MULTIPLE SIMULATOR NETWORKING (MULTISIM)

The Way to Provide Effective Combat Training Today

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ABSTRACT

Tomorrow's state-of-the-art training systems will be networks of high-fidelity simulators coupled to provide aviator crews with advanced training as players in combined-arms teams. In addition, networked simulators will provide crews with an advanced facility to exercise and enhance their air-to-air skills by allowing combat against equally trained crews in a hostile environment. To reach such training levels, tomorrow's simulators can be specified to incorporate designed-in network interfaces and system-to-system compatibility. There is, however, an alternative to waiting for the development of next generation simulators. Today's alternative is to develop interfaces to network simulators which are currently fielded or scheduled for fielding in the near future. The Multiple Simulator Networking Program (MULTISIM) is a research effort which has provided proof-of-concept for this alternative. This paper describes the MULTISIM prototype, the missions performed, and insight gained relative to the potential of networking to change current concepts of overall combat training.

INTRODUCTION

Much of the career of today's Army aviator is dedicated to a continuous cycle of training and practice; he constantly strives to increase his knowledge and skills in preparation for actual combat. To support the development of aviator skills, the Army employs a progressive training program which seeks to utilize the safest and most cost-effective tools available to facilitate each stage of training.

Much of today's training is accomplished in ground-based flight and weapon simulators. These devices allow effective training for flight and navigational skills (in optimum and adverse weather), weapon and system operation, crew coordination, and emergency procedures. The AH-64 Combat Mission simulator (CMS), with its high-fidelity systems simulations and hostile interactive threat environment, supports real-time training in crew tactical decision-making in addition to training in the more fundamental skills.

Higher levels of tactical training, however, presently require expensive field training and the mobilization of actual military combat systems. While this provides effective training, many of the stress factors associated with actual combat cannot be completely evaluated in such training exercises due to safety considerations. Such high level training is required, however, to refine the aviator's skills in team operations and in operating as an effective element of a large-scale combined-arms force, just as he would be deployed in actual combat operations.

The networking of ground training devices is an essential adjunct to mobilizing actual combat equipment. Administrative, logistical, and operational costs are greatly reduced; in addition, much higher levels of fidelity can be achieved in the simulated combat environment since the crews are protected from real-world hazards. Current technology can be readily adapted to allow near term team training to be accomplished in networked simulators. In addition, networking can permit aviation simulators to participate with other Army and joint services training devices in force-on-force simulations (artillery, armor, close air support, etc.).

The MULTISIM prototype represents the first linking of existing full-scale simulators within the Army's Synthetic Flight Training Systems (SFTS) inventory. The prototype system utilized three SFTS devices; the AH-64 Apache Combat Mission Simulator, the AH- 1S Cobra Flight and Weapons Simulator, and the UH-60 Black Hawk Flight Simulator. Team and counter-air missions were performed on a common database with a common set of hostile threats. Evaluations and mission testing provided valuable insight on how training can be significantly enhanced at low cost while still retaining the stand-alone features of each simulator.

RESEARCH OBJECTIVES

The purpose of the MULTISIM research program is to develop the technology needed to network full-scale training devices for increased realism in the combat training environment. The objectives of the program include:

(1) Development of an affordable and expandable interface and control system to network currently existing simulators

(2) Use the MULTISIM prototype to evaluate new training objectives in a total mission environment such as team and counter-air concepts.

(3) Refinement of requirements and technologies to allow for the specification of "designed in" networking capabilities in future simulators.

(4) Refinement of the evolving networking technology in relationship to long-term goals for optimization and standardization, including the future possibility of an industry networking standard.

THE NEED FOR FULL FIDELITY

Simulators and training devices at all levels of sophistication can be networked to support some degree of team and interactive training. Generally, the level of device and network complexity determines the number and complexity of the training objectives that can be supported.

In this program, a new set of tactical training objectives was identified, which are not addressed in individual simulators or training devices. Missions assigned to teams of scout and attack helicopters were analyzed to identify the tasks and task training objectives associated with those missions. A number of primary training objectives were identified which relate to the skills required to analyze complex tactical training situations, and to identify and execute likely courses of action in cooperation with other members of the team and in the presence of a dynamic, interactive array of threats. While these objectives are characterized by a large cognitive component, they involve another overall objective: learning to prioritize, time-share, and articulate the analytic and decision processes within an ongoing context of flight control, navigation, and weapon system operation, all under time pressure and the stress of tactical operations.

Today's state-of-the-art helicopters have widely varying flight characteristics and highly individualized operational complexities. To survive in a hostile threat environment aviation crews must fully exploit the specific aerodynamics and the tactical capabilities of their aircraft and avionics, whether they are operating autonomously or as a member of an attack team. Accordingly, high-level aviation team and counter-air training requires the use of full-fidelity devices such as the AH-64 CMS to impose a realistic combat workload on the crews. By networking full-fidelity simulators a new level is added to the training hierarchy, as illustrated in Figure 1.

It should be noted that requirements to network full-fidelity simulators for advanced aviator training do not preclude, but in fact assume, the utilization of lower-fidelity devices to support and enhance the training environment created by such networking. Recent networking approaches have successfully used selective-fidelity simulations to provide team training for armor crews. The designs were developed based on the low transition rates and limited maneuverability inherent to armored vehicles, the specific training objectives associated with the crew tasks involved, and a system environment significantly less complex than that of today's attack helicopter. In the future, interactive training systems will employ different networking technologies supplementing each other. For example, aviator crews could train in full-scale devices in conjunction with armor crews training in selective-fidelity devices. Additional selective-fidelity devices could also be networked to represent air-defense units, with each device designed to support the needs of the respective crews.

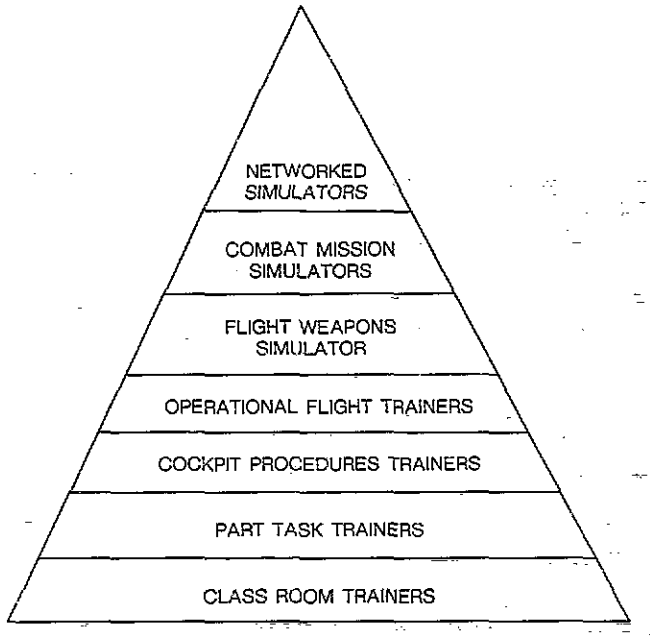

Figure 1 TRAINING DEVICE HIERARCHY

THE MULTISIM PROTOTYPE

The MULTISIM concept was demonstrated utilizing the AH-64 Apache CMS, the UH-60 Black Hawk Flight Simulator, and the AH-1S Cobra Flight and Weapons Simulator as illustrated in Figure 2. These devices were networked utilizing adaptations of commercially available hardware and specially designed interface and management software. The simulators were operated in a common tactical environment, including common database, targets, weapon effects, communications, etc.

In networked operation, each of the participant simulators may be visually represented to the other simulators as a friendly or threat aircraft. This selection is made by the MULTISIM instructor operating from the Apache CMS Instructor Station. The Instructor may only change the visual representation. Other characteristics of the individual simulators, such as aero, flight, sensors and weapons cannot be changed currently, although such changes could be readily incorporated in the future.

Hostile activity of the inserted automated targets is controlled by the MULTISIM instructor. These targets respond appropriately depending on whether the participant simulator is friend or foe. The AH-64 CMS threat algorithm reacts to each participant simulator (and combination of simulators) and causes targets (both friendly and threat) to engage the nearest foe. The algorithm also provides for coordinated operation of the APR-39 radar warning receivers on the individual simulators.

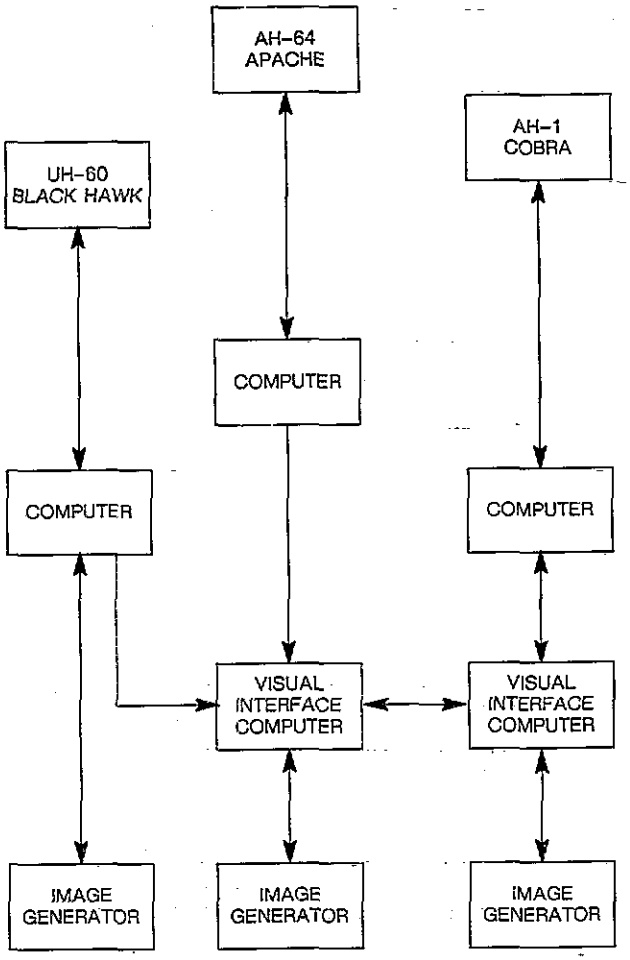

Figure 2 INITIAL NETWORKING PROOF-OF-CONCEPT APPROACH

The AH-64 CMS threat algorithm provides realistic interactive threats for developing tactical decision-making skills. This feature, coupled with the high-fidelity CMS systems simulations, is the heart of the Combat Mission Simulator and has been described in other papers [1,2,3]. The adaptation of the AH-64 threat algorithm to respond to all MULTISIM participants is an example of how networking can enhance the capability of lower-fidelity simulators.

The Black Hawk has no sensors or weapons and is therefore unable to engage and destroy other entities. The Cobra and Apache, however, are fully equipped for battle and may engage and destroy entered threats, the Black Hawk simulator, or each other. Visual weapon impacts and kill effects are displayed to all participants.

The prototype MULTISIM network requires separate operators for each of the participant simulators to provide basic control functions, such as initial conditions, freeze, edits, etc. Further research into a battle control station will consider single-point control as well as scoring displays. The networked participants have a direct intercommunication system (ICS) tie-in, allowing all participants and instructors to communicate. The ICS tie can be physically removed to isolate friendly and enemy participants. The Apache maintenance communication system was extended and is utilized to allow private conversation between instructors.

Visual repeater monitors are provided for on-the-floor or remote observation of networking operation. Three out-the-window monitors (one repeating the front window of each participant) and two sensor monitors (Apache Target Acquisition and Designation System and Cobra Telescopic Sight Unit) are provided.

The networked system operates on a common 32 km x 40 km visual database which is identical to the current Apache CMS visual database. Unique characteristics of each image generator such as differences in hardware texturing have an effect on the participant simulator only, not the network in general.

Completion of the prototype system demonstrated the ease of integration and cost-effectiveness of the MULTISIM concept.

A MULTISIM MISSION

To provide insight into the MULTISIM capability, the following MULTISIM mission is described. This mission has been performed on the MULTISIM prototype system. The mission begins with an Apache approaching a Forward Area Armament Refueling Point, or FARP. The crew is directed to replace another Apache that has maintenance problems for a cover mission escorting a troopcarrying Black Hawk. The Apache acts as lead for the team, which includes a Cobra.

Utilizing Doppler systems and APR-39 Radar Warning Receivers in conjunction with nap-of-the-earth flight to avoid hostile threats, the team navigates to the Black Hawk and begins its gun support mission. Enroute to the Black Hawk drop zone the two attack helicopters are diverted to intercept two air threats that have broken through the front lines. The air threats are the UH-60 simulator (visually modeled as a threat) and an automated target flying a programmed path. After navigating to a supporting firing position, the Apache first acquires and identifies the threats with its infrared sensor. This information is radioed to the Cobra. Once the lead target is in range of the Cobra's gun system, the Apache destroys the trailing threat with an autonomous missile while the Cobra neutralizes the first threat with gunfire.

The attack units rejoin the Black Hawk and continue the cover mission. On completion of this mission, the Apache and Cobra proceed to a battle engagement area as requested by the instructor, who acts out a scout's role throughout the mission. Enroute the Apache conducts a remote Hellfire launch. This missile, guided in its terminal flight by the scout aircraft (instructor), destroys an air defense artillery unit to the north of the engagement area.

On arriving the attack team selects appropriate firing positions within the battle position, giving them adequate backdrop to minimize radar detection while at the same time allowing them to overlook the engagement area. Here the Cobra engages and destroys two ZSU's to the west with TOW missiles while the Apache destroys an SA-8 to the north autonomously with a Hellfire missile. A number of

T-80 tanks are then destroyed cooperatively by both attack helicopters using missiles.

At this time two threat aircraft approach the battle area, the trailing threat being flown from the UH-60 simulator and displayed as a Hind (Mi-24). The Apache destroys the lead threat while the other seeks cover. The attack units exit the area at max power following the threat and maneuvering at low altitude to avoid fire from ground forces. As they close in on the threat the two attack helicopters perform a decoy maneuver to draw the threat out and destroy it.

Conducting this mission illustrated the need to use all the available aircraft systems to defeat the threat, including navigation, weapons, and survivability equipment. It also showed the teamwork required to assure a successful mission. The crews were forced to make fast decisions in regard to threat movement and position, nap-of-the-earth threat avoidance, and coordinated fire. In close range air-to-air engagements the crews learned quickly that in addition to concentrating on their airborne foe they must also be constantly alert for ground threats. Although the scout aircraft was the instructor, important training capabilities were shown, such as target handoff and remote designation. Future simulator networks including scout aircraft will support valuable training in their different tasks.

Other evaluations in the MULTISIM prototype included covert interdiction (with fixed threat sites and a man-in-the-loop air threat), air-to-air maneuvering free-play, and an air-to-air missile study using a manned threat aircraft.

IMPACT OF MULTISIM TRAINING AND RESEARCH

The application of MULTISIM can add significantly to the value of simulators used to train Army aviators. The MULTISIM concept allows for the very important individual training, but offers the opportunity for expansion to the entire combined arms area. As the aircraft employed for modern warfare become more complex, missions also become more complex, in turn requiring more complex and detailed training. These missions will require teamwork with scouts, air assault, and lift segments of the aviation forces. This development of team combat skills can be accomplished with MULTISIM in a cost-effective way using existing and near-future devices. This is particularly important with training dollars becoming tighter and the machinery of warfare costing more to operate.

This does not mean that all tactical training needs to be accomplished in simulator networks. Many important training objectives can be achieved in such a network, however. In addition, networks of full-fidelity simulators represent a unique and valuable resource for supporting research in team training.

Networking allows for team combined skills training. The section leader, platoon leader, company commanders, and battalion commanders are directly involved in training. It expands the overall combat decision-making skills of an effective fighting team. It can provide training in collective gunnery and many support/mixed team missions. It can allow such training to be conducted in simulated night and adverse conditions using advanced sensors and night vision goggles in a safe, effective manner. Conducting this training in high-fidelity simulators against a realistic lethal simulated threat results in training that could be only obtained otherwise in actual wartime conditions.

MULTISIM, using existing UH-60, AH-64, and AH-1S simulators, can provide cost-effective team mission training and research today. Training can be provided in some very difficult and mission-critical tasks, including:

Escort Mission/Formation Flying - Depending on the unit the UH-60 may be escorted by the attack helicopters. The safety of the simulators allows these missions to be conducted at dangerous nap-of-the-earth altitudes with adverse weather conditions and with hostile threat activity.

Target Handoff - The AH-64 with its FLIR system provides an excellent means of quickly acquiring and identifying threats. Handoff of these close targets to the Cobra is possible while the AH-64 concentrates on targets outside the range of the Cobra's weapon and acquisition systems.

Counter-Air Training - The new requirement for helicopter counter-air training is an excellent potential use for MULTISIM. Although basic maneuvers may be taught in single-crew simulators, advanced instruction requires combat with skilled opponents rather than against computer-modeled threats. In addition, Army doctrine dictates mutual support teams for counter-air activities. Thus training is required for 2-on-1, which MULTISIM has today, or 2-on-2 encounters, which could be accomplished with the addition of a fourth simulator. Counter-air training in actual aircraft is severely limited by safety considerations in such areas as allowed aircraft maneuver envelopes, aircraft-to-aircraft separation, aircraft altitude, weapons employment, and incorporation of ground threats. All of these limitations can be overcome with the employment of networked simulators.

Research - Recently AH-64 air-to-air missile research evaluations were conducted using the UH-60 in the network as a missile target.

Future enhancements of the existing simulators and further additions to the network will provide additional training and research opportunities, including:

Scout Training - Addition of a scout aircraft such as the OH-58D to the network would allow for laser handoff and remote missile missions. Furthermore, the UH-60 is expected to have Hellfire missiles in the near future; the OH-58D and the AH-64 will be their lasing platforms. Training and research in scout attack and lift division interactions is unlimited with networking.

ATHS - Automatic Target Handoff System (ATHS) is a complex system linking many team members. The network is an ideal setting for training in the use of this system under realistic battlefield conditions.

Mission Rehearsal - A current Army requirement is for a safe, realistic, and secure mission rehearsal capability, especially in relationship to Special Operations activities. An attractive solution is the employment of networked

simulators operating on a database generated from Defense Mapping Agency (DMA) data and intelligence photographs, and programmed with threats identified by cognizant sources. Such a system would allow a detailed rehearsal of planned missions, including the evaluation of various options and of the effects of system failures or unexpected threat encounters. Security would be greatly enhanced over in-field operations since the system would be housed in a secure building with minimum personnel access.

System Evaluation – A network of full-fidelity simulators could help the Army to evaluate new systems and tactics. Operational employment of new weapons such as the air-to-air Stinger or modified systems such as an air-to-air gun solution for the AH-64 Fire Control Computer may be evaluated in a full-fidelity simulator such as the AH-64 CMS. The advantage over field evaluations is the ability to analyze the system relative to the crew total combat workload imposed by systems operation and the interaction of programmed hostile threats. Networking further increases the workload realism in these cases since the threat target can be flown by a pilot trained in offensive and defensive maneuvers.

Tactics – Networked systems could also be employed to evaluate existing and potential aviation tactics such as those recently created for counter-air missions. Furthermore, by modeling one of the networked simulators with the threat aero and flight dynamics, counter-air performance can be precisely evaluated for different aircraft. This would include the capability to easily collect data on line printers and strip chart recorders which are presently part of the simulator complex.

C2/C3 – A significant future application of the MULTISIM concept is the coupling of multiple full-fidelity simulators with the emerging new generation technology of Force Level Simulation (FLS) currently being developed by Link Flight Simulation. While current threat simulations reflect modeling of threat emitters, FLS will provide highly accurate simulations of the Command and Control structure and Tactics employed by the threat force. More specifically, the FLS will have, as its principal design feature, the capability to explicitly model the Command and Control (C2) processes and the Communications (C2/3) systems within a specific geographic area of the world. The FLS will model the various doctrines that govern the behavior of forces in the accomplishment of mission objectives with respect to the types of conflict in which the forces are engaged. The C2/3 simulation will serve as a configurable "executive" from which data inputs describing national or political objectives will alter the doctrinal actions of forces in accordance with the rules of engagement applicable to either global or regional conflict scenarios. MULTISIM will allow an attack helicopter team to train utilizing multiple full-fidelity simulators interfaced to the comprehensive threat force environment generated by FLS.

CONCLUSION

The networking of existing full-fidelity simulations is a cost-effective method of significantly expanding training capabilities to provide the Army aviator the training he needs to fight, survive, and fight again. Further expansion can provide research and training opportunities to levels unthinkable a few years ago.

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