TRAINING THE MULTIPLE-AIRCRAFT COMBAT ENVIRONMENT

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ABSTRACT

Aircrew training devices for the teaching of tactical combat maneuvering currently range from simple desk-top trainers to large weapon system trainers with limited visual systems. Still missing from the spectrum is the capability to practice full-mission multi-ship scenarios. At present such training can only be provided by major field exercises such as Red Flag, at great expense. A network of hostile-environment simulators could greatly increase the frequency of training, provide more realistic training, and keep pilots at a higher state of readiness than by using aircraft alone. The Air Force Human Resources Laboratory is exploring technology requirements for multiple aircraft simulation under Project 2743, the Combat Mission Trainer (CMT) program. The goal is to develop a full-mission combat simulator affordable at the wing level and capable of training all air-to-air and air-to-ground tasks.

INTRODUCTION

With all of man's sophisticated gadgetry and knowledge of up-to-date training methods, there still does not exist a completely adequate training environment for practicing multiple-aircraft weapons delivery. Although major field exercises such as Red Flag closely approximate the realistic scenarios needed for the training of essential combat tasks, field exercises are expensive and infrequent and do not expose pilots to actual air and ground fire. The best training environment of all is combat itself. Historical data from World War II has shown that losses decrease dramatically following the first four to five missions of a confrontation (see Figure 1). Ideally, pilots should be trained in advance to this "fourth mission" level of readiness to increase their survivability. This should be the goal of

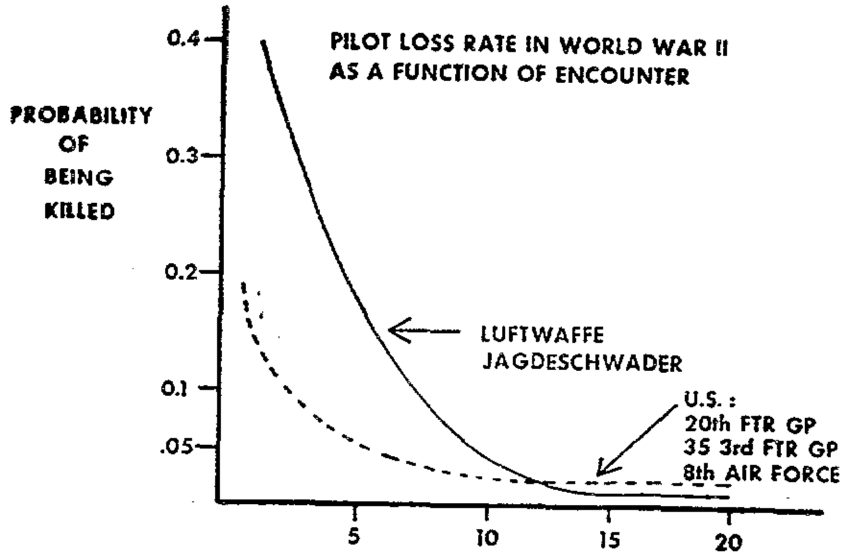

Figure 1. Losses drop remarkably following the first few missions.

day-to-day tactical training.

Flight simulators are slowly evolving into the ideal vehicle for providing the desired level of training. The use of simulators could dramatically improve the combat capability of the Tactical Air Forces (TAF), and serve as a valuable complement to large-scale field exercises (1). A Red Flag exercise, which can consist of 100 aircraft flying over 4000 sorties, is an extensive undertaking. The logistics involved in getting pilots and aircraft to Nellis AFB are of such magnitude that most pilots are able to benefit from the experience only on an annual basis. It is impossible to maintain exacting skills at a peak level when they are practiced so infrequently. If combat simulators were available at every wing, practice would be much more intensive.

Simulation can offer many other advantages. Although TAC training programs currently provide flight in the presence of threat radar emitters, pilots never see actual SAM launches, AAA tracers, etc. In the simulator, ground threats can be accurately modeled to provide striking realism for the practice of defensive maneuvers. Seeing a hostile missile approaching his aircraft will make a believer out of any pilot trying to master the art of terrain masking. Safety-of-flight rules of engagement such as those for minimum altitude and minimum separation can be varied at will in the simulator to see what the results would be in actual wartime conditions. Weather conditions can be selected for the particular area of the world for which you are training, instead of seeing only the clear dry Nevada desert air encountered in the Red Flag exercises. The experience level of adversaries can be varied to provide increasing challenges to pilots as they master new skills. Unorthodox or unusual tactics can be examined to determine their feasibility. Complex scenarios can be played back immediately for thorough debriefing and analysis. Expensive weapons such as the Maverick missile can be utilized far more frequently than during the few actual live firings permitted now.

CURRENT TRAINING DEVICES

The present-day spectrum of aircrew training devices includes, at one end, simple terminals for computer-aided instruction and desk-top trainers with interactive graphics for training specific instruments, displays and systems. The more advanced Cockpit Procedures Trainers and Instrument Flight Simulators may or may not include visual systems and are used for basic aircraft systems familiarization, instrument training, and limited visual maneuvering. At a still higher level, Operational Flight Trainers and Weapons System Trainers are now available for such front-line aircraft as the F-16, F-111 and A-10, but these also possess only limited visual systems. This spectrum must be extended to include the full-mission multi-ship environment. Some specialized simulators have been developed which provide limited interaction with another aircraft (see Table 1) but none of these devices provide a high degree of sophistication. The most seriously deficient area is that of the complex air-to-ground multi-ship mission, in which flight leads must coordinate with their wingmen and with other flights while evading multiple air and ground threats. Filling this void is the main thrust of AFHRL's Combat Mission Trainer Program.

COMBAT MISSION TRAINER

The objective of the Combat Mission Trainer (CMT) program is to develop a full-mission simulator affordable enough for widespread distribution, effective for training all air-to-ground and air-to-air tasks, and interconnectable for practicing large-scale exercises.

In its ultimate form, the CMT concept would link together a large number of simulators to provide the capability for practicing major campaigns at greatly reduced cost and without

TABLE 1
SOME CURRENTLY AVAILABLE INTERACTIVE SIMULATORS

<u>AIR REFUELING</u>	
Boeing C-5/C-141 Aerial Refueling Simulator	Seattle, WA
Singer B-52/KC-135 Weapon System Trainer	Castle AFB, CA
<u>AIR-TO-AIR</u>	
Simulator for Air-to-Air Combat (SAAC)	Luke AFB, AZ
Visual Technology Research Simulator (VTRS)	NTEC, Orlando, FL
Device 2E6	Oceana NAS, VA
McDonnell-Douglas	St. Louis, MO
British Aerospace Air Combat Simulator	Warton, England
<u>AIR-TO-GROUND</u>	
Advanced Simulator for Pilot Training (ASPT)	Williams AFB, AZ

CMT CONCEPT

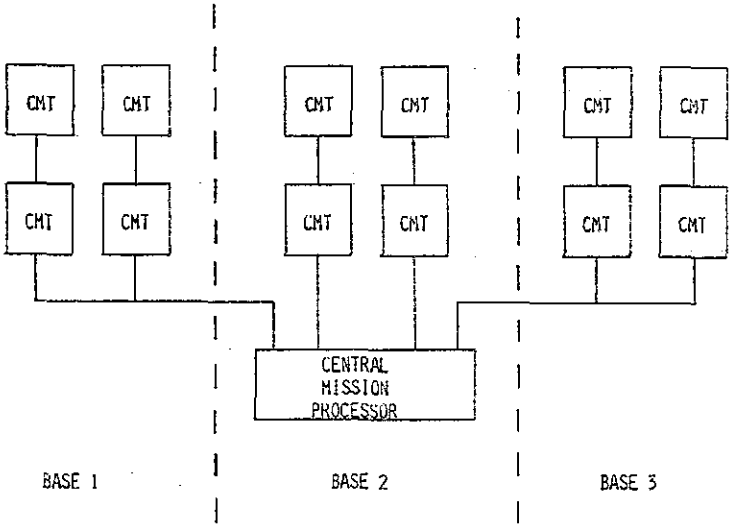

Figure 2. Interconnected simulators can provide superior multi-ship training.

loss of life or equipment. Such a system would enable pilots to interact with all other participants in the combat environment, including forward air controllers and command-and-control aircraft, as well as Army helicopters, tank formations, and other ground units (see Figure 2).

TECHNOLOGY REQUIREMENTS

Significant technology advances must be made in a number of areas before the CMT concept can become reality. A viable program for developing an affordable multiple-aircraft combat simulator must address the following design areas:

1. Visual Display
2. Image Generation
3. Data Base Generation and Update
4. Cockpit Displays and Controls
5. Basic Computational Capability
6. Instructor Operator Station
7. Multi-Cockpit Communication/Control

Visual Display

The most critical initial problem is the development of a new visual display which will provide the improved field of view, resolution, brightness, and color required for an all-purpose combat simulator. Combat simulation requires a full 360-degree coverage of the visual scene, which is not attainable in current simulators. Dome or dodecahedron simulators can provide up to 300° horizontal by 150° vertical, but do not provide the six o'clock view so critical to tactical survival. Limited field of view systems such as those proposed for TAC Operational Flight Trainers will not provide the necessary coverage for training all combat tasks.

Resolution, brightness and contrast must be adequate to support the training of tasks requiring acquisition of other aircraft or ground targets. Color could provide useful differentiation of scene details which are of the same contrast level. The display must be reduced in size from that provided by current dome and mosaic CRTs in order to eliminate the associated costs of a large, expensive supporting structure and facility.

Helmet mounted displays appear to provide a promising solution for achieving the improved capability, small size and lower cost required for the CMT application. Some current approaches being monitored for their applicability include AFHRL's Fiber Optic Helmet Mounted Display, Aerospace Medical Research Laboratory's Visually-Coupled Airborne Systems Simulator (VCASS), and the McDonnell-Douglas Helmet Mounted Visual System. For a complete description of the AFHRL approach, see the paper entitled FIBER OPTIC HELMET MOUNTED DISPLAY: A COST EFFECTIVE APPROACH TO FULL VISUAL FLIGHT SIMULATION elsewhere in these proceedings.

A typical simulator using microprocessor technology and a helmet mounted display might appear as shown in Figure 3.

Image Generation

Image generators for the CMT must provide a high-quality out-the-window visual scene and multiple sensor displays such as forward looking infrared (FLIR) and radar.

The image generator is presently the greatest cost driver of the entire system. In the near future, if image generator channel requirements can be reduced to three or four through the use of head coupled displays, then cost could potentially be reduced to $3-5 million per simulator. Systems currently in design and development by major manufacturers could be used for an interim CMT, but no real progress will be made in this area until advances in Very High Speed Integrated Circuits (VHSIC) and Very Large Scale Integration (VLSI) produce dramatic decreases in cost similar to those already achieved in the computer industry.

Scene detail as determined by edge count, texturing, and quadratic surfaces must provide the minimum essential information required for target acquisition and low level terrain cues. AFHRL's Project 2363, the Advanced Visual Technology System, will provide essential answers to the questions regarding these minimum levels following its delivery in 1984.

Sufficient moving models must be provided in the scene to handle all participants who are within visual range of each other. A moving model capability is being included in new simulators such as the General Electric C-130 simulator at Little Rock AFB, and the proposed AV-8B simulator for the Cherry Point Marine Corps Air Station being built by Rediffusion/Evans & Sutherland (2). However, more moving models than currently available on these new systems would have to be included for a realistic combat scenario.

FLIR image generation poses challenges and risks similar to that for outside visual scenery. Given appropriate algorithms for handling the unique characteristics of infrared imagery such as atmospheric and time-of-day effects, FLIR imagery can be produced by the visual image generator. Air-to-air radar is not difficult to simulate and should be relatively inexpensive to duplicate. Air-to-ground radar simulation, on the other hand, is sufficiently different from visual image generation that it requires its own separate generator, usually referred to as a Digital Radar Landmass Simulator (DRLMS). Current air-to-ground DRLMS do not readily lend themselves to the CMT concept because of their expense. Much development work is needed to provide a low-cost air-to-ground radar simulation, especially for the newer types such as Synthetic Aperture Radar (SAR).

Data Base Generation and Update

The present capability to generate and update a data base is an order of magnitude away from CMT requirements. If possible, only

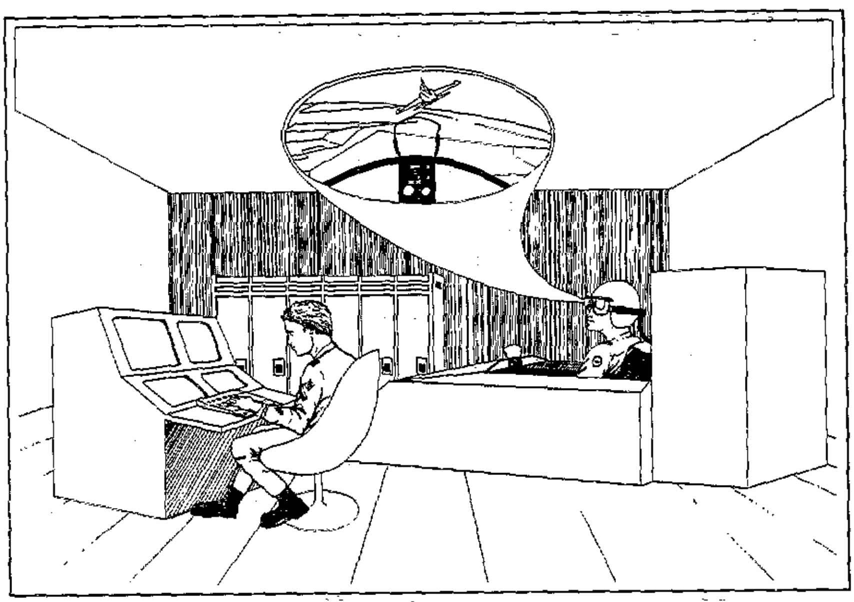

Figure 3. Compact design envisioned for a combat mission trainer.

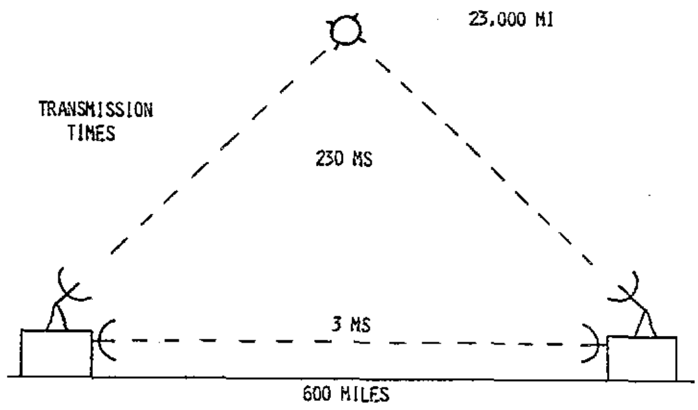

Figure 4. Satellite relay is unacceptable due to the long transmission time.

one data base should be required for storage of all out-the-window and sensor parameters required for visual representation, infrared emissivity, and radar reflectivity. Extensive hand modeling must give way to automatic techniques to greatly increase the responsiveness and flexibility of the system. Data bases must be capable of rapid update with the latest digital terrain data from the Defense Mapping Agency, and the latest threat information from various intelligence sources. Automatic input of intelligence data is a critical requirement for responding to rapidly changing threats. For best efficiency, rapid update should be limited to just threat, target, and minor terrain feature relocation.

Cockpit Displays and Controls

Development of cockpit displays and controls is a low risk area, since this technology has been demonstrated repeatedly. Fabrication of cockpit controls is a minimum cost item compared to the rest of the system, although some specialized displays such as radar warning receivers and Maverick missile displays may be required. Fixed-stick cockpits such as the F-16 have the advantage of requiring no control loading development. Newer generation aircraft are also employing multipurpose displays which will help eliminate the need for large numbers of specialized displays.

AFHRL-developed micro-linkage techniques can provide an inexpensive connection between cockpit and computers. This was demonstrated on the U-2 Cockpit Procedures Trainer (CPT) constructed by AFHRL and delivered to Beale AFB in 1982 (3). Use of micro-linkage greatly increases the flexibility of the system and lowers its cost by reducing the required hardware. Other alternatives to the linkage problem have been proposed, such as the use of separate microcomputers for each instrument (4).

Basic Computational Capability

State of the art microprocessor technology is adequate for current research efforts. A cost-effective host computer using commercial technology is practical today, although microprocessor technology is moving so fast it wouldn't pay to rush into a pre-production system before the rest of the CMT is ready. Distributed microprocessor technology was effectively utilized in the AFHRL U-2 CPT (3).

Instructor Operator Station

The CMT concept will require an extensive instructor operator station (IOS) to monitor the interaction of multiple aircraft during air-to-air and air-to-ground maneuvers. The ASPT has a very successful air-to-ground display, while the SAAC can display three dimensional air-to-air maneuvering. Neither of these designs would be adequate for both air-to-air and air-to-ground missions, so a new concept in multi-mission, multi-participant instructor operator stations must be developed.

Multiple-Cockpit Communication/Control

A number of alternative configurations exist for networking from two to fifty combat simulators. The optimum approach is to make all CMTs stand-alone capable, and connect them to a central control facility for distribution of position data, weapon status, and damage determination. Transport delay can be minimized by passing attitude and velocity data and predicting the correct actual position for the moving models.

Small-scale experience from the cross-town ASPT-SAAC linkup demonstrated the feasibility of interconnecting dissimilar simulators through telephone lines for one-on-one air-to-air combat. AFHRL will test simple two to four cockpit arrangements in-house to ascertain the feasibility of conducting multi-ship multi-mission training with more complex air-to-ground data bases. Once the concept is proven feasible the interconnection of two distant simulators can be tried using microwave links and/or land lines. The use of satellites is infeasible (5) because the average transmission time of 230 milliseconds gives a totally unacceptable transport delay for real-time interactive flight simulators (see Figure 4).

Whatever transmission method is used, security protection becomes a vital concern because classified tactics would be vulnerable to compromise during the conduct of large-scale exercises. Use of a central facility for rapid database and threat updates poses a high security risk during the transmission of new data to all interconnected simulators.

A full CMT system would also require a voice communication channel for participants to communicate with each other and with their instructors. This will further complicate the interconnection process.

CONCLUSIONS

Combat simulation is rapidly becoming a necessity for the training of future fighter pilots. A multi-cockpit, multi-mission simulator can increase readiness by improving the weapons delivery capability of the participants and by enhancing their survivability.

New technology must be developed to provide lower-cost, higher-capability simulators designed specifically for multi-ship combat interaction. The great costs associated with image generation and display must be reduced. The challenge is before industry to make lower cost image generators a reality.

As current simulators become upgraded with advanced visual systems, they can be interconnected to create a large network of interim training devices for multi-participant scenarios prior to the deployment of next-generation combat simulators.

Advances in many technical areas are required before widespread combat simulation will become a reality, but continued investment promises ultimate success and a high payoff.

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