# SIMULATION OF AN ADVANCED SCOUT ATTACK HELICOPTER FOR CREW STATION STUDIES

P.A. Lypaczewski, Eng
CSRDF Systems Architect
CAE Electronics Ltd.
Montreal, Canada

A.D. Jones
CSRDF Project Manager
Flight Systems & Simulation Research Division
NASA Ames Research Center
Moffett Field, CA

Maj. J.W. Voorhees
CSRDO Research Manager
Aeroflightdynamics Directorate, AVSCOM
Moffett Field, CA

## ABSTRACT

The system complexity and high workload of the next generation of light scout/attack helicopters is a major cause of concern for the U.S. Army. The Crew Station Research and Development Program has been established by the Army to study the issues of battle captain performance for one-man versus two-man crews. A Crew Station Research and Development Facility (CSRDF) has been contracted for. It consists of a distributed computer system with several stations which play different roles in experiments. Coordination of experiments is done from the Experimenter/Operator Console where a team of Army experimenters and NASA personnel control and monitor the mission scenario used to test the crew members.

## INTRODUCTION

The system complexity and high workload of the next generation of light scout/attack (SCAT) helicopters is a major cause of concern for the U.S. Army. In response to these concerns, the Crew Station Research and Development Program has been established to study the issues of battle captain performance for one-man versus two-man crews when confronted by a hostile environment. The experiments will be conducted at the NASA Ames Research Center by the Crew Station Research and Development Office with the support of NASA's Flight Systems & Simulation Research Division. These groups have contracted CAE Electronics Ltd. of Montreal, Canada and Flight Systems Inc. of Newport Beach, California to provide the Crew Station Research and Development Facility (CSRDF) for the running of these experiments. To support the research, the Army has provided the loan of a digital image generator (DIG), manufactured by Singer Link of Sunnyvale, California, from the Cobra training program.

## CREW STATION EXPERIMENTS

The Crew Station Research and Development Facility is a distributed system consisting of several stations which are used to support the Army experiments. The pivotal element of the facility is a two seat tandem helicopter cockpit which provides a realistic environment to the test pilots taking part in the experiment. Three Blue/Red team stations augment the scenario realism by simulating other aircraft on the battlefield while a White station is used to simulate supporting forces with which the crew would be expected to interact during the engagement. The coordination of the experiment is done from the Experimenter/Operator Console (EOC) where a team of Army experimenters and NASA personnel control and monitor the mission scenario that is used to test the crew members.

A composite mission scenario has been developed by Command Systems Group Inc. of Torrance, California, for the Army experiments. This is a multiple employment scenario which is divided into three 45-minute portions: an initial phase where the simulated SCAT team interworks with air cavalry and conducts a route reconnaissance; a subsequent phase where, after refueling at the forward area rearming and refueling point (FARRP), the team initiates a meeting engagement with hostile forces; and a tertiary phase where the SCAT team employs maneuver and fire to disrupt the enemy units which are engaged in a deliberate attack. In all three phases of the scenario there is an unscheduled change in mission to extract personnel from the enemy rear, and an air-to-air engagement with gunships from the enemy forces. Also, as the mission progresses through the three phases, the threat level that is presented to the crew station is increased as well as the crew member communications tasking and level of fatigue. The capability is also provided for malfunctions to be inserted to degrade the simulated aircraft systems.

The composite mission scenario provides a realistic workload which enables the performance of the battle captain to be studied and compared under various circumstances. By configuring the crew station to run with either one or two crew members, the effectiveness with which the mission is accomplished can be compared including how well the battle captain has controlled the resources of the SCAT team, as well as those of his own aircraft. Also, the effect of different cockpit layouts on battle captain performance can be studied by using either the front or rear crew positions for that function.

Since the mission scenario is based on employment of a team of SCAT helicopters, it is essential that those members be present to interact with the battle captain. This role is fulfilled by the three Blue/Red team stations and the White station. Each Blue/Red team station can be configured to simulate a section of four friendly (Blue) aircraft or as enemy (Red) aircraft for the air-to-air engagements. When running in the Blue mode, the experimenters manning those stations interact with the crew station as section leaders and can communicate verbally via the simulated commo system or electronically using a full data link simulation.

The White station completes the cast of the scenario participants. The experimenter at this station simulates ten other units which interact with the crew station. These include elements such as the Ranger unit to be rescued, AWACS aircraft that warn of approaching Red aircraft, and the headquarters for ground-based artillery and air cavalry to which the battle captain must transmit reports either verbally or by data link.

## FACILITY ELEMENTS

The design of the various stations in the CSRDF has been undertaken with the requirements of Army experiments in mind. This has been accomplished by taking into account the overall performance envelope as well as the need for ease of use and flexibility for research.

The tandem crew station (as shown in Figure 1) has been designed to represent the technology which is expected to be available in the 1987/1988 time frame. The primary flight instrument for the pilot is a wide field of view Fiber-Optic Helmet-Mounted Display (FOHMD) which presents a panoramic view of the world coupled with sensor outputs and symbology for pilotage, threat alerts and weapon release. Programmable display push buttons allow rapid input to critical aircraft systems such as weapons and countermeasures. Control of the aircraft systems is effected using "glass cockpit" Systems Management Displays (SMDs) via the various tactile data entry devices such as touchpads and touchscreens (as shown in Figures 2 and 3) or through the interactive voice input/output system. Monitoring of the aircraft situation may be done with the Tactical Situation Display (TSD) that displays a scalable plan view of the gaming area along with several overlays showing the status of threats and friends. These may be modified using the touchscreen, as may the navigation and tactics overlays that may also be shown on the TSD.

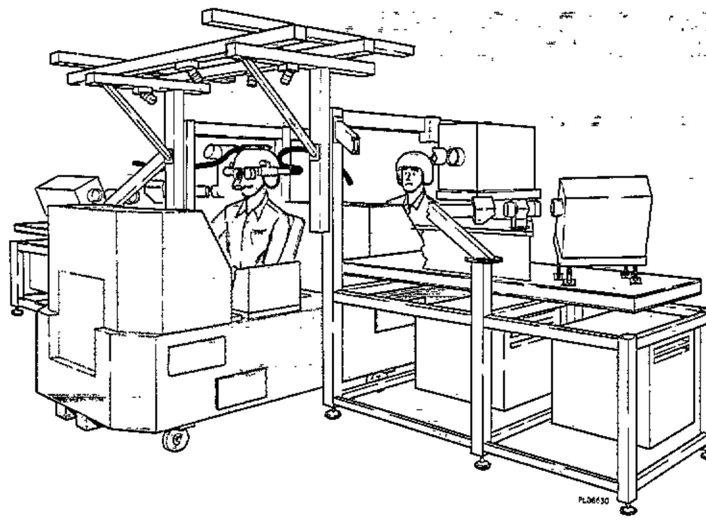

Figure 1. Crew Station Structure

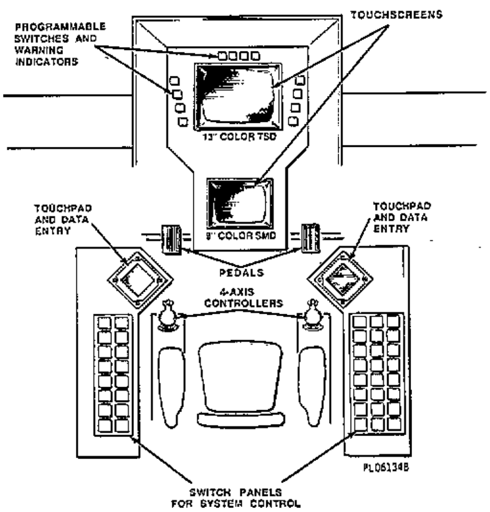


Figure 2. Front Crew Station

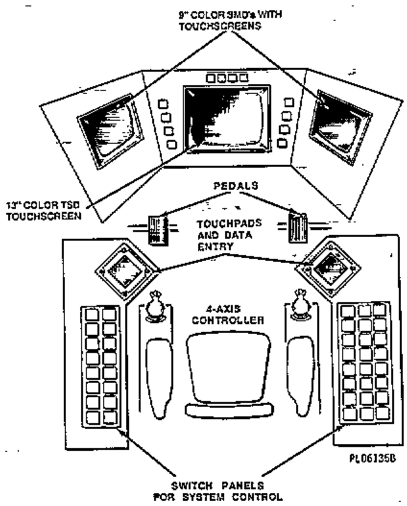


Figure 3. Rear Crew Station

The flight controls in each crew station consist of two four-axis limited-displacement controllers plus foot pedals (allowing full control in each crew position). The longitudinal, lateral, directional and collective controls may be assigned to any combination of the hand controllers and pedals in a given crew position. This reconfigurability allows for the investigation of the impact of various control configurations on crew member efficiency. The flight controls are also dynamically selectable between the front and rear crew positions in order to support the two-man configuration. In order to properly task the crew members in all regimes of flight, the flight control simulation interacts with a real-time blade element rotor model. Given that nap-of-the-earth (NOE) flight will be used for most of the mission, the faithful simulation of the transitioning effects that the rotor model provides is particularly important for the Army experiments.

A key consideration in the study of crew member fatigue is the level of noise that they are subjected to on the aircraft. In order to provide a representative environment in which to do these studies, the crew station has been surrounded by a six-channel sound system. This provides directional sound cues for such items as rotor and transmission noise, weapon firing effects, dispensing of chaff and flare, and the other various noises that occur during the scenario. The noise levels that are produced are comparable to those which are experienced on the aircraft.

The three Blue/Red team stations (shown in Figure 4) furnish a user friendly interface for the experimenters manning these stations to interact with the crew station. A plan view or stylized forward view display are the chief references for pilotage and are displayed on a 19-inch ultra-high-resolution full-color monitor. Selection of weapons, control of the flight modes and receipt and transmission of data link messages are all done using soft-key selections on the touchscreen. Control of the communication system is via a programmable plasma touchpanel display. Highly automated flight modes are available for the experimenter's use to allow the stations to fly in concert with the crew station. The team station is then controlled using simple commands from a joystick. The distributed nature of the CSRDF will allow these stations to be upgraded to complete team member helicopter simulations in the future, however, the simple stations are presently adequate for the system's intended use.

In addition to those display features which are at the Blue/Red team station, the White station (shown in Figure 5) has other equipment to support it's communications-intensive task. A voice alteration unit modifies the output of each of the station's ten channels so that each of the ten units simulated at the White station speaks with a different voice. Ten channels of background chatter are also injected from the White station onto the communication system output to further augment the realism of the simulation. The frequencies for the chatter are automatically assigned under experimenter control to those frequencies which are used in the scenario.

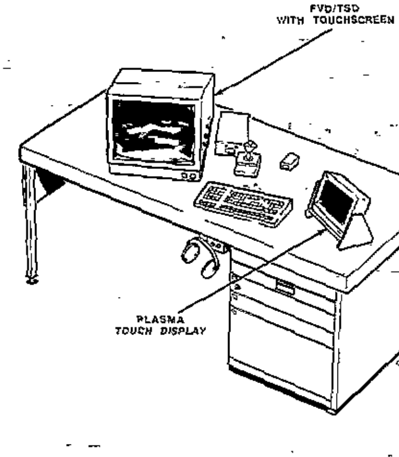


Figure 4. Blue/Red Team Station

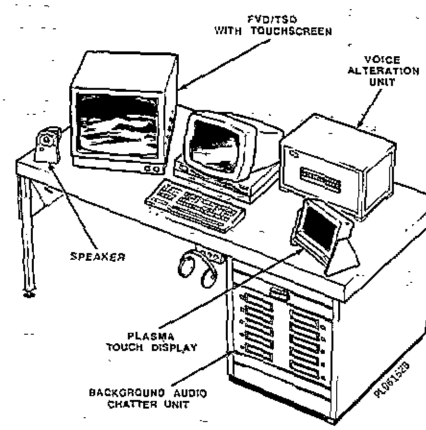


Figure 5. White Team Station

The running of the experiment and the data recording and analysis are conducted from the experimenter/operator console (shown in Figure 6). A myriad of tools are at the experimenter's disposal for monitoring and controlling the experiment. Any part of the gaming area may be viewed under experimenter control using a plan view similar to that used in the crew station, or a stylized forward view display which is used to give a "God's eye view". Ultra-high-resolution monitors repeat the outputs from the Singer Link digital image generator (DIG), the various crew station displays and the displays at each of the Blue/Red team stations. Low light level cameras display an over-the-shoulder view of each of the crew positions. An eight-channel studio-quality audio recorder saves time-stamped recordings of the mission communications for later analysis. Data recording utilities save critical parameters for analysis after each experiment. Control of all elements of the experiment is made possible by using programmable control pages in conjunction with touchscreens mounted on 19-inch color monitors or via keyboards and plasma touch-panel displays. In this manner the experimenter can effectively keep track of the experiment as it progresses.

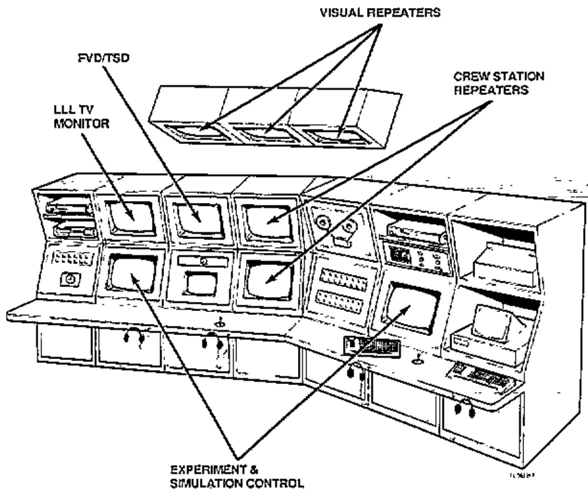


Figure 6. Experimenter/Operator Console

## SIMULATION DESCRIPTION

A distributed multiprocessor system has been set up to support the CSRDF as shown in Figure 7. This consists of a host computer system which controls and schedules the various satellite processors driving the crew station, team stations and the EOC. The host computer system consists of a VAX 8650 iterating at a basic rate of 60 Hz coupled with an array processor running the real-time blade element rotor model at 120 Hz. The Blue/Red team stations and EOC are controlled by MicroVAX II microcomputers which are connected to the host by Ethernet serial data buses. Twelve Silicon Graphics IRIS graphics workstations are distributed throughout the facility for driving the various team station and crew station displays and are connected to the VAX 8650 and MicroVAXs by Ethernet. A Perkin Elmer PE 3250 drives the Singer Link visual system and is connected to the host by a parallel DMA data link.

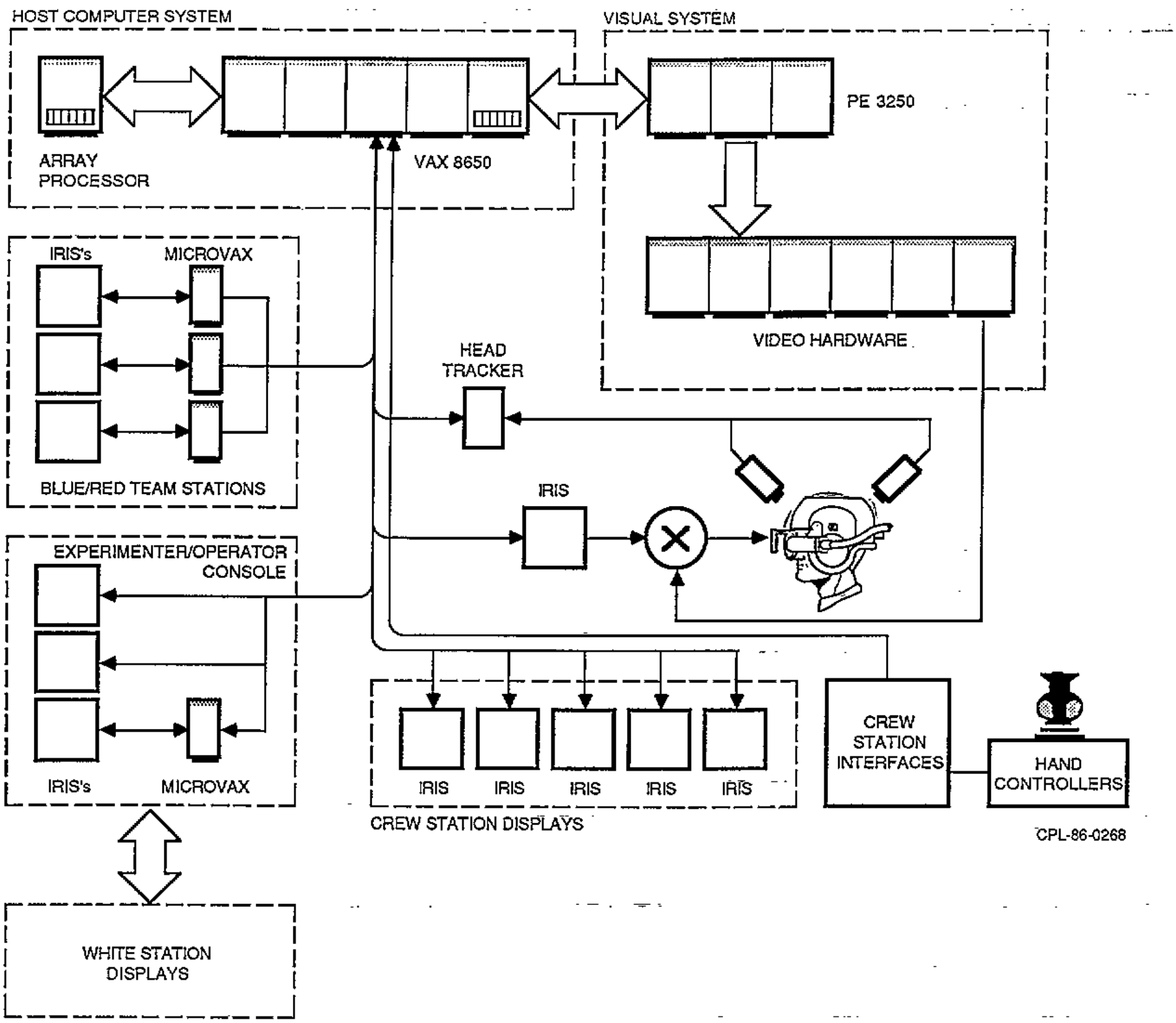


Figure 7. CSRDF Computer Architecture

The real-time software in the host computer may be divided into two groups: the simulation of the air vehicle and crew environment and the system software furnished by CAE, and the simulation of the threat environment and crew station tactical systems supplied by Flight Systems Inc. The CAE simulation comprises the basic airframe, the nontactical systems, the user interfaces for the facility and the software environment in which all the software executes. An example of the run-time simulation is the blade element rotor model which partitions each blade into segments and computes the lift and drag for each segment in real time. Of equal importance is the system software that establishes a modular, adaptable environment for running the simulation software. This supports the linking and configuration of the simulation in a way to simplify the task of changing models or modifying existing ones. Using well-defined interfaces into the various models permits the adaptability that is essential for an experimental device.

The responsibility of the mission scenario software developed by Flight Systems is the realistic simulation of the tactical environment. One example is the distribution of threat sites in the gaming area which can simulate a combination of up to one hundred and ten players (including tanks, SAM sites and anti-air-artillery (AAA) sites). The tactics software also simulates the crew and team station weapons and aircraft survivability equipment (ASE), as well as the simple flight models which run in the Blue/Red team stations.

The experimental nature of the CSRDF dictates that the system cannot be set up as a point design (i.e., the design cannot be "carved in stone" to suit the first set of tests). In order to support future experiments, it is necessary that the facility be easily reconfigurable. To that effect, editors are being furnished which will allow all of the user interfaces to be easily modified. An interactive graphics editor allows new crew station displays to be built and existing ones to be changed and linked into the simulation quickly and in a user-friendly manner. A syntax editor allows the syntax trees which drive the crew station voice input and output systems to be modified to suit the experiment. Data base processors automatically extract the terrain information from the Singer Link visual data base to build the forward view displays and the TSD contour maps used in the facility. Utilities are also being furnished which allow the threat lay down and characteristics to be modified between experiments. Using these sorts of software tools, the facility may be radically reconfigured in a very short period of time.

The heart of the CSRDF and the key item for the simulation of the next generation of SCAT helicopter is the Fiber-Optic Helmet-Mounted Display (shown in Figures 8 and 9). Through the FOHMD, it is possible to present the pilot with an instantaneous horizontal field of view of 125 degrees and a field of regard that is effectively unlimited. Using an infrared optical head tracker, the pilot's head position is monitored by the host so that the visual scene displayed corresponds to where the pilot is looking. Accelerometers are affixed to the pilot's helmet to allow lead predictions to be calculated in

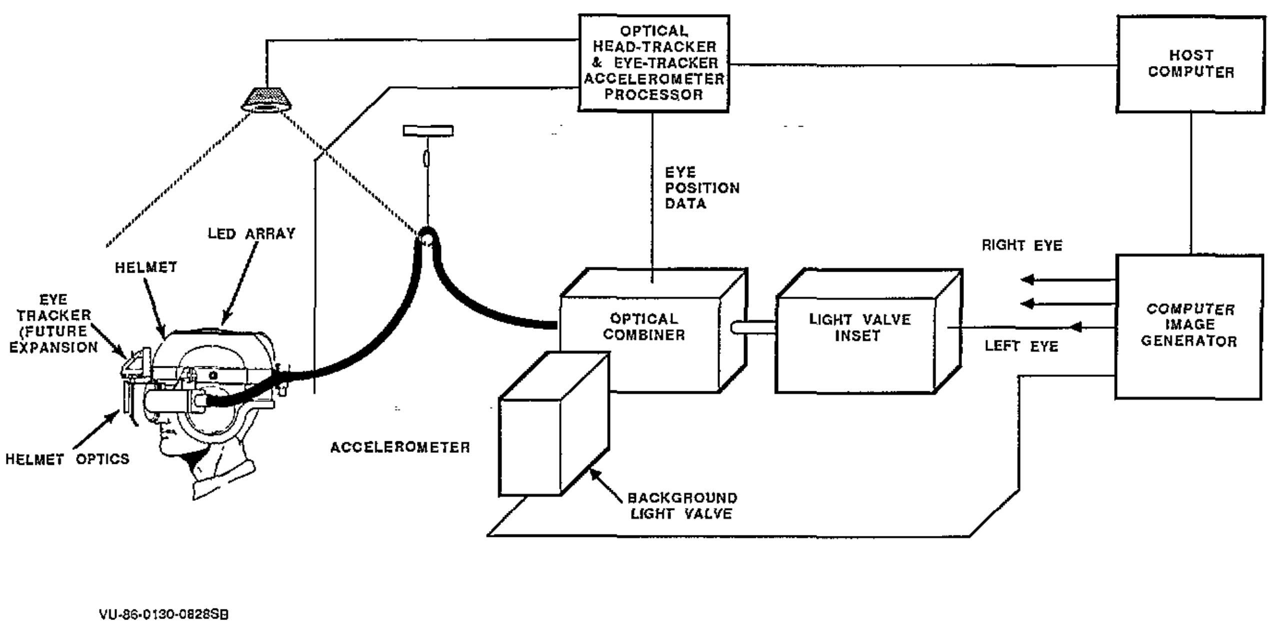


Figure 8. FOHMD System

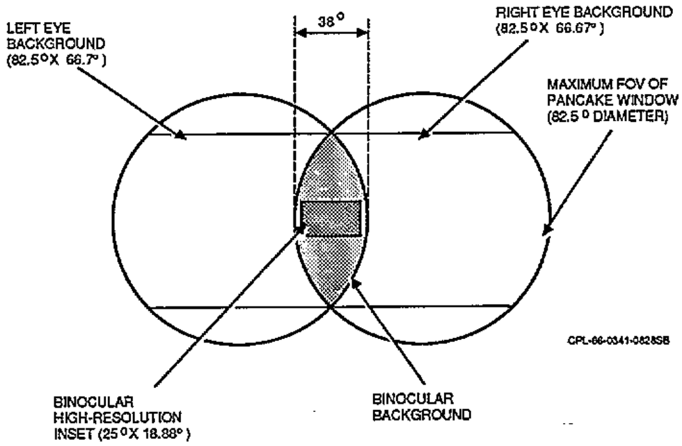


Figure 9. FOHMD Fields of View

the host to counteract latencies in the processing and visual image generator loop. This results in a stable, flyable image which tracks all of the pilot's head movements. A high-resolution inset is used to simulate sensor video (such as FLIR from a mast-mounted sight) merged with IRIS-generated symbology. A future enhancement to include eyetracking will permit the inset to be used as a high-resolution eye-slaved area-of-interest (AOI) display. The background channels of the FOHMD are used to simulate a wide field of view night vision pilotage system (NVPS) using a FLIR image generated by the DIG. A 30- by 40-km tactical data base, developed for training on the Apache program, is included with the DIG. Areas in the data base have been modeled to provide accurate pilot cues for NOE flight, which is further reinforced by the texturing of the visual scene by special hardware. Full-color daytime out-the-window, FLIR and daylight television images are available to the pilot from the DIG output channels as viewed from the FOHMD. The visual system interacts with the host computer to show the crew station position within the gaming area and to display weapon effects and target positions in concert with the tactical scenario which runs in the host computer.

## CONCLUSION

Given the hostile environment that crews are expected to face in the modern battlefield, it is crucial that the aircraft man-machine interfaces be configured in such a way as to optimize survivability. Through the Crew Station Research and Development Facility, it is felt that the Army has a flexible tool for an effective investigation of the questions that must be answered for the next generation of light Scat helicopters.

## ABOUT THE AUTHORS

Paul A. Lypaczewski is the Systems Architect for the Crew Station Research and Development Facility, working in the Flight Simulation Engineering department of CAE Electronics Ltd., Montreal, Canada. His present responsibilities include supervising all technical matters which pertain to the CSRDF as well as managing the Avionics Department of Simulation Systems Engineering at CAE. He graduated from McGill University in 1979 with a Bachelor of Electrical Engineering degree. On graduation, he joined CAE where he worked as a systems engineer on autopilot simulations. He has since been the Group Leader for several tasks, including the integration of advanced airborne equipment into simulators and visual system development. Mr. Lypaczewski has presented papers on the installation of avionics on advanced flight training simulators and has lectured part time at Concordia University.

Maj. James W. Voorhees, PH.D. is currently serving as the Technical Manager of the Crew Station Research and Development Office of the U.S. Army Aeroflightdynamics Directorate at Moffett Field, California. Maj. Voorhees is a master Army aviator with two combat aviation tours in the Republic of Vietnam. He received his PH.D. in experimental psychology in 1980 from Texas Christian University in Fort Worth, Texas. He is the author of over twenty-five papers in the area of Aviation Human Factors, and represents the directorate as simulation and flight test evaluation chief for the Army's Advanced Rotorcraft Technology Integration (ARTI) Program.

A. David Jones is currently assigned to the Flight System and Simulation Research Division of the NASA Ames Research Center, Moffett Field, California. In his current assignment as Project Manager of the Crew Station Research and Development Facility, he is responsible for the design, development, integration and initial operation of this new capability. His most recent assignment was as Chief of the Simulation Investigations Branch. He also served as Facility Manager for the development of the Vertical Motion Simulator and has more than twenty-years experience in the development, operations and management of real-time piloted flight research simulators. Mr. Jones received his Bachelor of Science degree in Aeronautical and Astronautical Engineering in 1964 from the University of Illinois.