight screening and a pilot's initial training. Over time, realism in simulation completed the trend away from the literal design approach. Soon after WWII, designs focused around human learning. Human factors engineers began the trend by altering simulator designs to be similar in appearance to what we see as the modern day aircraft simulator. They realized the immediate area around the pilot(s), i.e., the cockpit, required the preponderance of design emphasis. With the advent of the jet age and computer technology, engineers understood the necessity to match the simulator's flying characteristics to those of the aircraft but lacked the computing power for little more than rudimentary modeling.[27] It was during this time that interest spurred civil aviation to begin utilizing simulation for pilot training.

The military used simulation from its inception in training crews for combat but has maintained a more neutral stance than civil aviation for the credit given to simulated flight training. Following WWII, the USAF used simulators to rehearse strategic combat missions.[28] This vision continues as DMO hopes to achieve a similar mission rehearsal capability, but for an entire package of aircraft versus a single crew. "By fiscal 2007, [DMO] program managers envision… supporting the entire spectrum of training from the individual up to campaign-level mission rehearsal."[29] However, 1960's technology did not permit this level of integration.

It was 1965 when the USAF embarked on its first journey into what might be considered a genesis simulator for the MTC concept. The system known today as the simulator for air-to-air combat (SAAC) remains a viable operational tactical air-to-air mission trainer.[30] Key elements to this simulator's realism are the dome visual system and the capability to fly against another simulator. Technological advances in visual systems continued, as well as the introduction of motion systems throughout the 1970s for both the military and civilian aviation communities. These advances allowed the Federal Aviation Administration (FAA) to grant credit towards civilian currency for certain tasks performed in the simulator.[31] Nearly every flight-training program from this point forward integrated some level of simulator training.

Realism continued to drive simulation and its corresponding training value. Technological advances in computing power, visual, and motion systems allowed the entire aviation community to overcome many hurdles in training and to maintain both basic and complex task proficiency. Simulation excels in training to non-permissive tasks such as emergency procedures or combat tasks unexecutable in the air due to peacetime constraints. Both military and civilian aviation authorities recognize this merit. Under emergency procedure conditions, many "safety experts agree that simulators are actually more valuable than an airplane for training."[32] USAF regulations require the conduct of periodic emergency procedures evaluations in a simulator if available.[33] The civilian aviation community goes further. Flying evaluations are conducted in the simulator, and simulators are certified for updating currencies as well as the actual logging of flight time. However, a notable caveat to all this must be stated. Specific accreditation of the simulator is required, and a corresponding effective transfer of training must be demonstrated before exploring the credit for "permissive live fly" events.

Requirements for Effective Training Transfer

The USAF accreditation standard for DMO and the corresponding MTCs is currently under review, so a detailed discussion is not provided.[34] However, the basic principles of transfer of training (TOT) research are relevant as training programs evolve to augment flying proficiency requirements. "TOT is the ability for a skilled behavior which has been learned in one situation to be carried over to another," and is then measured by a training effectiveness ratio (TER).[35] One such definition given to TER is expressed by the transfer of training in terms of the training time saved in the air through simulation. The formula used is $TER=A-A_S/S$, where $A=$ aircraft training time when not using a simulator, A_S = aircraft training time when using a simulator, and $S=$ simulator training time.[36] To achieve a TER value of +1.0, the amount of training time saved in the air equals the amount of time spent in the simulator. Values above and below +1.0 correspond to an equivalent ratio between the time spent in the simulator and time saved in the air. However, this comparison requires another important caveat.

"TOT studies do not compare simulator training to flight training; they make no attempt to prove that simulation is better than in-flight training."[37] However, if a TER value indicates a positive number approaching +1.0 or better, then the noted positive transfer may infer that the "use of the simulator can reduce the dependence upon operational aircraft during training by influencing the learning of tasks that must be performed in those aircraft."[38] Most importantly, simulator training indicating positive TER values should result in more efficient flight training, requiring fewer flights to reach a proficiency goal or reach a higher goal provided the same number of flights. Put in the context of Figure 2's "Total Gap" challenge, we are already more than 30% behind the power curve. In this case, positive TER values are required from the tasks executed in the MTC environment just to make up lost ground. Only then will additional training permit closing the combat proficiency gaps above the continuation training ramp.

Multiple studies over the past several decades explored the effectiveness of flight simulators to augment "live" flying training. Some early theorists in the field, such as Edward Thorndike (1931) and Charles Osgood (1949), believed that common elements were the requirement for positive TOT.[39] Their common elements referred more to a direct correlation of the physical features rather than requirements today, which focus more on the replication of physical, aural, and visual environments. Subsequent theories of TOT related much of a simulator's success to four underlying concepts that Paul Caro's book *Human Factors in Aviation* describes in depth. The four primary concepts are cues, discrimination, generalizations, and mediators. These concepts form a basis for evaluation criteria, both subjective and objective, when observing training transfer from a simulation device to task proficiency.

Few past studies provided researchers accurate measurements of TOT for complex combat tasks. Studies from the 1950s to the mid-1980s generally focused efforts on basic pilot tasks such as take-off and landing. Although some trends exhibited a positive correlation, little was concluded about complex high-level tasks.[40] AFRL conducted a further review into 67 studies during the period from 1986 to 1997 and found only 13 directly related to the TOT.[41] Again, most of these studies centered on basic skills. Several studies examined the impacts on bombing accuracy and instrument flying. Both cases revealed positive trends in providing an effective transfer of skills.[42] Unfortunately, specific studies yielding reliable or conclusive results into a simulator's TOT applied to complex combat mission tasks are all but non-existent. This is especially true for multi-ship simulation over the past twenty years.[43]

Even though specific empirical data driven TOT studies are elusive, several previous and on-going efforts provide positive insight. The few available and published studies center on training accomplished in the SAAC or in the F-15 McDonnell aircraft simulation facility. Two AFRL studies (1977, 1980) using the SAAC demonstrated small transfer effects for specific air-to-air combat competencies and subordinate tasks.[44] More importantly, an evaluation of the SAAC in 1976 discovered how paramount a pilot's use of visual cues is to accomplishing air-to-air tasks. Visual cues for these tasks provide essential information for positional relationship, own-ship attitude, and performance in relationship to adversary aircraft and terrain.[45] This visual information is not generally derivable from other cockpit sources. Therefore, a key link from SAAC to DMO is the 360-degree wrap-around field of view. Visual *cues* are crucial in providing appropriate *discrimination* of surrounding events in the complex mission arena. Appropriate *discrimination* in the simulated environment permits *generalization* to carry over to the aircraft via the *mediator* of repetition in hi-fidelity simulation. While visual cues are one piece of the puzzle, the studies at the McDonnell facility point to another key factor.

Again, like the SAAC studies, those accomplished at the F-15 facility failed to demonstrate significant positive measurable TOT empirical data. The studies did yield another subjective, yet tangible measure of training transfer. In two separate tests, the pilots flying "consistently reported that such simulations are an enhancement to their current mission training."[46] Although the scientific community likes to see resultant empirical data, the authors of one report contend, "there is little reason to suspect that such training within a multi-ship simulation environment would not have a positive effect upon subsequent performance in the air."[47] Current endeavors therefore may be relegated to measuring realism and TOT by the subjective eye of the user. This may be appropriate for tackling the gap created by Figure 1's noted peacetime safety factors because few real measures of transfer are available unless actually flying in combat. However, this approach is not as appropriate for the technology gap and reduced sortie gaps described by Figure 2. If then, accreditation of DMO is to fulfill a long-term desire to "replace" (or recapture the lost) flying hours with simulator hours, future TOT studies must strive to gather empirical results to prove the merit to the skeptical aviator.

Acceptance and Accreditation

Whether attempting to execute the training of basic or complex tasks through simulation, pilot acceptance and accreditation always play significant roles. Pilot opinion drove much of the current design for advanced simulation training. Accreditation of F-16 simulators was pivotal to the evolution of increasingly advanced visual systems. Concurrency with the many technological advances drove this continued need. In the late 1980s, the USAF looked to replace their weapons system trainers due to underutilization and annual cost.[48] The replacements varied from a small desktop air intercept trainer to the multi-task trainer (MTT).

The replacements all were characterized by limited screen visual displays. The MTT's design concept was to provide "CT/refresher training in selected emergency procedures, basic instrument flight, and air-to-air and air-to-ground weapons system employment."[49] The MTT eventually evolved to the unit training device (UTD) utilized by the Block 40 community and an additional weapons task trainer (WTT) utilized by the Block 50 community. Both systems arguably filled the task at hand of training basic proficiency tasks, but nothing complex or tactical. Common pilot remarks about the systems focused on their inadequacy to provide accurate visual cues and the inability to network multiple devices.[50] These devices continually lagged the software and hardware updates in the aircraft. These lapses created unwanted negative opinion on simulation's effectiveness, and concurrency became a key issue.

Concurrency, as described in Air Force Instructions 36-2251 and 36-2248, is central to device accreditation.[51] The rapid aviation technological advances over the last decade, particularly CCIP, complicated this requirement. In Block 50 units, the WTT continued to lag the software and hardware modifications. For example, the WTT at the USAF F-16 Weapons School was finally upgraded to the first software version of CCIP (M2.3) months after the last aircraft was modified. This level of difference between aircraft and simulator is a bit beyond what most consider negative "sim-isms" and does not facilitate a great deal of positive TOT. In this case, training students to basic SEAD tasks is somewhat futile, as evidenced by the all too frequent remark, "don't pay attention to the monochrome green displays and symbology- it will ALL be different in the jet tomorrow."[52] With the decline in pilot sorties, this approach is not the right answer and thankfully, MTCs are being proliferated at Block 50 units.

Concurrency, realism, and TOT all appear favorable for the advanced visual systems and networking capability of the MTCs. The DMO roadmap identifies how MTC accreditation will ensure the system simulates the desired combat environment and interactions. Specifically evaluated are "the quality of the visual cues, accuracy of the sensor presentations, environmental factors, validity of threat models, fidelity of the cockpit, and overall hardware/software capabilities."[53] Concurrent with accreditation, ACC tasked AFRL to continue to investigate DMO effectiveness in the transfer of Ready Aircrew Program (RAP) training elements and the amount of credit given for this environment's experience.[54] Directly tied to this research are ACC's studies into the MECs appropriate for training applicability in the DMO environment.

ACC previously completed MEC analysis for the F-15/E-3 and recently finished establishing the baseline F-16 MECs in both air-to-air and air-to-ground arenas.[55] The MEC analysis should help to bridge the existing gap between the current "soft" subjective advanced simulation TOT effectiveness studies to more concrete metric driven empirical methods. The training task list (TTL) associated with the baseline single ship simulation of the past derives some of these baseline metrics. These more fundamental tasks focused on a pilot's ability to "learn the basics of the weapons system…learn which button does what, but [not to] learn essence of [the fighter] business, which is team combat."[56] The MTC provides the venue for team- as well as single-ship-combat proficiency training. Even though the MECs are defined in general operational terms, subject matter experts demanded that they be specific and relevant.[57] This allows for a link between lower level TTLs and higher-level MEC objectives, providing the metrics for TOT data. Figure 11.3 illustrates the direct link from TTL to MEC.

Colegrove and Alliger's MEC paper provides a more detailed description of the TTL to MEC relationship.[58] Suffice to say, metrics can and should be developed to measure training effectiveness targeted at any of the combat proficiency gaps illustrated in Figure 11.2. Subsequent results from continued research should be incorporated into the emerging integrated simulated and live fly training syllabi associated with MTC capable bases. This research must require deliberate data gathering over a long enough period to establish DMO's TOT validation.

Figure 11.3 MECs Conceptual Hierarchical Relationship[59]

V. Current DMO Utilization

Weapons School Training at Mesa DMO

Some of this on-going data gathering occurs every six months with the F-16 Weapons School class' weeklong syllabus directed DMO training. The training at the Mesa AFRL DMO was formally initiated in September 2002 and consists of five syllabus simulator sorties. Since AFRL is using the 16th Weapons Squadron (WS) as one of its active test subjects for research, no empirical performance data for TOT is formally releasable. However, several observations are available from other limited research and 16th WS DMO hot wash debriefs.

An AFRL study from 2002 outlined the knowledge acquisition data collected from 84 pilots forming several different 4-ship teams flying the DMT in similar scenarios as the 16th WS.[60] This study reiterated the difficulty in establishing TOT to actual flying performance. "Such data take considerable time and effort to collect, and there are major issues associated with developing appropriate methods and measurements to assess performance in flight."[61] However, the study revealed significant results after just a week of training for the knowledge acquisition of less experienced pilots in air-to-air combat concepts. In effect, the data showed the mental models of inexperienced pilots aligned more closely to experienced pilots after receiving the training.[62] This data is promising if similar results are attained by focused training to bridge the knowledge gaps for inexperienced pilots left by declining sorties and technological advances.

Another study attempted to find a correlation between the 16th WS DMO training and a student's success rate during follow-on live fly air combat tactics (ACT) syllabus sorties. The study examined pass/fail rates for seven 16th WS classes from 2000 to 2003. Four of these classes did not have the DMO training as part of the syllabus. The statistical results were inconclusive in demonstrating enhanced student performance from DMO training, but "subjectively and financially it [DMO] appeared beneficial."[63] The subjective nature centered on favorable student and instructor comments concerning mission rehearsal and repetition.

Few voice arguments about the repetition and intrinsic ability to increase proficiency on basic tasks such as radar/shot mechanics and communications. An AFRL White Paper noted:

> During 5 days of DMT training at AFRL (Class 03B), WIC [16th WS] students flew 236 engagements, spent 7.5 hours

> of time “flying”, 17.5 hours in debriefings, with ZERO dollars spent in maintenance, fuel costs and red air support. Back at Nellis, those numbers would be reduced to 75 engagements (a 66% reduction) assuming a 10 turn 10, 3 engagements per mission, with at least 6 adversaries every go, and ZERO losses due to weather, MX, etc.[64]

Pure repetition of any task provides proficiency benefit assuming no negative transfer occurs. Unfortunately, there is some negative transfer in the AFRL DMO. Concurrency in the simulators is an issue, as they are configured as an F-16 Block 30 with minor differences in weapons employment and situational awareness displays. Sometimes limitations with visual displays also force pilots to fly “TAD (tactical awareness display) visual,” requiring them to fly focused “inside the cockpit.” This trend subjectively appears to carry over periodically to live fly sorties back at Nellis with an over-reliance on data-link positional awareness displays.[65] These minor discrepancies aside, the DMO experience for the 16th WS appears positive.[66]

Shaw and Mt. Home F-16 MTCs

Shaw AFB and Mt. Home AFB are the first F-16 operational bases to receive MTCs to conduct DMO operations. Unfortunately, in contrast to the F-15/E-3 MTCs at Langley, Eglin, Elmendorf, and Tinker AFBs, operations are currently limited to intra-MTC only networking. Shaw is taking large strides to leverage the MTC against the CCIP technology and safety gaps. Unlike the AFRL simulators, concurrency is not a problem. The MTC nearly replicates the full capabilities of Block 50 MMC 3.3 software and hardware. Various modifications will permit complete capability replication with the SNIPER pod, night vision goggles, and the JHMCS by the end of 2005.[67] This robust capability makes the Shaw MTC a desirable training location.

Currently the Block 50 transition course conducts its simulator instruction in the Shaw MTC. This course is for all F-16 Initial Qualification Training students with follow-on Block 50 assignments throughout the USAF. This venue is a temporary work-around until CCIP Block 42 equipped airframes and a Block 50 configured MTC are available at Luke AFB. This demonstrates how the MTC is being leveraged against the CCIP technology gap, but the larger challenge to close the combat proficiency gap is somewhat being achieved in smaller steps.

Shaw is currently revising its training syllabus to include a greater number of MTC events to supplement live fly sorties. These simulator events are not replacing sorties. They provide an opportunity for basic skill enhancement prior to wasting JP-8 while an instructor coaxes a student through unfamiliar and complex display symbology. Shaw pilots will receive six MTC sorties in addition to twelve flights during their initial MQT program, three focused on basic skills at the TTL level and three at the combat MEC level.[68] One benefit Shaw currently has is the ability to use the Boeing contract instructors to conduct these simulator sessions. This leaves the "green suit instructors" free to conduct flight instruction or other squadron duties.[69] MTC sorties are also integrated throughout the flight lead and instructor programs.

To begin bridging the safety limited CT gap, Shaw is leveraging the MTC again. In February 2005 the wing pilots executed an air-to-air turkey shoot in the MTC. They are also conducting CT combat verification missions in the MTC, the equivalent of combat mission rehearsal. In preparation for DMO operations, they recently held a meeting with JSTARS and AWACS representatives to construct generic training scenarios.[70] All these efforts are on the leading edge of MTC integration and demonstrate the beginning of an effective approach to leverage the high-tech simulation environment of the MTC against the current training gaps.

VI. Future Bridges to the Gap

> *The F-16 fleet is going to go away. It's going to go away because we will have exceeded its airframe life. One way to stretch that life is to rely more on simulation and less on live flying. That way we can accumulate those hours on that fleet of airplanes at a slower rate.*
>
> -- General Richard Hawley

Beyond Taking Ready Aircrew Sorties and FHP Money to Fund DMO

As if the pressures describing Figure 11.2's Total Gap were not enough, those who believe that flying hours are protected from further reductions will be left scrambling for solutions when they again are cut. General Hawley's comments above, whether clairvoyant or not, speak of the realities of our aging legacy aircraft and the distant hope of quick replacements. In short, a critical and integrated approach needs to be taken in the development of CT programs.

The merits of DMO should be apparent. The myriad of training challenges or gaps warrants leveraging high-tech simulation in an integrated training approach. Future enhancements must place primacy on simulator concurrency, ensuring that a realistic simulated environment is created for pilot acceptance. The transition to DMO could easily be stifled if the aviators' generalized perceptions of simulators remains as a stand-alone single-ship training device. The transition is possible with a continuation of demonstrated realism married with a demonstrated positive transfer of training, whether by perceived or empirical DMO results.

Using the Virtual World to Train Inexperienced Pilots

Gadgets to Proficiency

Aviation technology continues to add new "eye candy" for pilots to absorb; CCIP is certainly no exception. One measure of the F-16's corresponding increase in complexity might be the number of added symbols that CCIP requires a pilot to differentiate and interpret. In most cases, these added symbols are not displayed as a collective "fusion" of sensor data. Mastering sensor data interpretation, therefore, will take time and practice. Leveraging the high-tech MTC simulators is imperative, with a comparative cost per hour of "proficiency practice" time being roughly ten times as costly in an aircraft.[71] The challenge increases with Block 50 MMC 4.2.

MMC 4.2 permits dual HTS and SNIPER pod carriage along with another lethal weapon, the AIM-9X. The single seat fighter pilot may have effectively reached "sensor management overload" with this modification. A recent 59th Test and Evaluation Squadron paper comments on the growing safety versus lethality dilemma facing multi-sensor capable platforms. It postulates that an average pilot can operate one sensor at a time, while monitoring a second sensor with an occasional glance, but is generally limited to one cognitive task at a time. The key to training becomes developing an understanding of when to use a given sensor and when to "hide" the data.[72] This dictates time spent and experience garnered with the available gadgetry.

Complicating matters for CCIP Block 50 units is the latest Ready Aircrew Program guidance. This tasking should land the Block 50 at the top of every combatant commander's wish list. In this ***single***

airframe now resides the capability to execute most missions in counterland, counterair, and non-traditional intelligence, surveillance, and reconnaissance roles. With the emphasis placed on the "airframe," the question is whether the "man in the machine" is truly combat proficient at all these roles and missions. Further research is essential to provide an honest assessment of the average F-16 pilot's capability to absorb and retain the required proficiency training, before the resounding answer is yes.

Gaining Experience in a Safe Environment

Safety is a key element of any simulator training. The capability for the instructor to hit the "freeze" or "crash over-ride" buttons is a life or death difference from live flight. DMO, however, are not conducive to the "freeze" function due to the potential connectivity of a large amount of players. This would be akin to calling a "knock it off" in the middle of a large force exercise because you needed to get a learning point across to your wingman. However, the MTC environment or single ship simulation certainly provides this learning environment. This environment permits an on-the-spot discussion of a learning point and then a reset of the scenario. The experienced gained by rote repetition of any task is tough to dispute, assuming it is conducted in a device with the appropriate measures of realism and TOT accreditation.

Baseline arguments for DMO funding tout the safe environment that facilitates the conduct of MEC derived non-permissive combat tasks. Accurate weapons and threat modeling are paramount, but this environment permits real-time "kill removal" of both red and blue forces. The action and resultant effect reinforces correct and proficient tactical execution. However, pilots need to remember that this environment creates a tendency to "over or max perform" an airframe in order to bail out of a given threat scenario. Because these simulators do not replicate the physical forces placed on the body, these maneuvers could lead to a habit of performing a less than desirable maneuver during actual live flight when posed with a similar problem.

Constructive Players with Live Fly using Link-16 Data

Any pilot who has spent time recently in an operational squadron understands the challenges to the successful execution of a complex mission such as a 4 v 4 offensive counterair mission. For all the factors earlier mentioned, the challenges for upgrade sorties are especially real and numerous. DMO are well suited to augment this type of training and experience. The individual or complex task proficiency benefits derived from flying a 4 v 4 from the Shaw MTC against the Langley F-15 MTC are currently unmeasured, but subjectively are great. Now take that one-step further and mix constructive players with live fly.

This very scenario is under concept development at Elmendorf AFB.[73] The goal is to fly a 4-ship of *live* blue players against whatever remaining *live* red players are available from the maintenance schedule. C*onstructive* players flying in the MTC then augment the red force. However, several technological challenges exist before this becomes reality. Scenarios also would require close management to prevent *live-constructive* "virtual merges," but this is a small cost for the benefits reaped by enhanced CT. This combined training should permit the recapture of some previously lost combat proficiency training in RAP by a re-allocation of red air sorties.

Red Air Reallocation

Notice the emphasis on re-allocation. This is not meant to be another way to cut flying hours but rather an effort to regain some lost ground. The added benefit of flying some red air sorties from the simulator should go largely to the inexperienced pilots. This provides them yet another opportunity for immersion into the operation of complex avionics and gadgets in a safe environment. Any angle to leverage the MTC or DMO against the training gaps created over the last decade will not only justify the expense, but also get the CT ramp closer to training pilots to the ever-elusive goal of combat proficiency.

VII. Conclusion

> *On the day of battle, soldiers and units will fight as well or as poorly as they are trained. Training to high standards is essential in both peace and war; never can U.S. forces afford not to train and maintain the highest level of readiness. Every commander, every soldier, every unit in a force-projection military must be trained and ready to deploy. Leaders have the responsibility to train subordinates. This may be their most solemn responsibility.*[74]

Combat proficiency training for today's fighter pilot is an increasingly daunting task. As Field Manual 100-5 alludes, this responsibility ultimately falls to the unit commander. Commanders have a great new tool at their disposal with MTCs. Integrated training programs must be developed that maximize the training benefits permitted by hi-tech simulators. By no means should anyone be looking in the near term to replace additional flying hours with simulator hours. Rather, the approach needs to be one bent on recapturing the massive amount of continuation training lost over the last decade. Concurrently, the benefits of DMO can be leveraged in a manner to close the gap on the CT ramp towards combat MEC proficiency.

The continued initial success of DMO according to pilot opinion will only remain so with continued efforts to ensure realism, concurrency, and transfer of training remain high. DMO truly can provide the leverage needed by the USAF to bridge the training gap created from a decade's worth of technological advancement but hampered by massive reductions in sorties.

LIST OF ABBREVIATIONS

AAI- Air-to-Air Interrogator

ACC- Air Combat Command

AFI- Air Force Instruction

AFRL- Air Force Research Lab

AMRAAM- Advanced Medium Range Air-to-Air Missile

CT- Continuation Training

CCIP- Common Configuration Implementation Program

CMR- Combat Mission Ready

DMT- Distributed Mission Trainer

DMO- Distributed Mission Operations

FAA- Federal Aviation Administration

FHP- Flying Hour Program

F-16 WIC- USAF F-16 Weapons School

JHMCS- Joint Helmet Mounted Cueing System

LANTIRN- Low Altitude Navigation and Targeting Infrared for Night

MC- Mission Capable

MEC- Mission Essential Competencies

MMC- Modular Mission Computer

MQT- Mission Qualification Training

MTT- Multi-Task Trainer

O&M- Operations and Maintenance

ON/SW- Operations Northern and Southern Watch

PAA- Primary Assigned Aircraft

RAP- Ready Aircrew Program

TOT- Transfer of Training

USAF- United States Air Force

UTD- Unit Training Device

UTE- Utilization

VFR- Visual Flight Rules

WTT- Weapons Task Trainer

WOT – War on Terrorism

Notes

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