

# **USING DISTRIBUTED MISSION TRAINING TO AUGMENT FLIGHT LEAD UPGRADE TRAINING**

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## **ABSTRACT**

Previous research on Distributed Mission Training (DMT) has shown that pilots and AWACS Weapons Directors rate DMT as highly effective for training multi-ship, multi-bogey air combat. DMT exercises have also been utilized as opportunities for pilots participating in Flight Lead Upgrade (FLUG) training to gain experience in planning, briefing, leading, and debriefing four-ship missions in an intensive air-to-air threat environment. A four-phase research program to assess the effectiveness of using DMT to augment FLUG training was undertaken in Apr 99 by the Air Force Research Laboratory, Warfighter Training Research Division. First, training records were reviewed to identify four-ship FLUG missions that would most benefit from DMT experience and to establish baseline rates for sorties that were repeated due to non-effective upgrading pilot proficiency. These data indicated that among four-ship training missions, the highest re-fly rates are for Dissimilar Air Combat Tactics, and Low-Altitude Surface Attack Tactics. Second, a five-day DMT-FLUG protocol was developed targeting these missions. Third, DMT-FLUG training exercises were conducted over a one-year period. During these exercises, upgrading pilots lead several missions of increasing complexity using the Air Force Research Laboratory four-ship DMT testbed located in Mesa, AZ with AWACS weapons controllers participating from AFRL's research facility at Brooks AFB, TX. DMT-FLUG exercises were conducted in Jun, Aug, and Oct 99, and Feb 00. Fourth, transfer to aircraft training was assessed through review of training records and interviews with both upgrading pilots and their instructors. As of 1 Sep 00, eight out of twelve upgrading pilots who participated in DMT-FLUG have successfully completed the FLUG program without any repeated missions, one pilot repeated one mission, two transferred out of fighters, and the remaining pilot is still in training. Performance of pilots and AWACS weapons directors within DMT exercises is discussed with emphasis on identifying the mission tasks that are most appropriate for DMT.

## **BIOGRAPHIES**

Peter Crane is a Research Psychologist at the Air Force Research Laboratory, Warfighter Training Research Division. His major research interest is enhancing the effectiveness of Distributed Mission Training Systems. Dr Crane earned a PhD in Experimental Psychology from Miami University in Ohio.

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## INTRODUCTION

The Air Force's Distributed Mission Training (DMT) program is a major advance in ground-based training that will allow pilots and other warfighters to train for complex, multi-player combat operations. Researchers from the Air Force Research Laboratory, Warfighter Training Research Division (AFRL/HEA) are investigating strategies for using DMT to augment advanced flying training in operational units.

### Background

Research on training effectiveness of multi-ship simulation systems has been on-going at AFRL/HEA for almost ten years. In addition to research on networked simulation technologies, activities have focused on effective and efficient application of DMT for continuation training of fighter pilots and air weapons controllers. Hoog (1999) described how DMT systems are being designed to enhance skills that warfighters will employ both as individuals and as members of a team. Effective application of multi-player simulation for enhancing individual and team skills has been demonstrated for F-15 pilots (Houck, Thomas, & Bell, 1991), F-16 pilots (Berger & Crane, 1993), Tornado pilots and navigators (Huddleston, Harris, & Tinsworth, 1999), pilots, forward air controllers, and ground forces executing close air support (Bell, et al., 1996), and Air Force Special Operations teams (Nullmeyer & Spiker, in press). F-16 pilots who have flown in a distributed environment have rated DMT as particularly effective for training four-ship air-to-air employment against multiple enemy aircraft (Crane, Schiflett, & Oser, 2000). Individual skills identified by F-16 pilots as being enhanced by DMT include radar mechanization (i. e., using the various modes and capabilities of the air-to-air radar to efficiently detect, track, and target

multiple aircraft), communication, and building situation awareness; team skills included maintaining mutual support, tactical execution, and flight leadership. Crane (1999) reported that F-16 instructor pilots participating in DMT research would frequently fly as flight leader for the morning mission but would then assign a less experienced pilot to serve as flight lead during the afternoon. The instructors explained that these pilots were participating in Flight Lead Upgrade (FLUG) training at their squadrons and that DMT was a valuable complement to aircraft training.

### Flight Lead Upgrade Training

After graduation from a formal training course, U. S. Air Force fighter pilots must first complete Mission Qualification Training at their assigned unit before serving as mission ready wingmen. After gaining the required flying hours of experience as a wingman, and having demonstrated solid flying skills and in-flight discipline, pilots can then be selected for FLUG training. Here they will learn to lead an element of two aircraft and eventually an entire flight of four. Although general guidance for upgrade training is specified by Air Combat Command, each fighter wing develops its own program of academics, simulator exercises, and training flights. For F-16 pilots these training flights include a mix of both air-to-air and air-to-ground missions. Even though all upgrading pilots have gained considerable experience as wingmen, some missions are flown relatively infrequently due to airspace and resource limitations. The 4 vs X Dissimilar Air Combat Tactics (DACT) mission (four F-16s opposed by an unknown number of threat aircraft) is the least practiced mission as it requires at least eight aircraft (four friendly and four or more enemy) plus weapons controller support if available. Even when these resources are available, DACT training missions are often constrained by airspace

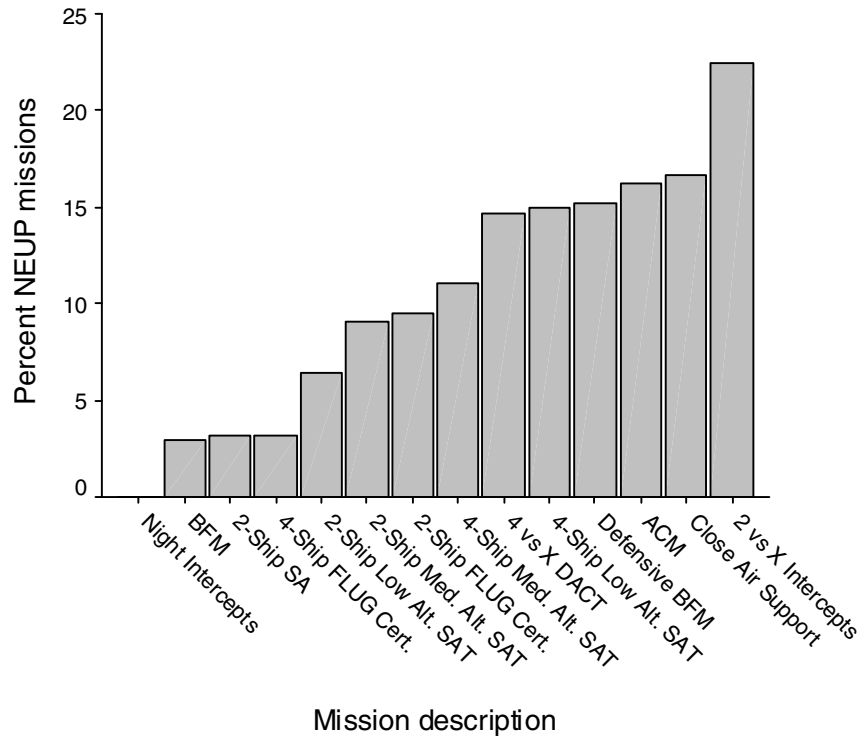


Figure 1. Percentage of FLUG training missions repeated for Non-Effective Upgrading Pilot performance.

limitations that prevent teams from employing complex tactics. Similar resource limits apply to Surface Attack Tactics (SAT) missions that incorporate enemy fighters defending ground targets. As a result, upgrading pilots often find themselves learning to lead highly demanding missions that they have infrequently practiced as wingmen. If the upgrading pilot does not demonstrate the required proficiency during a FLUG mission, the mission must be repeated so the upgrading pilot can attain the necessary level of expertise. Depending on the specific mission, this can place significant demands on squadron resources.

A four-phase research program to assess the effectiveness of using DMT to augment FLUG training was undertaken by the Air Force Research Laboratory, Warfighter Training Research Division under sponsorship of Air Combat Command's DMT office and with the cooperation of the 27<sup>th</sup> Fighter Wing, Cannon AFB and the 552<sup>nd</sup> Air Control Wing, Tinker AFB. The objective of this program was to determine how DMT experience can increase pilot readiness for FLUG missions and reduce the incidence of missions that were repeated due to non-effective upgrading pilot (NEUP) performance. First, training records were reviewed to identify four-ship FLUG missions that would most benefit from DMT experience and to establish baseline rates for sorties that were repeated due to non-effective upgrading pilot proficiency.

Second, a five-day DMT-FLUG training protocol was developed targeting these missions. Third, DMT-FLUG training events were conducted over a one-year period. During these events, upgrading pilots planned, briefed, led, and debriefed missions of increasing complexity using the Air Force Research Laboratory's four-ship DMT testbed located in Mesa, AZ with AWACS weapons controller support from AFRL's research facility at Brooks AFB, TX. Fourth, transfer to aircraft training was assessed through review of training records and interviews with both upgrading pilots and their instructors.

## DMT-FLUG TRAINING PROTOCOL

### Review of Training Records

At the 27<sup>th</sup> Fighter Wing during the review period, FLUG included 14 training missions; 10 in which the upgrading pilot leads a two-ship element and 4 leading a four-ship flight. In April 1999, AFRL researchers reviewed training records for all pilots who had completed FLUG in the previous three years or were currently participating in FLUG. Upgrading pilot proficiency for each mission is evaluated by an instructor pilot who rates performance on a number of factors using a scale ranging from 1: *Performance is safe but indicates a lack of proficiency*, to 4: *Performance reflects an unusually high degree of*

ability. A minimum score of 2: *Performance is essentially correct; recognizes and corrects errors*, on all critical items is required for a mission to be rated complete and effective. A mission that is rated non-effective must be repeated before an upgrading pilot can fly a check ride for FLUG certification. While researchers initially focused on overall mission score, this proved to be unnecessary as nearly all effective missions were rated two and all non-effective missions were rated one.

Training data for over 30 upgrading pilots show that the re-fly rates for non-effective performance ranged from 0% for two-ship night intercepts and less than 3% for two-ship basic fighter maneuvers and two-ship basic surface attack to over 22% for two-ship intercepts. Among four-ship missions, the highest re-fly rates, 15%, were for 4 vs X DACT and four-ship SAT (see Figure 1). Further, review of individual scores and instructor comments reveal that non-effective ratings for the four-ship SAT mission most often resulted from poor reaction to surface and airborne threats rather than for problems with navigation, air-to-surface tactics, or ordnance delivery.

### Protocol Development

Results of the FLUG training data analysis were briefed to wing and squadron leaders with the goal of selecting missions to be complemented with DMT. Wing leaders chose to correct two-ship mission problems using existing resources. Their most significant problem by far was the 4 vs X DACT mission based on cost and difficulties of scheduling so many aircraft and pilots. The four-ship SAT mission was also selected for additional training with DMT due to its high re-fly rate. A DMT-FLUG protocol was developed consisting of four missions: 4 v 4 Sweep, 4 v X Sweep, 4 v X Defensive Counterair (DCA), and SAT opposed by both airborne and ground forces (see Table 1). DMT-FLUG missions were designed to closely resemble FLUG flying missions in objectives, mission tasks, and suggested briefing items.

Design of DMT scenarios represents a middle ground between single-ship simulator training and large-force exercises (Crane, 1999). In single-ship simulator training such as learning to respond to in-flight emergencies, an instructor introduces an emergency such as an engine malfunction and then waits for the student to respond. Events are highly scripted and the instructor can readily evaluate good vs poor performance. In contrast, large-force exercises are much less scripted at the level of individual pilots. Evaluators will know where and when forces will engage but will have only limited control over each pilot's experience. The training methodology employed during DMT-FLUG took advantage of the instructor's ability to script the actions of computer-generated forces. The goal of this system was to create robust, focused practice scenarios that exercise pilots' skills and provide instructors with the tools required to assess an overall level of proficiency. The scenarios varied in difficulty from a single non-maneuvering enemy formation to a continuous profile containing six maneuvering formation groups and 16 enemy aircraft. Over 60 individual scenarios were available which allowed the instructor to present the FLUG pilot with increasing challenges by changing the tactical variables (see Table 2). Because of the large number of scenarios available, the tactical variables were similar between each FLUG pilot's missions, but no specific scenario was ever repeated between the pilots. The instructor could easily increase or decrease scenario difficulty based on the FLUG pilot's demonstrated proficiency.

Based on the training objectives and logistical considerations, a four and one-half day, intensive protocol was developed with pilots flying two DMT missions per day with each mission consisting of several scenarios. Each mission included a one hour briefing, one hour simulator mission, and a one and a half hour long debrief. Teams consisting of two upgrading FLUG pilots, two wingmen, an instructor pilot, and one or two AWACS weapons controllers flew each mission type (i. e., 4 v 4, 4 v X, DCA, and SAT) twice. This gave each FLUG pilot the opportunity to

Table 1. DMT-FLUG five day training schedule.

	Mon.	Tue.	Wed.	Thu.	Fri.
am	Familiarization	4 v 4 Sweep	4 v X Sweep	4 v X DCA	SAT – Medium and Low Altitude
pm	4 v 4 Sweep	4 v X Sweep	4 v X DCA	SAT – Medium and Low Altitude	

Table 2. Variables used in programming DMT–FLUG scenarios.

Tactical Variable	Values used in DMT–FLUG
Number of enemy aircraft	4 to 16 in one or more waves
Number of groups	1 to 6
Aircraft types	Fighters, low-level strikers, high-fast flyers
Rules of engagement	Visual identification required or beyond visual range
Enemy level of awareness	Unaware or aware
Permanent kill removal	Off (Shields-up) or On (Shields-down)
Mission type	Offensive sweep or defensive combat air patrol
Formations	Single heavy group
	2 groups divided in range
	2 groups divided in azimuth
	2 groups divided in altitude
	3 groups in champagne or vic formation
	Fighters protecting strikers
	Fighters plus high-fast flyers
	Maneuvers including flank, beam, drag, spin, and post-hole.

brief and lead each mission type. Each upgrading pilot also flew in the number three position leading the second element within the flight for three missions and observed one mission from the AFRL DMT control console. The instructor pilot flew four missions during the week in the two, three or four position which enabled him to assess the strengths and shortfalls of the simulators, and allowed the other pilots to observe one training mission from the console. Approximately 7 - 8 scenarios were flown during each sweep mission, 3 - 4 DCA scenarios, and two scenarios (one medium altitude and one low altitude) were flown during the SAT missions.

The 4 v 4 Sweep mission consisted of scenarios limited to four enemy aircraft in two groups or less. The first several scenarios required the FLUG pilots to visually identify (VID) the target aircraft before they could employ ordnance. Suggested briefing items included VID mechanics, sorting and targeting plan, and missile shot/kill criteria. Simulator “shields” were up which meant that the F-16 pilots could not be killed by the threat aircraft. The 4 v X Sweep mission limited the enemy to three groups with no maneuvering restrictions. Simulator shields were down which allowed for permanent kill removal. High fast flyer procedures and tactics were introduced as a new briefing item. The 4 v X DCA mission was flown shields-down and emphasized combat air patrol (CAP) management. Enemy formations were limited to three groups. However, the enemy groups had no range, azimuth, or altitude restrictions and a mix of hostile and bogey groups were presented. The SAT mission contained a low and medium altitude profile. In addition to enemy aircraft, enemy surface-to-air

missiles and anti-aircraft artillery were embedded in the scenario to evaluate threat awareness and reactions. The ingress route, target, weapons load, and known enemy ground positions remained constant between the two scenarios, but the number and location of enemy aircraft varied. This mission stressed changing air-to-air tactics to employ against enemy aircraft given that the F-16’s primary role was air-to-ground.

### DMT–FLUG TRAINING EVENTS

DMT–FLUG training was conducted using AFRL/HEA’s DMT testbed system which consists of four interlinked F-16 simulators, a control and observation console, semi-autonomous computer generated aircraft, long-distance network to an AWACS simulator located at Brooks AFB in San Antonio, TX, and a mission replay/debrief system. For the SAT missions, the Air Force Information Warfare Center, Kelly AFB, TX provided a constructive, integrated air defense system.

DMT–FLUG training events were conducted in Jun, Aug, and Oct 99, and Feb 00. Participants were selected by their squadrons based on availability and status within the FLUG program. Ideally, the upgrading pilots had completed their two-ship FLUG training flights and were beginning their four-ship flights. Due to deployments and other commitments, pilots in all stages of FLUG training participated. Weapons controllers from the 552<sup>nd</sup> Air Control Wing and the 970<sup>th</sup> Airborne Air Control Squadron were assigned by their squadrons based on availability. All pilots and weapons controllers were combat mission ready.

**Participants** Twelve upgrading pilots with 200 to 485 flight hours (median = 410) in the F-16 participated in DMT-FLUG together with 6 instructor pilots, 9 wingmen and 10 weapons controllers. None of the upgrading pilots had any previous experience in other fighter aircraft. One pilot was called away due to a family emergency after one DMT-FLUG mission, however, one of the wingmen was also in FLUG training and replaced him in the sample.

**Performance in DMT-FLUG**

Each scenario flown during a DMT-FLUG simulator period was graded by a laboratory subject matter expert. Initially the rating scales and mission tasks were similar to their mission grade sheets used at home station. However, early data analysis identified several mission tasks that showed little variability over the week and some mission tasks that were rarely observed during DMT-FLUG missions. To overcome these difficulties, the number of graded tasks were reduced and a new scale was devised to help obtain more meaningful information. The new three level rating scale (0, +, -) asked the subject matter expert to evaluate mission performance as being either average

for an upgrading FLUG pilot, above average, or below average. Coincident with the new rating scale, benchmark scenarios were introduced to better evaluate pilot performance during the week. Two sets of benchmark scenarios with equal difficulty were selected. Benchmark scenarios used with upgrading pilots on the same team were essentially mirror images. The first benchmark scenario was administered during the 4 v 4 mission, and the second was given during the 4 v X DCA mission. Six pilots have been evaluated using the new scale and benchmark scenarios. The overall performance between their benchmark scenarios improved for all six FLUG pilots. Several individual mission tasks also showed noteworthy improvement in half or more of the comparisons. These areas included correct picture call, tactical execution, mutual support, tactical decision making, radar mechanization, targeting/sorting, and use of weapons controllers (see Figure 2). Although the number of times that a flight member died increased slightly between the first and last air-to-air missions, this change was minor compared to the increased complexity of the scenarios. The number of total fratricide incidents was reduced from six during the 4 v 4 missions, to only one incident during the 4 v X DCA missions.

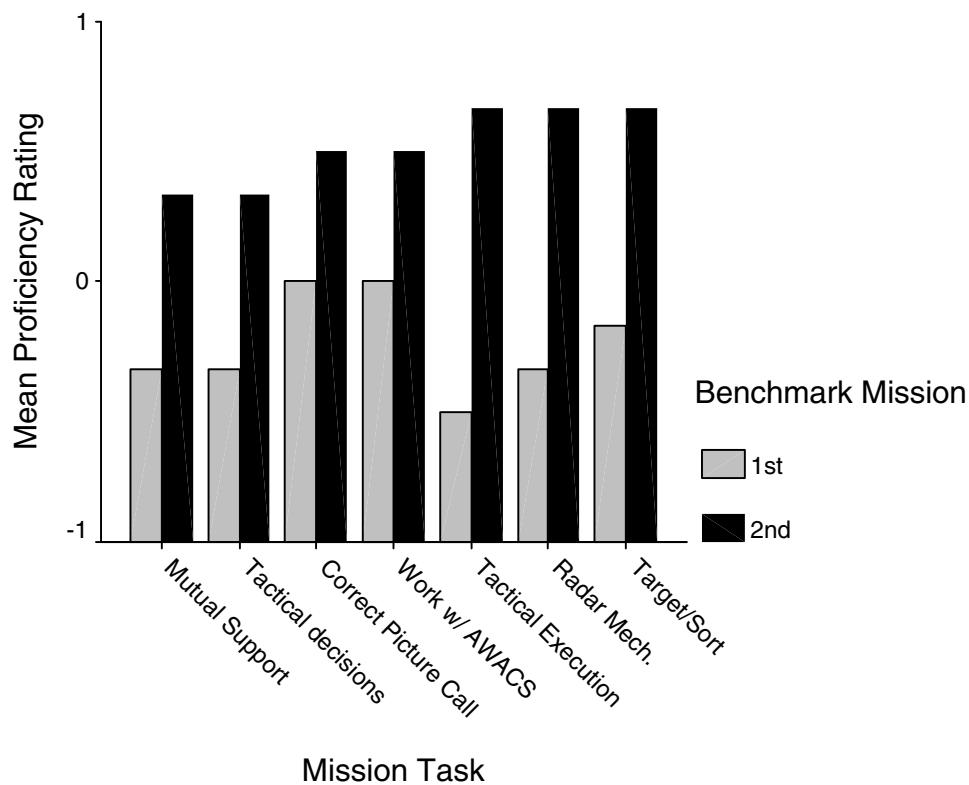


Figure 2. Changes in mean mission performance ratings between the first and second benchmark missions during DMT-FLUG training.

**Pilot feedback** Pilots and weapons controllers were asked to provide feedback to the research team after each mission and at the end of the week. Comments fell into three categories: system problems, training effectiveness, and recommendations.

Comments regarding system problems included minor issues that were typically corrected within a simulator session and more significant problems with the testbed. Minor problems include head-tracker failures, radio communications not correctly recorded for debrief, too much/too little air conditioning in cockpit, and visual system failure requiring restart. More significant comments include inability to determine aspect of another aircraft beyond 4000 feet, and modeling of threats and countermeasures.

Pilots and weapons controllers participating in the DMT-FLUG program agreed that DMT provides effective training for multi-ship, multi-bandit air combat. Strengths of the system are the opportunity for multiple engagements within an hour and the high level of situation awareness provided by the replay system during debrief. Specific skills cited include radar mechanization, work with weapons controllers, communication, tactical execution, situation awareness, briefing, and confidence building. Pilots also agreed that within-visual-range air combat and aircraft handling are not well trained in the testbed DMT system.

In addition to correcting system problems, participants offered several recommendations for improving DMT overall and DMT-FLUG. There was disagreement whether an intensive syllabus lasting several days such as DMT-FLUG was more effective than the more traditional simulator mission first followed by the aircraft mission approach. While some pilots wanted to rehearse each mission before flying it, all agreed that there is considerable benefit to an intensive DMT air-combat program. One instructor pilot stated that, "Pilots overcome simisms first, then demonstrate initial proficiency, and there is exponential improvement after that." A second recommendation was to integrate the weapons controller into the brief and debrief rather than use telephone brief/debrief between training sessions. Suggestions include video teleconference and interactive whiteboards.

### **Performance in subsequent aircraft training**

As of 1 Sep 00, eight of the twelve upgrading pilots who participated in DMT-FLUG have

successfully completed the FLUG program without any repeated rides. Two pilots, however, were accepted into the B-2 program and their squadron waived the requirement for a 4 v X DACT ride for these pilots. Both successfully completed a FLUG checkride, which is a four-ship SAT mission. Eight pilots successfully completed the 4 v X DACT ride on the first attempt. One DMT-FLUG pilot was required to repeat his 4 vs X DACT mission for non-effective performance on his mission briefing. This pilot participated in DMT FLUG in Oct 99 and did not fly the DACT mission until Apr 00. In addition, this pilot flew his DACT mission as part of an exercise consisting of several four-ship air-to-air missions so that scheduling an additional 4 vs X sortie was not required. The remaining pilot was still in FLUG.

Several weeks after returning to Cannon AFB, pilots were interviewed about the effectiveness of DMT. Responses have been received from 9 of the 17 pilots who participated DMT-FLUG: five upgrading pilots, two instructor pilots, and two wingmen. Four of the five upgrading pilots evaluated DMT-FLUG experience as significantly transferring to the aircraft; the fifth pilot rated transfer as moderate. Specific skills that were cited as showing transfer were briefing, communications, beyond-visual-range tactics, radar mechanization, situation awareness, decision making, leadership, plus developing and using backup / contingency plans. One of the upgrading pilots expressed concerns that DMT is too easy and lacks distracting elements of actual flying such as pulling-g's, noise, and vibration. One IP rated DMT-FLUG as transferring significantly to the aircraft citing pacing and situation awareness as skills well trained in DMT. The other IP, however, stated that there was no transfer and that DMT is no more than an expensive video game that does not provide useful training. The two wingmen stated that DMT transferred moderately to the aircraft with the most positive transfer for situation awareness, radar mechanization, and four-ship tactics. All pilots agreed that the four-ship DCA missions were the most effective and that the SAT mission was least effective. Pilots were asked whether they would recommend that DMT be used in an intensive syllabus as in DMT-FLUG or a more traditional approach of alternating simulator and aircraft training missions. Five of the nine pilots preferred the traditional approach so that DMT missions could be tailored to specific aircraft training flights although one pilot expressed concerns that this would slow the overall pace of training. Two pilots preferred the intensive approach and two did not respond. Recommendations for how frequently pilots should use DMT ranged from, "never" to, "any day that I'm not flying."

## DISCUSSION

As applied to FLUG, performance in subsequent aircraft training missions and instructor feedback demonstrates that experience in DMT enhances leadership skills for multi-ship, multi-bandit air combat. This is most likely a function of both DMT system capabilities and constraints on pilots' ability to train in the aircraft. In the next iteration of the DMT-FLUG training effort, we will be developing more comprehensive training and measurement capabilities that will permit us to identify what behaviors improve and how DMT helped in the improvement process so that we can provide this information to the mission training centers. Our findings to date indicate that minimum capabilities for effective DMT include the following. First, DMT systems must be supported by programmable scenario generation tools that permit the incorporation of instructional principles and training strategies to foster skills development and retention. Second, we view a mission replay and after-action reviewing capability as necessary capabilities for an instructionally viable training and rehearsal system. Finally, there must be a construct-oriented individual, team and mission measurement system in place.

Simple practice or free-play are not efficient training strategies. Programmable scenario generation tools including computer-generated threats with the capability for autonomous action permit instructors to take advantage of findings from research on instructional principles to design training and rehearsal events that will meet specified objectives. In multi-ship air combat, training objectives for upgrading pilots include learning to recognize enemy aircraft formations and selecting an appropriate tactic, communicating the plan to the rest of the flight, executing the plan, and changing tactics as required. The programmable scenario generation tools in DMT-FLUG were used to create enemy formations and tactics that varied across a number of dimensions as summarized in Table 2. This range of scenarios combined with the opportunity for teams to fly several scenarios in an hour provide upgrading pilots with opportunities to gain experience with many more tactics and situations than would be possible in the aircraft.

Another key element in the success of DMT is the replay and debrief facility. In the AFRL testbed, each cockpit's radar, radar warning receiver, head-up display, and stores management system, are recorded and played back synchronized with a plan view display and all radio communications. The flight leader can pause, rewind, or zoom the display as required. Using the replay system, pilots can review the information that was available to them inside the cockpit together

with the plan view display's depiction of the complete tactical situation. Execution errors, poor communication, and unplanned contingencies are quickly apparent. Debriefs were limited to 90 minutes for scheduling purposes which forced teams to focus on high level skills such as communication and execution without getting absorbed into analysis of individual, procedural skills.

Finally, it is important to note that the results presented in this paper represent an evolution of our training paradigm from one of structured practice to one that is more focused on both objectives-driven instruction and construct oriented performance measurement. The lessons learned from this initial FLUG effort have provided considerable insight into the problems and needed capabilities associated with implementing a high fidelity, adaptive training and rehearsal system for Air Force pilots. The following summary describes future directions in research being undertaken at AFRL/HEA based on the results of the FLUG effort.

### **Training needs assessment and content validation**

In the next iteration of FLUG, we will be conducting systematic assessment of training needs at additional F-16 bases. The goal of the needs assessment is to elaborate the specific tasks and mission areas that are especially problematic for pilots in upgrade training. Additionally, the needs assessment will provide the necessary data to develop an instructionally principled curriculum. By focusing on key needs, we can design a syllabus that fosters the development and retention of skills needed for FLUG success. Moreover, the needs assessment will complement our current research activities in the definition of mission essential competencies, i.e., the knowledge, skills, attitudes, abilities and capabilities required for combat mission readiness. This effort will help us develop a more comprehensive, objectives-oriented syllabus for DMT-FLUG and identify the important performance parameters associated with mission effectiveness. It will also help us in the development of metrics to quantify training impact in terms of combat mission readiness and performance.

### **Development of Performance Criteria and Measurement Instruments**

We are currently in the process of developing and testing evaluation instruments for individual and team effectiveness based on mission essential competencies. By adopting a competency-based approach to training development and evaluation, we are developing data collection and analysis methods for

use across the entire spectrum of DMT activities (e.g., mission preparation, briefing, execution, and debriefing). Measurement techniques are being developed for analysis of verbal communications, pilots' mental models, team processes, and mission outcomes.

**Content analysis methods** Content-analysis instruments are being developed to evaluate verbal communications in order to better understand the quality of briefings, within-mission communication, and debriefings. In addition, measures of attitudes toward training, motivation and perceived application and utility of the training have been developed for use in other training research and will be extended to FLUG.

**Mental modeling assessments** We are also conducting a series of studies on structured assessments of learning such as situational judgement assessments, mental modeling, Pathfinder, concept mapping, and multidimensional scaling. These are being applied to assess learning and understanding at both individual and team levels.

**Process and outcome-oriented measurement** Using mission essential competency definitions, it is possible to identify process-oriented behaviors that are associated with effective mission performance. We will then be able to develop process-oriented measures that will help us quantify the effects of DMT experience on individual and team knowledge acquisition, crew coordination/flight integrity (including leadership and assertiveness), situational awareness, communication, decision making/risk management, task management, and mission planning/debrief. As a part of these activities, we will develop, test, and validate protocols to capture data related to the identified processes. The key process behaviors and metrics will be used to further refine training objectives and to identify opportunities to improve training content and training policy.

Finally, we are evaluating the reliability and validity of mission outcome measures such as "Turkey Shoot" and "Top Gun" scoring. Based on this evaluation, we will be refining, automating, and applying measures for simulator and flying performance. It is critical that any developed measurement system provide reliable and valid data to demonstrate that training has had an impact on actual aircrew competencies, attitudes toward training, motivation to train, expectations regarding training and transfer, knowledge mastery and subsequent job performance. Furthermore, the data and instrumentation will serve both a formative assessment

function by providing feedback on problem areas in the training, and a summative function by permitting cost and mission impact assessments.

## Summary

DMT-FLUG research has demonstrated both the utility and effectiveness of DMT to complement aircraft training. DMT supports upgrade training by providing opportunities for pilots to plan, brief, fly, and debrief many more air-to-air missions than currently possible in aircraft. In addition, DMT provides instructors the capability to choose scenarios that exercise selected skills. Subsequent DMT-FLUG research will focus on developing a comprehensive training syllabus that will incorporate needs analysis, specification of essential competencies, scenario development and selection based on principles of instruction, and performance measurement systems that will assess both mission outcome and team processes.

## REFERENCES

- Bell, H. H., Dwyer, D. J., Love, J. F., Meliza, L. L., Mirabella, A., & Moses, F. L. (1996). *Recommendations for Planning and Conducting Multi Service Tactical Training with Distributed Interactive Simulation Technology (A Four-Service Technical Report)*. Alexandria, VA: U. S. Army Research Institute.
- Berger, S. & Crane, P. (1993). Multiplayer Simulator Based Training for Air Combat. In, *Proceedings of 15<sup>th</sup> Industry/Interservice Training Systems Conference*, Orlando, FL: National Security Industrial Association.
- Crane, P., Schiflett, S. G., & Oser, R. L. (2000). *RoadRunner 98: Training Effectiveness in a Distributed Mission Training Exercise (AFRL-HE-AZ-TR-2000-0026)*. Mesa, AZ: Air Force Research Laboratory, Warfighter Training Research Division.
- Crane, P. (1999). Designing training scenarios for distributed mission training. Presented at: *10<sup>th</sup> International Symposium on Aviation Psychology*, Columbus, OH, April 1999.
- Houck, M. R., Thomas, G. S., & Bell, H. H. (1991). *Training Evaluation of the F-15 Advanced Air Combat Simulation*. (AL-TP-1991-0047 AD A241875). Williams Air Force Base, AZ: Armstrong Laboratory, Aircrew Training Research Division.

Hoog, T. (1999). Distributed Mission Training Overview. Presented at: Distributed Mission Training Implementation, S. Swain, Chair, '99 *Industry/Interservice Training Systems Conference*, Orlando, FL

Huddleston, J., Harris, D., & Tinworth, M. (1999). Air Combat Training—The Effectiveness of Multi-Player Simulation. In, *Proceedings of '99 Industry/Interservice Training Systems Conference*, Orlando, FL: National Security Industrial Association.

Nullmeyer, R. T. & Spiker, V. A. (in press). The Importance of Crew Resource Management in MC-130P Mission Performance: Implications for Training Effectiveness Evaluation. *Military Psychology*.