TACTICS DEVELOPMENT AND TRAINING PROGRAM VALIDATION IN DISTRIBUTED MISSION TRAINING

A CASE STUDY AND EVALUATION WITH THE USAF WEAPONS SCHOOL

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ABSTRACT

When mission requirements emerge to test or validate tactics or training programs, state-of-the-art distributed training systems afford a bridging method for efficient exploration and development if used with appropriate attention to system strengths and limitations. The United States Air Force Weapons School's 16th Weapons Squadron is the first USAF advanced tactical training unit to harness distributed simulation technology specifically for exploration, validation, and enhancement of air combat tactics training programs. The Air Force Research Laboratory's F-16 DMO research site teamed with the USAFWS to provide DMO facilities, technical support, data collection, and training analysis. With fours years of program development and two years of performance data collected, this paper examines the 16th WS program as a case study to provide a roadmap of lessons learned for distributed training application in the advanced air combat training environment. The discussion opens with an assessment of mission constraints and requirements that drove the exploration of advanced training simulation applications in the F-16 and F-15 Weapons Instructor Courses (WIC). The examination then moves to a discussion of Air Force Research Laboratory and WIC data collection methods to assess graduate combat capability in DMO. The program's evolution provides the context for discussing perceived and tangible results along with their implications for future extension of simulation technologies tactical training. Performance assessment comparisons between AFRL and WIC methodologies are explored in the context of the current DMO training program in both objective and subjective methods. Finally, the results of the 16th WS training initiative are compared to the USAF concept of operations for distributed mission training/operations for an examination of the implications of current lessons versus long-term program vision.

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Major Lance Landrum is the phase manager for distributed mission training integration in the 16th Weapons Squadron's F-16 Weapons Instructor Course. He is a fully qualified F-16 instructor pilot in the program, employing all variants of aircraft and their sensor suites. Major Landrum's duty as the principal integrator of DMO to the current level provides front line empirical observations unavailable in any other forum. His outstanding work at the USAFWS has been recognized by the USAF Chief of Staff, who has recruited Major Landrum for immediate assignment to the CSAF staff.

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INTRODUCTION

In the continuing evolution of warfare and warfighting capabilities, those tasked to develop combat power with modern weapons systems must deal wisely with the confluence of resource shortages, heightened sensitivities to environmental impacts of military operations, expanding weapon and sensor envelopes, and increased population pressures on existing ranges. At conception, distributed mission operations (DMO) offered the possibility to bridge these obstacles to development of combat power by transferring much of the high impact and resource intensive training to virtual space. The lure of mission rehearsal, devoid of budgetary, resource, airspace, quiet hour, and environmental restrictions is compelling and quite necessary for the success of an emerging system. As researchers forge ahead in developing DMO systems, the attributes of the simulated fight space must align closely enough the real world mission environments to provide not only experiences of effective fidelity for quality training, but also prevent errant judgments about learning outcomes and warfighting principles at tactical and operational levels.

As research continues in DMO integration, it is important to maintain focus on areas that have high potential to degrade the final product both in the eyes of the operators it trains and in the reality of warfighting effectiveness. Key areas of concern center in the concept of training transfer and fidelity as is always the case in simulation training. In assessing training transfer, researchers must find ways to link existing live-fly training assessment techniques to those exploitable in DMO systems. Avionics software suites in fourth generation aircraft and beyond demonstrate the ability to capture relevant mission data for evaluation and learning. Additional systems such as air combat maneuvering instrumentation and sensor video recording aid in the capture. In practice, training operations attempt to assimilate as much of this data as possible for establishing truth conditions which are then manually processed in subjective evaluation procedures evolved over many years of human training practices. Distributed mission operations offer considerably more objective promise in evaluation and assessment since the system constellation generates all relevant mission data. This presents an opportunity to examine what trainers view as important in assessment and develop automated solutions in near real time for performance evaluations. The goal of researchers is to intelligently collect relevant truth conditions in an automated evaluative process that provides tangible assessment of operator performance at individual, team, and force levels. The first section of this paper examines a case study of the USAF Weapons School's F-16 Division, now the 16th Weapons Squadron to expose some of the transitional challenges between a structured operational syllabi and research. Both missions have divergent objectives, both rely on the same data availability, and both go about business in very different methods. For researchers to study training impacts of DMO systems, proper translations of methods and data must take place.

On the issue of system fidelity, developers must not only provide adequate cockpit or work station ergonomics (to include visual systems), but must also consider the impacts of constructive elements and their fidelity to training and to the more valued prize of warfighting effectiveness. Operators in the fighter community have seen a long list of training devices employing varied levels of simulation fidelity – from laptop part-task trainer to cockpit stations. In each system, operators have also quickly recognized not only the limitations of the representative setup, but also the *tactical representation* of constructive threat systems. Developing a threat system to complement DMO systems seems straightforward; model threat physics, place them in doctrinal locations, make them do what adversary forces would do. Simple, right? Now consider that intelligence estimates are just that – estimates. In the evolution of training devices, operators in the F-16 community have experienced a spectrum of perceived capabilities from *Nerf SAM* to *SAM from Hell*. Both happened to be constructive models of the SA-6. One was easily defeated using a non-doctrinal technique developed as a *cheat code* to the training device, the other simply went unused because neither existing doctrine nor a work-around cheat could be developed for it. While this is a limited example, it speaks to a larger problem that must be addressed in DMO – how to model the threat realistically and in a fashion that has control monikers and levels acceptable and familiar to instructors. The second section of this discussion examines a related case study in the F-16 WIC of a tactics validation phase using DMO-A resources at AFRL's Mesa site. The implications of this study translate to larger mission rehearsal operations proposed as the staple of DMO.

Before launching into the studies, it is important to note for the researcher, system developer, and academically inclined that much of the data for this presentation is first-run empirical observation. The operations were conducted under the leadership of the principal author at a time when the mission was to get the job done in a tight time frame and restricted resource environment to make substantive improvements to air combat training. It is offered in that light – the problem faced, the strategy employed, and the results perceived. The goal is to provide researchers with feedback from a real-world application of a DMO-A system to further the science behind future efforts in DMO development.

USAF Weapons School – A Case Study in DMO Training Application

The USAF Weapon School's DMO incorporation experience provides an example of the compromises and synergies of merging simulation capability with existing combat leader/instructor production. In developing a working relationship, research efforts remain sensitive to the important role the WS plays in developing real-world operational capabilities for the USAF. Emerging needs of the F-16 WIC's instructional mission has been one of the drivers of AFRL's DMO application during a 2.5 year research partnership. As the WIC syllabus closes in on its final form for DMO employment, a stable operating environment will allow research priorities to reemerge as recognition of need for data confidence in the effort takes center stage in both disciplines. Both researchers and WS program managers are looking for concrete, objective observations of performance enhancement. The aims of data collection are divergent, but compatible. AFRL's data collection supports development of the *mission essential competencies* construct for DMO/RAP integration, while the WS pursues demonstrable increases in instructional competence out of its trainees, training efficiencies, as well as hard data to buttress budgetary positions for the long-term stability and effectiveness of the program. The WS's F-16 WIC is, in many ways, a concentrated example of problems operational fighter units face in normal conditions. As such, it amplifies some problems faced in operational integration of DMO across the USAF. The following discussion puts light on some of the complexities of DMO inclusion when employing a unit in its real world mission and how the AFRL and USAFWS team approach provides options for resolution to the final goal of DMO incorporation through mitigation of conflicts and enhancement of mission support.

Weapons Instructor Course and Environment

The F-16 WIC, one of 14 separate units in the Weapons School, is charged with the annual production of 20-24 fully qualified F-16 weapons and tactics officers. These officers, upon graduation, become the chief instructor of a line unit in their specialty. Later, in secondary assignments, WS graduates advise major command staffs on matters of tactics, training, weapons development, weapons system upgrades or combat planning and execution or assume command of line units. The 5.5 month course of study repeats semiannually in coordination with all other WS units. Attendance requirements are driven by operational unit needs worldwide and codified by personnel action requests developed at the Air Force Personnel Center. Qualification received upon graduation becomes the officer's primary specialty for a minimum of 3 years and a maximum of the extent of the officer's career. The course of instruction is formally reviewed on a biennial cycle to adjust resources and schedules of DoD resources to support this highest level of training a fighter pilot (or any other mission specialty covered by the WS) will receive in any formal training program.

Elements of all services, and the most coveted operational resources of the national command and control structure, must be scheduled up to 24 months in advance to meet the restrictive schedule environment of the WS program. Additionally, nearly all of the Weapons School's WICs conduct training on or in support of missions on the Nellis Tactics and Training range. The NTTR is a national-level asset with multiple users vying for the limited time in a 24-hour day. The F-16 WIC is one player in a large population, tightly packed into existing range schedules, and movements of time and resource requirements have a ripple effect to all other users. A central influence for the 2.5 year span of program adjustment is the inherent inertia of range scheduling and support integration in the larger NTTR program. A decision to incorporate DMO training in the F-16 WIC required manipulating many other integrated resources with 2-year scheduling horizons to achieve the proper instructional system characteristics for DMO optimization.

The instructional environment of the WIC is the most rigid of F-16 training in the USAF. The WIC provides the highest level of training in two separate and specialized versions of the F-16. No other unit in the USAF provides this level of training to F-16 pilots. The course builds skill levels in four separate planes of competence – individual aircraft operation, tactical team conduct, combat leadership, and instructional capability. The course spans the realm of training experiences used in the combat air forces (CAF) to focus skill building on the instructorship level. A central issue in instructorship is having the credibility to demonstrate skills and provide correct examples of behavior. It is in this area, that the WIC develops its most intense character for the student trainee. The course is not designed deliberately to develop proficiency; it instead relies on the selection process to provide proficient operators to be developed into highly capable tactics instructors. The repetitive conditioning focus of the WIC is *instructor fundamentals.* Candidates progress through a series of sample building block sorties taken from the CAF that extend capabilities from previous experiences and afford little if any focused practice or repetition.

Mission Need – Critical Skill-Building Experiences in Air Combat and SEAD Missions

Minimal repetition within a rigid schedule of progression in the F-16 WIC is a result of instructional system design grandfathered from early F-16 operating protocols and continuation training regimens. It now stands as the most enduring detriment to WIC training operations. The F-16 has evolved into three unique types with moderately different missions and avionics capabilities. The ANG F-16C is a precision strike aircraft with slightly different sensors than the USAF/ANG F-16CG. The F-16CJ is primarily an electronic warfare asset for suppression of enemy air defenses (SEAD) missions, but continues to evolve precision strike capability. The simplistic operating protocols of the early F-16 have been expanded beyond a basic conventional attack role while simultaneous pressures on the flight training regimen have reduced inherent practice time at home units. Candidates come to the WIC from all three F-16 types. While engaged in the course, they are required to operate both the F-16CG and F-16CJ. Active duty trainees operate one of these two aircraft in their home unit but must quickly gain or regain (if previously qualified) proficiency in the other aircraft. Students from the Air National Guard are more likely not qualified in either CG or CJ version because of the large population of F-16C Block 30 aircraft in the Guard. Guardsmen attending the course are required to adapt to both active duty variants in limited time. Fortunately, the air combat equipment of each variant retains strong correlation of switchology, radar modes, and weapons capabilities, but situation awareness avionics present diverse capabilities. Aside from the WIC's requirement to build rapidly the ability to operate unfamiliar avionics suites in unfamiliar missions, the experience base brought by each candidate serves to complicate skill and proficiency development.

According to Rand Corporation's Project Air Force study, an empirical review of unit readiness found declines in combat readiness due to over-manning policies, shrinking range resources, and dilution of training effectiveness within established flying hour programs. The Rand study surveyed standardized command reporting data under both *graduated combat capability* (GCC) and *ready aircrew program* (RAP) standards to arrive at the basic conclusions. Within the F-16 operational community itself, unit commanders establish training priorities based on their perceptions of real-world mission requirements. In doing so over the last 10 years, air combat training has atrophied behind training for air-to-surface missions consistent with expectations of Operations SOUTHERN WATCH, NORTHERN WATCH, ALLIED FREEDOM, etc. The resulting conflict at the F-16 WIC is the arrival of students to a course for which they not only lack individual skill proficiency to accomplish, in some cases, but also never developed requisite leadership and instructor skills to accomplish air combat missions within the syllabus. A compounding of organizational and environmental detractors conspire to reduce student performance in areas once regarded as challenging only in leadership and instructional skills, not in individual and team execution tasks.

Air combat training is collectively acknowledged by the F-16 community as a secondary mission behind strike and suppression. It is also long recognized as the only live-fly training accomplishable in training venues where adversary exposure and feedback is readily generated and gleaned for mission analysis in a threat environment. In the community of weapons and tactics officers, air combat capability holds another highly valued measure of personal competence. Air-to-air combat skills, knowledge, and leadership qualities are the most dynamic and most difficult to master. Therefore, rightly or wrongly, the community of aerial tacticians favors it as the absolute measure of projected combat competence for a variety of missions in the absence of anything more scientific. While there are many reasons for the shift in training focus in the F-16, the continually declining competence in air combat execution in comparison to previous classes is noted with increasing alarm at the WS. Empirical reviews of WIC training summaries confirm low skill levels in basic air intercept switchology as well as procedural C2 and situation awareness development at the beginning of air intercept training. This condition has been resident throughout the course's life, beginning at sporadic nuisance levels and eventually developing broader and more consistent character as the F-16 dispersed into broader mission areas and avionics suites. In order to be an effective instructor in the operational environment, students are required to meet high standards of personal execution and leadership skills in all missions and roles. If they fail to achieve these benchmarks, missions are repeated until they do. The WS flying hour program and range availability preclude more than an occasional failure. In an environment typically hostile to simulation the WS concluded, in the face of shrinking range resources, static flying hour allocations, and limited schedule adaptability, that training devices must be employed to relieve the pressure of poor trainee performance on schedules and resources.

Prior to DMO availability, the F-16 WIC initiated two simulation experience elements to bolster student performance in several areas of the WIC course. Both efforts were primarily focused on specialty roles of the F-16CJ (SEAD) and the F-16CG (Precision Strike); however, both devices were employed in air combat disciplines to counter low intercept procedures proficiency levels as well. In fairness to the devices, it is important to note that neither was developed for advanced tactical training, nor were the peculiarities of the F-16 WIC course taken into consideration during development. Both were fielded for unit-level proficiency maintenance versus skill development in a formal course setting. The *weapons and tactics trainer* (WTT) is a CJ part-task trainer of moderate fidelity. Its role in the F-16 WIC was and is to acquaint non-CJ students with the basic switchology of suppression avionics and weapons. The shortfall of the WTT is a low fidelity characteristic in the radar display and switchology when dealing with targets in close proximity. The *unit training device* (UTD) is a higher fidelity device capable of acquainting non-CG students with the avionics and weapons switchology of precision strike capability using the LANTIRN[1] system. The UTD's fidelity emulates aircraft capabilities in close-grouped target detection and is the preferred air combat training device for primary skill development; however, in broader targeting applications, both devices can provide acceptable experiences to develop desired skills. In air combat training, both devices have been employed as preemptive remedy to combat two tiers of performance deficit recognized in the student population – radar manipulation skills and command and control interaction. Course managers have developed substantial scenario sets and instructor support guidance to expose and practice procedural C2 with a weapons director entity; however, the systems are incapable of adequately simulating full team play in a tactical scenario. Both devices are single cockpit part-task trainers with an instructor console. Neither can link to another device in the WIC course to provide basic team interactions or C2 support.

In the F-16 WIC curriculum, single cockpit device training simultaneously exercises mission rehearsal and fundamental skill development. Scenarios for basic air intercept expose the student to the fundamental working parts of tactical protocols and procedures used in the F-16. In the part-task trainers, time is somewhat limited, but the ability to rapidly reset failures for further attempts allows proficiency development through repetition while reserving time for complete examination of adversary countertactics principles. In live-fly training, range time precludes full examination of countertactics proficiencies, so instructional strategy relies on sampling across a spectrum of complexities to provide the student a sampling of efforts to instructionally assess knowledge and skill levels. In these missions, basic operations and tactical protocols are stressed as a foundation for proper team intercept operations. The intercept syllabus phase rapidly progresses to four-ship employment in multiple adversary threat pictures. Single station device training, as important as it is for switches and procedures, falls well short of preparing students for the rapid onslaught of team play and command and control interaction necessitated by the limited flying hours afforded to tactical intercept training.

Since starting in 1982, the F-16 Weapons Instructor Course syllabus has expanded from 4 months to 5.5 months and assimilated new missions (SEAD, precision strike, night operations), new weapons (AIM-120, Paveway I/II/III, various canister weapons, AGM-88 HARM), and their accompanying avionics suite upgrades (Blocks 10/15/15S/30/40/50, LANTIRN, HARM Targeting System, NVG, radar OFPs, Multi-mission modular computer, etc). As a result of these expansions in mission responsibilities, syllabus time devoted to air combat has atrophied naturally from mission prioritization in the instructional system development process. The syllabus followed a structure carried forward from the first multirole fighters in the USAF until the most recent revision in 2002. Historically, multirole fighter training divides the course into two distinct and nearly independent sections. The first segment of training is devoted to air combat, the second into the surface attack disciplines. All levels of F-16 training have been conducted in this manner until the WIC's most recent

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[1] Low Altitude Navigation and Targeting Infrared for Night

syllabus change. Examining the rationale of the original sequence, developers of the existing multirole training concept provide a credible method to acquaint a novice with a basic aircraft in its lightest and most forgiving configurations. After basic aircraft control proficiency standards are achieved, training moves on to more dynamic mission elements with a lightly loaded, low drag aircraft to maintain the highest margin of safety possible. Until proficiency is mastered in the basic aircraft configuration, all training is conducted at high altitudes. Once the student has proven mastery by completion of the air-to-air training segment, graduation to more difficult aircraft handling scenarios and mission complexities follow.

The second segment of basic multirole training begins with surface attack basics and again proceeds to more dynamic levels with mission-realistic weight and drag configurations. For WIC training, following this sequence produced a period known to students as the *horse latitudes*, a nautical description for periods of extreme calm. A relaxation of effort back to basic skill refreshment in air-to-ground disciplines consistently atrophied skills sharpened in the complex finish of the air-to-air phase. Examination of training records from 1988 to the last class in this syllabus structure (fall of 2002) demonstrates increasing commentary of weak starts in air-to-air skills after the mid-course retreat from air-to-air skill development. In the air-to-ground phase of training, complexity rose from basic applications of ordnance to full blown contested matches with live A-S weapons and live airborne adversaries. Following this sequence, the program of instruction was unable to refresh air-to-air skills to the level required in the final phase of training, and attrition was historically high for student performance deficits in air combat basics, leadership, and instructional levels. The WIC retains a characteristic of mission training wherein the highest level of mission complexity requires the fighter team to fight through substantial air and surface threat to deliver air-to-surface weapons on a relatively deep (behind enemy lines) target. The rationale for going to this extreme rests on both over-training principles as well as the objective of training weapons and tactics instructors versus basic operational pilots. It should be noted that in basic qualification training, the level of scenario complexity does climb to the intensity of the WS because USAF training structure feeds these graduates into follow-on *mission qualification training* (MQT) programs immediately after graduation. In MQT the trainee expands skills with more robust scenarios, but typically never at the level of the WIC's final phase. For the WIC graduate, the end of the course typically means assignment to lead a unit's tactical training program. In addition, WIC graduates are delegated responsibility from the unit commander to develop flight leads and instructors from within the unit's personnel resources. Instructional credibility and situation awareness requirements in increasingly complex training scenarios demand the graduate be able to understand and demonstrate desired behaviors of execution while providing the highest quality training.

The latest WIC syllabus reflects a training method suited to experienced F-16 pilots training for instructional proficiency. Training paths examine the same training scenarios in a revised sequence blending air combat and surface attack fundamentals early in the course to refresh skill levels across the spectrum of missions. Following this segment, the new program aligns the higher complexity experiences to provide a pathway which continually improves and expands air combat proficiency while steadily introducing greater air-to-ground mission complexity. The rationale behind this reorganization stems from recognition that the most practiced arts in operational flying, those surface attack procedures used nearly every day in an operational squadron, appear to have the longest shelf life when not exercised. Again, review of training reports for the period 1988 to 2002 indicate students had little to no problems in air-to-ground skill retention after a two-month period of concentrated air combat training in the beginning of the previous course method. The empirical evidence forms an opportunity to examine periods of inactivity in both air-to-ground and well as air-to-air skill maintenance with important influences. In the air-to-ground role, a lengthy period of practice and skill development measured in years appears to have a better retention level than a recent concentrated skill development period measured in weeks.

The inclusion of DMO training and rehearsal for F-16 WIC candidates began informally as a precursor to the actual course of instruction before syllabus reorganization. Mesa's ongoing DMO training and rehearsal research using visiting teams of USAF and ANG F-16 pilots was recognized by WIC leadership as a beneficial experience in coping with the demands of the WIC course. The genesis of WIC interaction with DMO training was initially to endorse the Mesa program to prospective candidates and establish selection guidelines giving credit for those attending within the previous year.

In spite of previous interaction with Mesa's DMO training research facility by WIC candidates and instructors alike, inclusion into the formal WIC training program began as a modified approach to Mesa's ongoing research rather than a clean sheet WS approach. Modifications were made for time constraints more than any other factor. The existing research program brings teams of pilots together for an intense exposure to air combat lasting 4.5 days. At the beginning of the week, all pilots are tested and exposed to benchmark scenarios to subjectively evaluate their current level of competence across the set of mission-essential competencies required to conduct air combat. The training regimen following initial benchmarking exposes pilot teams to progressively more demanding scenarios until on the final day, benchmark scenarios are again flown to formulate a "before and after" measure of various competencies. The F-16 WIC initiated training using this approach to build experience before engineering more focused training. It is important to note that, from the WIC perspective, team performance, individual performance, and mission accomplishment can often be highly variable within the same operation and one does not necessarily establish a valid or reliable measure of another. Mesa's program attempts to bridge all of these variables to assess the true state of competence at all levels. The WIC likewise views all aspects of performance and objective accomplishment to draw conclusions on student performance. The similar viewpoint is not by accident. AFRL's Mesa facility operates on knowledge gleaned from the best operators in the field and reflects the warfighter's needs accurately. This attitude was instrumental in developing the first formal relationship with the WIC.

Each class conducted by the F-16 WIC at Mesa brought new variations to DMO training and rehearsal nearly every training evolution. The initial training/research periods shared characteristics of both existing placement in the syllabus as well as some individual phase manager interpretation of training requirements and methodology. It is important to note that trial and error instructional system development is a long-standing success in WIC development. The first divergence from the Mesa approach occurred as a result of the first attempt to solve the syllabus' long layoff in demanding air-to-air scenarios between the end of focused air combat phase and realistic mission training at the end of the course. It was thought that DMO training and rehearsal would prove useful in combating this layoff-produced drop in air-to-air skills, so it was first employed as a mission rehearsal tool for the end-of course Weapon Phase. This phase is the final stretch of training in which students fight through live air and surface threats to bomb targets with actual operational weapons. Mesa's research was not fully capable of replicating the WIC scenarios, so extensive console intervention was engineered and executed to close the gaps. This experience was considered beneficial by the WIC DMO training and rehearsal phase manager as well as participating students in end-of-course critiques. However, a review of training reports and gradebooks from the class showed no appreciable gains in graded performance over previous classes. Unfortunately, the WS-generated revision of scenarios did not serve AFRL researchers either as the set of conditions upon which to measure was inconsistent with all other data compiled to that point. The WS's consistently inconsistent approach to DMO employment over the next several classes produced unique data sets which could not be analyzed confidently under existing AFRL research protocols. The one consistency noted in the transitional period of DMO incorporation is a favorable subjective evaluation of DMO experience by course graduates and a request to align to the proposed final syllabus form for January 2003.

The latest F-16 WIC syllabus was approved for training beginning January of 2003. The course now opens with rudimentary aircraft handling and basic visual air combat, and then shifts to the basics of air-to-ground employment interleaved with air combat skill retention. The next phase of training focuses on air-to-air skill building and retention by starting with basic intercept training and progressively increasing complexity of air combat scenarios and seamlessly transitioning into the weapon employment phase where air combat continues to increase in complexity with the added complications of external stores and more mission objectives than simply killing an airborne enemy force. DMO now fits into the program at the beginning of this long ramp-up to air combat capability. It is employed by the WIC to develop the most critical skills in the areas of radar operations, air-to-air weapons employment, situation awareness development and maintenance, and combat leadership and decision making. The DMO phase manual stages the training to exercise major tactical maneuver concepts in the context of scenarios that the student will see in the coming two to three week period. This focused intervention, first conducted in the 2003 spring class (03A), has been subjectively judged a striking success by the WIC's squadron commander. Initial survey of the grading results of missions accomplished by the students of 03A indicate a higher level of task performance (the USAF grading standard) and a lowered attrition rate due to student performance deficits.

At this point in time, the WS and AFRL have agreed to stabilize the program for a period of time sufficient to gain confidence in data collection and assessment. The next step will be to establish credible performance assessment tools using the *mission essential competency* construct and *performance evaluation and tracking system* under development at AFRL. One of the measures likely to be taken will be the comparison of subject matter expert grading practices with performance evaluation tools. At face value, both grading standards may appear to target the same skills and knowledge sets, but it is important for the credibility of the program to understand and account for WS instructor expert grading practices. The most visible difference between AFRL and WS efforts is the existence of leadership and instructor skill sets graded in all missions by the F-16 WIC. The fundamental mission of the WIC is to produce instructors and combat leaders. Both programs focus on operational skill sets as well. The grading standards employed by the WS demonstrate a concomitant stability and noise-level inconsistency that may prove problematic for research comparison due to their purpose as defined within the WS mission.

Gradebooks at the USAFWS are active only during the course and do not follow the student to his/her next assignment. The purpose of the grade book is to provide the next instructor with details of previous performance and guidance for conduct of the next mission within the syllabus. The F-16 WIC is a small operation by formal training standards and much of the instructional crosstalk occurs less in grade valuations than in the commentaries conveyed in both written and verbal formats between WIC instructors. To make the point more graphic, examination of distinguished graduate grade averages over 10 courses compared to averages of remaining participants showed no definable margin in valuation of flying events. Examination of commentaries made by instructors provided a clearer picture of performance discrimination; however, the commentaries also reflected personality traits of individual instructors as well as indications of time in status and time available to complete the commentary. Simply stated, evaluation practices at the WS are highly subjective within the latitudes of performance standard descriptions set forth by Air Combat Command, yet they provide the WICs with sufficient information to conduct the course confidently. For researchers, a substantial portion of the WS methodology is and will remain untenable. That portion is the verbal transactions between instructors conducted between flights and in summary meetings at the end of each phase. To the WS's credit, procedures are evolving to capture large-grain performance from class to class; however, individual performance documentation must be re-engineered for accuracy. If undertaken, the process will aid research efforts in comparing performance evaluation methods, yet must continue to serve the WS's mission as a top priority.
To establish credible comparisons in research, AFRL is examining methods to enhance objectivity of operator skill proficiency in WS grading practices using the *mission essential competency* construct. The project will examine rapid documentation methods for instructors to form a more complete *documented* evaluation while reducing overall administrative time and effort related to grade book maintenance. Key attributes of the system must include speed, accurate descriptive and constructive commentary, consistency of grading across the instructor population, and access to both numerical scales of performance as well as commentaries, real-time reporting to commanders, security, and confidentiality in exports to research efforts. If this proves a reliable method of data capture, it will help to align AFRL and WS evaluation standards into comparable data sets and pave the way for objective performance tracking and comparison studies.
A note of follow-up is needed at this point to discuss the F-15 WIC's examination of DMO-air employment in training. An initial consideration was made by the F-15C school to employ DMO-air within the syllabus in a similar fashion to the F-16 WIC. To date, that incorporation has not happened. The reasons are fairly straightforward and should speak to DMO developers about what drives the force to DMO. First, some of the F-15C community has DMO-air trainers at home stations and uses them frequently in Ready Aircrew Program (RAP) training. Second, the F-15C operational mission and WIC program is a single mission focus training program that is adequately resourced with live-fly adversaries. As, such, it does not have the same skill deterioration factors to deal with when training in multiple mission roles. Third, the current threat modeling and inability to control tactical attributes in the same terms used throughout doctrine and training venues generates some disappointment among WIC IPs. The F-15C also enjoys a single mission focus retained and unchanged since its initial operational capability in the U.S. Air Force (F-15E aircraft have a separate WIC and personnel system). Students arriving for WIC training are the model for WIC training – proficient expert operators ready to be made into the highest level instructor. In short, there is insufficient crisis in resources to drive the F-15C WIC toward DMO for course conduct at this time. However, effort should be exercised to look at options. This effort may show efficiencies to be gained in course conduct, increased competency levels at graduation, and most to account for possibility of reduced resources in a fiscally limited environment. The program gained momentum for a short time during the F-16 spin-up, and then died a smothering death under the weight of other more time critical priorities. Time restrictions in the F-15C WIC course precluded devoting the time necessary to examine options. It may be to the WS's advantage to reenergize this effort. An added benefit of incorporating DMO resources in the WIC syllabus is so WIC graduates will learn to effectively utilize the capabilities of DMO resources in their home station operational training environments.

Mission Need – A Venue to Contemplate and Validate Methodologies

Prior to DMO becoming a formal part of the WIC course, the USAFWS's F-16 Division employed Mesa's DMO training technology in employment training validation studies. At issue for study: development, adoption, and incorporation of tactical employment standards for air combat missions. In short supply: range space, aircraft, adversaries, and time to exercise the options available. Tactics validation was first sparked in late 1999 when the F-16 WIC recognized a clear division in thought processes employed by pilots in air combat scenarios. This division existed at all levels in the operational community and formal training units and divided the community of aviators into two camps of dubious interoperability. A growing awareness of incompatibility of methods was noted and frequently highlighted in evaluations as the culprit for declines in overall mission effectiveness at the WIC. The genesis of employment divergence stems partly from the aircraft's history of development and the lack of a focused effort to reengineer employment doctrine as capabilities expanded beyond initial AIM-120 missile incorporation. Prior to AIM-120 operational capability, extensive operational test and tactics development was conducted with F-15C and F-16 airframes to establish the first comprehensive tactical doctrine for beyond-visual-range (BVR) missile employment using the missile's revolutionary *launch and leave* capabilities. For the F-16, whose secondary mission is air combat, the tactical doctrine remained relatively intact for approximately 10 years.

The F-16 began as the low end of the USAF's high-low mix of F-15C and F-16 aircraft to combat the growing strength of the Soviet Air Force. As the low end, the F-16 was developed as a fighter bomber with only short-range missiles and conventional freefall bomb capability. The evolution of the aircraft saw repeated additions of new equipment with companion shifts in training focus and predictable dilution of exposure to each mission area as the set of missions the aircraft could conduct became progressively larger. The F-16 continues to grow in capability to rival the F-15C in air combat. The main differences are radar detection range and total weapons load-out capability. The F-15C enjoys superiority in both areas over the F-16.

The F-15C's mission is solely air superiority. Initial tactics development produced similar concepts in both aircraft and led to operational compatibility as an objective end state of the original *high-low mix* fighter concept. Differences in the F-15C and F16 tactical doctrines for air combat began to emerge in the mid 1990's when the F-15 reexamined targeting principles to obtain better situational awareness for the flight leaders charged with managing forces during engagement. Fighters employ the fire control radar not only for missile support, but also rely on it to provide the highest fidelity of information about the combat situation immediately in front of them. When radars are employed to support missiles, a measure of radar resources are tied up and not available for intelligence gathering within the fight space. To avoid delving into classified tactics discussions, the situation developed into the F-15C force departing on a divergent employment philosophy as their systems grew *more into alignment* with expanding F-16 air-to-air capabilities.

A study of F-15C tactical employment was undertaken by the F-16 WIC in order to examine the lessons learned over 10 years of operational employment in the single role of air superiority with the AIM-120 missile. It was decided, that a bridge from the F-15C's high experience level with similar capabilities could span to the F-16's increasingly similar capabilities to close the gap of experience in development of a common tactical employment method for the F-16. Additionally, the USN's F-18 TOPGUN methods, taught worldwide to USN carrier pilots, were examined for both concept and compatibility. The outgrowth of the tactics cross-flow study showed the F-16's traditional doctrine being challenged by exposure to the re-engineered F-15C and F-18C doctrines. Hence, competing and incompatible doctrines as noted earlier in the discussion. The particulars which make the doctrines incompatible quickly traverse security bounds and must be reserved for discussions in another forum.

Mesa's DMO testbed availability for tactics validation study coincided with early efforts to align research and subject matter expertise in pilot training. The needs of both organizations produced a synergistic relationship which fueled resolution of F-16 doctrine as well as developing DMO training system converts from a traditionally *simulation-hostile* group of operators. The organization and methodology of this effort sheds some light on mission rehearsal uses for DMO as well as establishing a framework for the long-term development of useful mission rehearsal suites. Simulation at any level <u>is</u> mission rehearsal. Current Air Combat Command guidance states that DMO air (fighter cockpit linked simulators) are only part of a larger *distributed mission operations* concept where mission rehearsal for theater-wide employment will be the primary focus. DMO-air provides mission rehearsal capability heretofore unavailable at the flight employment level. Consistent with mission rehearsal concepts, establishing a trial effort in simulation to validate planning and projected execution may exist at lower levels. The WS's validation occurred at a lower level, using <u>existing tactical concepts</u> formed into an employment plan against a defined threat level. In considering Mesa's DMO facility for mission validation studies, the WS identified characteristics that would shape the extent to which validation studies may be taken. The foremost issue for any mission rehearsal simulation is to what degree accuracy of real-world threat emulations must exist to produce the desired preparation of mission crews. Other items identified by the WS's analysis included visual acuity issues of target contrast in a visual arena, weather effects, lack of motion, lack of G force, and differences in cockpit configuration from USAF F-16CG and F-16CJ aircraft.

Workarounds were established to compensate for the different cockpit configuration. The baseline air-to-air capabilities of each F-16 type are close enough to allow acceptable skill development in the F-16C Block 30 cockpits of the Mesa facility. Weather issues were considered and quickly diminished in importance for several reasons. First, Nellis AFB rarely experiences weather conditions that affect tactical employment. Second, the objectives for DMO employment were less than full tactical development in all weather conditions. Lack of motion and G force was considered a minor issue prior to the study; however, these inputs were later recognized as major factors in station-keeping while in formation. Loss of tactile cueing as it exists in the real aircraft places a burden on the pilot's visual scanning and cognition of visual cues that is not resident in live-fly operations. When paired with visual resolutions that are less than real-world vision inputs, the situation presents an even greater burden on cognitive visual skills used to fly formation than would exist in a real aircraft. Workarounds developed for formation flying rely on data link position information. This method was deemed acceptable because it aligns closely to night operations where night vision systems reduce visual acuity and ability to accurately estimate range and closure in comparison to day operations. This caused a minor shift to daytime DMO-air employment strategy, but called upon resident skills from night employment and so was considered minor in affect. Visual imaging of close threats was considered to be of unacceptable character for close-in combat maneuvering. Nearly all feedback for visual fighting was negative with the exception of DMO's expanded visual azimuth and elevation coverage over existing F-16 training devices. The objective of the employment study was focused on BVR missile doctrine so the visual arena was considered to be out of bounds for valid data gathering.

The characteristic having the most impact on BVR tactical validation studies was not identified by the WS until the program began. After experiencing the threat presentations and emulations, it was clear that the existing system of threat replication would require operator intervention to maintain consistent exposure to threat definitions as expressed by intelligence estimates. An enduring problem in AFRL's simulation facility as noted by the WS's simulation processes is the inability to present constructive threat models capable of being controlled to the degree required for instructional scenario purity. In the current threat model used in Mesa's DMO facility, considerable effort must be placed on preparation of scenario presentations to affect training objectives. Once the system is in operation, missile fly-out calculations, aircraft performance characteristics, and probabilistic interpretations require operator control to establish proper training outcomes. To allay detriments to student learning, AFRL and WS operators man the DMO mission director console and fine-tune outcomes of engagements to reinforce training objectives. In validation studies, such interventions run a moderate to high risk of producing improper conclusions. On the other hand, allowing a constructive model of dubious emulation quality to run untethered may also produce equally errant conclusions. As the WS considered the impact of threat modeling, it was decided to augment DMO validation studies with live-fly scenarios at Nellis using live adversaries skilled in accurate threat replication. DMO validation studies were primarily constrained to flight leadership, system operation, weapons targeting, and communications pacing. Mission results became more important in live fly training scenarios to establish a rating of tactical effectiveness.

The conduct of validation studies in DMO followed two main avenues of attack. First, existing employment methodology, timing and team contracts were examined using F-15C and emerging F-16 doctrine. Second, DMO was employed as a tool to examine the validity of arguments against the new employment standard. Teams of WS instructors were sent to Mesa for concentrated studies of the new doctrine over multiple day periods. On average, instructors experienced in one week a level of air combat exposure that would require six months of time under the scheduling constraints at Nellis AFB. These focused exposures allowed already proficient operators and instructors to overcome DMO differences quickly and gain considerable experience in revised employment methods. Subjective feedback within DMO trip reports was consistently favorable from the instructor staff about the training potential of DMO. Validation studies were focused by providing AFRL staff members with the revised doctrine in higher detail than existing F-16 tactics manuals. With both teams understanding the nature and objective of the effort, significant progress was made on each experience.

Doctrine validation required exposure at varying levels of execution. Individual skill sets were practiced prior to DMO exposure using the F-16 WIC's WTT and UTD trainers. In these sessions, instructors examined employment actions from both element leader and wingman perspectives. The limited time afforded to WS validation drove preparatory examination in lower fidelity devices before full DMO-air events. In future DMO employment, consideration for inefficiencies of unused cockpits must be addressed by training and rehearsal staffs. At Mesa, cockpit vacancies were deemed by the WS to be ineffective use of the system. While this thought process was evident in validation build-up, the lack of two-ship linked simulation at Nellis required a limited degree of two-ship employment at Mesa. Once the preparatory training was accomplished, teams of WIC instructors examined the revised tactical concept as a flight of four with equal exposure to both flight lead and wingman positions.

The effort to consolidate F-16 air combat targeting and engagement methodologies into a single, coherent system was not entirely welcomed by the community at large. Key opponents to the system reacted with very little knowledge of the effort, objective, or the considerable advance studies undertaken by the F-16 WIC. Commanders of field units were mostly positive to the change when briefed. Those that resisted were concerned that the "new" method would take away valuable training time from staple missions. Some operational test pilots also offered resistance. Their objections took two forms – displeasure with what seemed to be their mission of *tactics development,* the perceived capabilities and employment training of average leaders and wingmen in field units (the WIC's mission), and argument over intelligence estimates of future threat systems. In order to answer these attacks adequately, validation branched in several directions.

The most straightforward portion of the validation occurred first. F-15C tactical targeting and engagement methods were practiced and evaluated in F-16 DMO air cockpits to validate similar avionics suites' capabilities. These exercises primarily focused on sensor cueing, leadership decisions, communications, and radar targeting allocations. A previously discussed limitation of formation station-keeping required assessment concurrently, but could not adequately be examined until live-fly validation studies due to the DMO's inherent visual and tactile limitations. Once the basics were studied and resolved to account for F-16-unique avionics issues, the study then branched to attack directly the concerns determined by advance studies and confirmed by elements of the operational and test communities.

The most prevalent argument used against the plan to consolidate tactics centered on the wingman. In an operational squadron, the average wingman is a novice with 100-300 hours experience encompassing all mission areas. The F-15C methodology employs the wingman as a near equal in fighting capability with the all others on the team. In early F-16 tactics development, the wingman's role conveys a lack of trust resulting possibly from the many other missions the F-16 conducts and corresponding lack of training time. To provide data for validation, several graduates of the F-16 basic course were employed as wingmen with WIC instructor leadership and instruction. As basic course graduates, they had no operational experience, approximately 80 hours of flight experience, and provided an example of the worst-case inexperienced pilot an operational unit would face. The pilots were exposed to a program of air combat training over one week in which the scenarios expanded from training experienced in the basic course to the most difficult scenarios employed in F-16 WIC instructor training. AFRL observers as well as the participating WIC instructors graded the students. Observer data showed skill progression to a level consistent with a high-experience wingman over the week. WIC instructor reports concluded that the week of training produced skill levels it would normally take 2-3 years of operational experience to develop. Three wingmen participated in the study with similar results. This is a small data set upon which to draw conclusions for research purposes, but for the operational objective it set out to achieve, the unimaginable wingman capability espoused by commanders and operational test pilots now existed in triplicate – issue laid to rest by DMO-air.

Another of the arguments against the WIC's plan was that the plan would not work for future threats and for similar-on-similar training due to avionics limitations. Live-fly studies supported the similar-on-similar argument and it remains a limitation to effective combat training. The answer for the field in this area is to secure as much dissimilar air combat training as possible on a regular basis. The ability to meet that objective is difficult with diminishing resources and high operations tempo around the world. Enter DMO-air again. A constructive threat array in simulation is not bound to operations tempo and is available for training as needed. The most pressing problem with constructive threat arrays is the confidence that they portray what operators will find in the real world. For the purposes of tactics validation, the intricacies of existing DMO-air threat constructs were not used to buttress any of the tactical principles. Instead, the F-16 WIC relied on extensive F-15/18 history and live-fly conclusions. In the near future, promising progress may be made with AFRL's next-generation threat system. In this system, researchers are employing physical modeling of threat systems and probabilistic computations to more accurately present threats in training. An enduring issue with threat modeling is how it is presented and controlled by the console operator, scenario developer, and/or instructor. The effort to create a viable training tool must include attributes which align to intelligence estimates and employment realities. Aircraft and weapons are straightforward physical models. Done correctly, they will remain relatively unchanged after implementation. The problem area in modeling, as it is the most decisive in real battle, is the modeling of the human attributes in the adversary force. In the WIC validation study, console intervention was required to control certain unrealistic inputs. For example, a constructive threat given *aggressive* human attributes generally does not emulate the constant compromises of teamwork, situation awareness, system operations inefficiencies, and tactical doctrine that a real-world adversary faces in battle. Likewise a threat modeled as *moderate* has nebulous meaning to an instructor aiming for the training of decision processes based on specific actions an adversary force might take in the conduct of known tactical doctrine. The answer for improved constructive threat modeling is three fold – use descriptions that follow doctrine/training practices and build the human attributes around their real-world determinants – awareness of fighter forces, reactivity to targeting, and rules of engagement – and ultimately the construction of accurate behavioral models.

The last of the major issues presented in the WIC validation study involved an examination of WIC and operational test practices and how they may or may not be best suited for support of the operational forces. In many instances, the Air Warfare Center draws fire for fighting the *Nellis War* for many reasons. A segment of the validation study required examination of highly experienced pilots developing tactics and procedures for low-experience operators. Previously it was noted that the average wingman has about 100-300 hours of flying experience. The average flight leader weighs in at about 500-700 hours of experience. The average WIC or OT&E pilot weighs in at roughly 1500 hours and generally because of his duties, has considerably more air combat exposure than a similar time operator in the field. During the validation study, careful consideration was given to assessing whether a task was considered easy because of the high automaticity of the WIC instructor or whether the tasking was easy because of a low complexity nature. Key areas of interest were the development of suitable tasking for the experience level average in each team position and in examining previous tactical methods for inappropriate or high task loading for each member of the combat team. In determining courses of action for validation, the WIC did not have time to study all of the aspects of experience versus complexity. Instead, the WIC provided the air combat standards developed for its course to AFRL to employ in existing research of field unit performance measures. The WIC partnered with AFRL to continue studying F-16 tactics training for operational units and continues to use feedback from its own participation in DMO-A training to establish refined training techniques. To date, this study is in progress using *mission essential competency* constructs to examine wingman and leader performance measures. The partnership is set for long-term mutual benefit.

The WIC validation study was the first of its kind using DMO-air devices to answer specific questions and counter-arguments. The result of this study provided tangible examples of possibilities in small mission rehearsal operations. Results were of sufficient quality to convince the larger tactical community to accept the consolidation of tactics and publish them as F-16 tactical employment doctrine in 2001. The WIC study was a short-term attempt to answer question on real-world tactical employment – exactly the focus of mission rehearsal – see what goes right, what goes wrong, make adjustments and proceed to the real world. Examining the output of the effort, it can be judged a qualified success for the limited objectives it set out to achieve. The gray areas experienced by the WIC in this validation study represent a starter set of flags for researchers to consider in making DMO a viable resource for mission rehearsal. It will be essential that the constellation of systems in DMO provide adequate fidelity of the threat environment in both physical and human attributes to allow mission rehearsal to take full shape. The system must provide sufficient truth in the mission development phase to make operators confident in concept exploration and course-of-action development. Likewise, it must be *human* enough to present variations of tactical environments for the operators to examine and practice contingencies during rehearsals. Finally, it must be user-friendly to the console operator and interact in doctrinal terms he or she understands to make control of the learning or rehearsal environment acceptable.

Conclusion

The USAF envisions DMO as a complementary capability to conduct large-force training with substantially less impact to logistics, environment, and warfighting resources. The ability to train at this level on a regular basis holds the promise to expand combatant performance on many levels. Employing DMO for large force follows proven strategies in smaller venues using simulation and part-task training to accelerate learning and performance levels. The examples provided for consideration also warn of limitations which must be addressed by developers of DMO to avoid its demise as a costly lesson in follow-through. In order for DMO to be successful, it must be broadly accepted and employed regularly and appropriately by the operational forces in the field. Time and resource management were critical drivers of the F-16 WIC's validation study as well as training initiative in air combat. Distributed mission operations provided solutions with sufficient credibility and confidence for these limited objectives. As operational objectives expand, DMO must also expand mission emulation credibility to provide quality training and mission evaluation. The results of the F-16 experience are a trailhead for the incorporation of better threat emulations and system interoperability as well as some additional insights into the challenges of incorporating DMO in a tightly packed schedule. As DMO transforms into its future shape, the challenge for researchers and developers is to make the system as credible an emulator of the real world as possible. Likewise it must present itself as an efficient and effective training medium that reduces preparation time rather than devouring it.

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