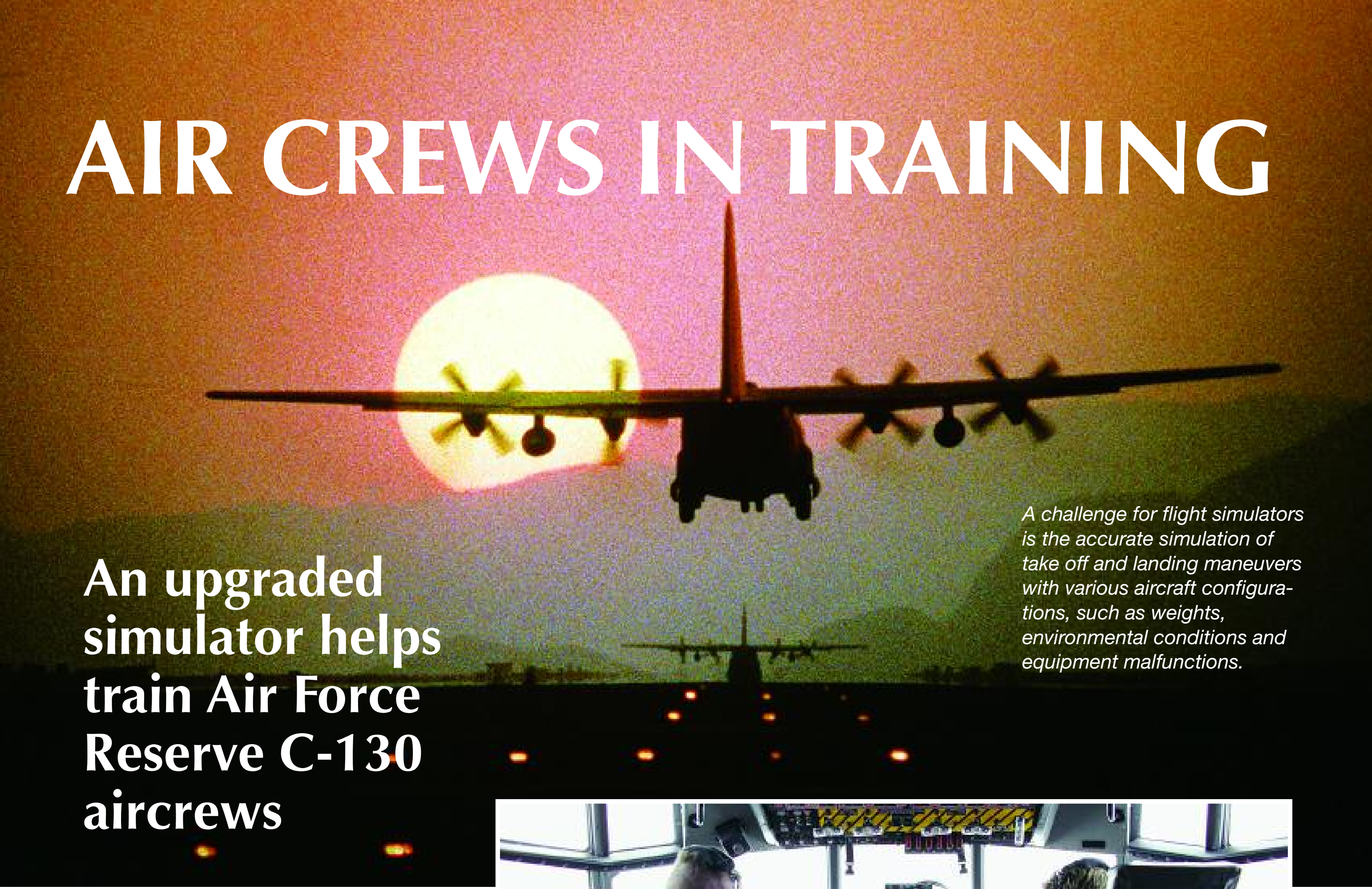
AIR CREWS IN TRAINING



An upgraded simulator helps train Air Force Reserve C-130 aircrews

A challenge for flight simulators is the accurate simulation of take off and landing maneuvers with various aircraft configurations, such as weights, environmental conditions and equipment malfunctions.

By Kevin Miller

Imagine an Air Force flight crew on a critical mission to support troops. The pilot is responsible for safe transport of the crew and cargo to the final destination. The takeoff, flight and landing are smooth and successful.

Given the high fidelity of present-day flight simulators, plus mandates to reduce training costs, it's quite possible that the majority of flight crew training may have taken place in a simulator. Aircrew training and certification traditionally have been conducted in aircraft, but it is increasingly being conducted in simulators.

At Dobbins Air Reserve Base (ARB), Georgia, the flight training unit incorporates classroom instruction, simulator training events and actual aircraft flights to train and certify aircrew for the C-130H2 transport aircraft. Until recently, the C-130H2 Weapon System Trainer was the only simulator available for pilot, copilot, and flight engineer training and certification. It was in use up to 18 hours a day, six days a week to handle the student load, and this congestion was considered a bottleneck for aircrew training. The Air Force Reserve Command (AFRC) decided in 2003, to procure a second H2 simulator. Budget limitations and numerous studies led to the development of a unique acquisition plan. The AFRC would contract services to upgrade an existing simulator in lieu of developing a new device.

In August 2003, the AFRC directed the Air Education and Training Command (AETC) at Randolph Air Force Base to convert an uncertified C-130H3 Unit Level Trainer to a certified Level-6 C-130H2 Flight Training Device (FTD). The conversion was a joint development effort

The FTD student training positions, pilot (forward left, occupied here by Maj. James Grogan), copilot (forward, right, occupied by MSgt. Michael Macaleese), and flight engineer (aft, center, seat not shown), are a replica of the C-130 H2 model flight deck. The instructor station positions are located aft of the student positions.

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Courtesy U.S. Air Force

between the AETC, Southwest Research Institute (SwRI) and a team of subcontractors under the direction of SwRI. The Institute was the prime contractor and technical manager. The three-year, $5 million program recently concluded with the delivery, installation and certification testing of the device at Dobbins ARB.

Training Environment

Just as aircrew members are certified in a simulator to operate a certain aircraft type, the simulator itself must also be certified. Most commercial and government flight simulators that are built to represent a specific cockpit configuration are certified in accordance with Federal Aviation Administration (FAA) guidelines or standards and are assigned a complexity, or "fidelity" level. Levels A (lowest) to D (highest) are reserved for top-of-the-line airplane simulators containing a full-size replica of the cockpit, an out-the-window visual system and a motion cueing system. Simulators that lack visual or motion systems are classified as Level 4 (lowest) through 7 (highest). Certification is a complicated, time-consuming and costly process where simulators are tested and their performance is compared with actual aircraft performance as recorded in an instrumented aircraft.

The flight training device is to be used for tasks that were previously taught in the weapon system trainer: familiarize students with cockpit controls, practice checklist and emergency procedures, and practice instrument flying including take-offs, landings and in-flight navigation. To support training, the device's simulated cockpit contains a replica of a C-130H2 flight deck that includes a pilot position, a copilot position and a flight engineer position. A fourth position for the navigator was not replicated. With few exceptions, the controls and instruments look, feel and operate like actual aircraft components. However, unlike the weapon system trainer, the flight training device does not have an out-the-window visual system, nor is the flight deck mounted on a motion base.

Three instructor positions are located behind the student positions. The most valuable quality of the flight training device, as with most flight simulators, is its ability to save and restore the simulated conditions of the aircraft and its environment, "freeze" the simulation, and insert malfunctions. None of these can be easily or safely performed in the actual aircraft. The freeze capability allows an instructor to interrupt the simulation to insert guidance or discuss an operational error with the student. A simulation freeze, combined with the capability to restore the simulation to an earlier flight condition, allows the student to repeatedly practice a training event, such as landing with one engine out, until the skill is mastered. More than 200 simulated malfunctions, ranging from an engine fire to a faulty temperature gauge, can be inserted on the fly or automatically at a predetermined time or under certain flight conditions.

Conversion Approach

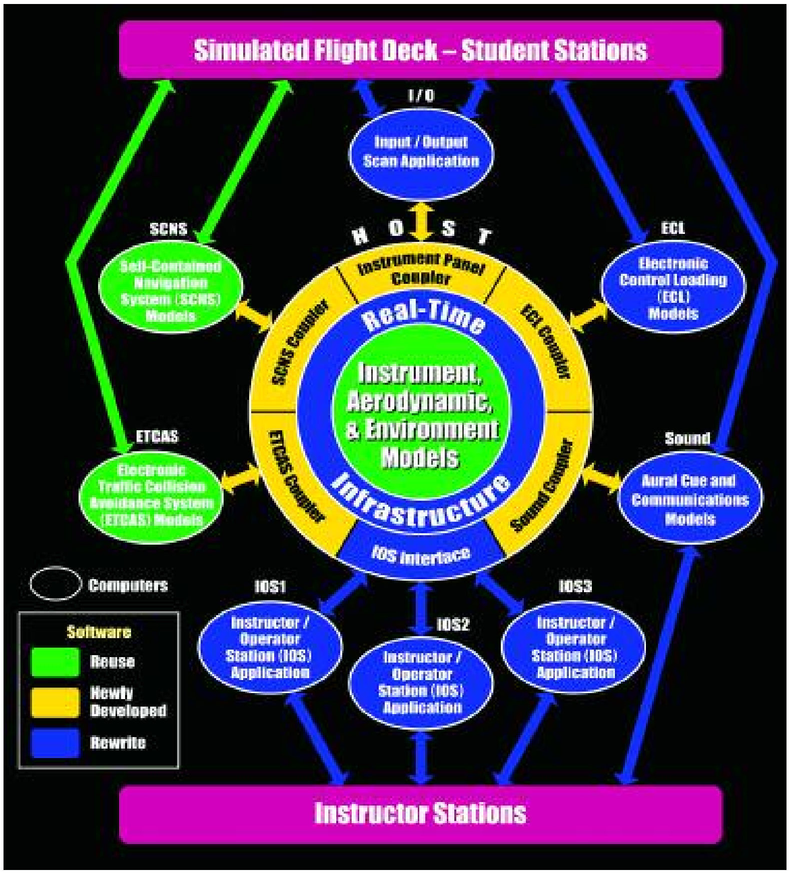
The approach used to convert the existing trainer is similar to an automobile overhaul, but more complicated. The instrument panels and wiring harnesses were removed and refurbished, the computers and software were replaced, student seats were reupholstered, and the device received a new paint job.

Replacing the computer systems was the most complicated of the conversion tasks. It was bound by five critical client requirements: 1) to reduce life-cycle costs (acquisition plus 10 years of maintenance), 2) to maximize reuse of government-owned instrument and aerodynamic modeling software from the weapon system trainer, 3) to maximize use of new computer systems based on commercial off-the-shelf personal computer technologies, 4) to replicate the weapon system trainer instructor interface; and 5) to remove all proprietary software and replace it with open-source software.

Instrument, Aerodynamic and Environment Models

A host computer serves as the simulation master that executes the reused aircraft instrument and aerodynamic models. Real-time infrastructure components control the execution of each model and maintain a pool of shared variables that facilitate inter-model and inter-computer communications. The input/output (I/O) application scans the position of flight deck controls, such as switches or knobs, and passes the data to the host computer instrument models. In turn, the models use the data to set variables that are passed back to the I/O application to drive display components such as lamps and gauges.

The FTD uses a network of nine computer systems to simulate the C-130 flight deck environment and allow instructors to monitor and control the simulation.



More complicated instrumentation warranted independent computer systems to host the simulation models. The Self Contained Navigation System (SCNS) was simulated using existing models. The primary pilot interface is a multi-function display unit containing a small monitor and a keyboard. In combination with the aircraft's autopilot system, the SCNS can automatically "fly" a flight plan. The Electronic Traffic Collision Avoidance System is also simulated by reused models. The pilot interface is an LCD (liquid crystal display) monitor that displays information about adjacent aircraft and provides navigation solutions and audio warnings to avoid a collision.

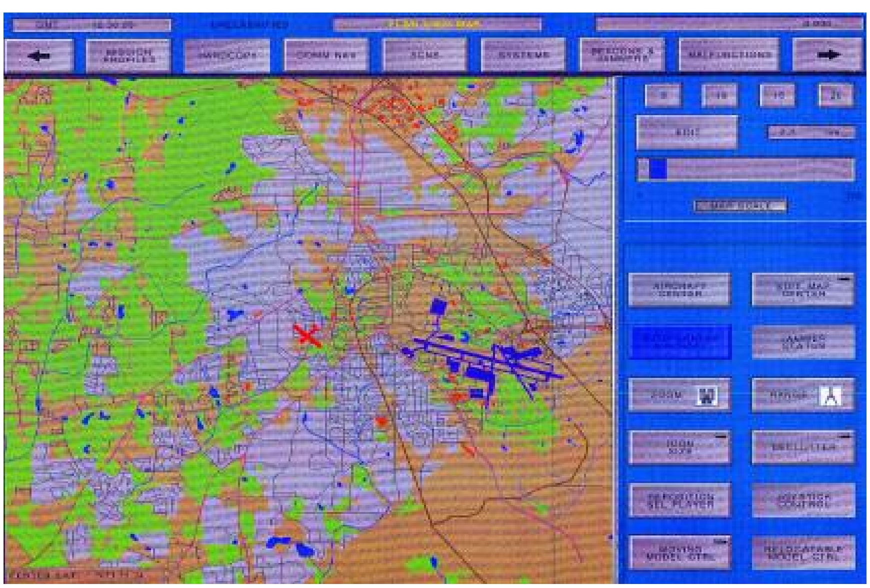
Environment models showing the Earth and its atmosphere provide additional realism. Simulated atmospheric components that affect aircraft performance include pressure, wind, temperature and icing. Ground elevation at airports determines the radar altimeter reading during takeoffs and landings. Finally, ground-based navigational aids simulate instrumentation that assists the pilot during landings and provides distance and bearing information for in-flight navigation.

Electric Control Loading System

A foundation of C-130 simulator certification is the testing of models that simulate the hydraulic-driven flight controls: the push-pull column that controls aircraft pitch, the column wheel that controls aircraft roll, the rudder pedals that control aircraft yaw, the foot-operated brakes, and the hand-operated nose steering wheel. Because of existing proprietary software, the control loading models were rewritten to replicate the weapons system trainer performance. The models drive electric motors that are coupled to each hand- or foot-operated control. The result is a simulated control that has the look and feel of the aircraft during all aspects of operation, including hydraulic malfunctions. To certify that the feel is accurate, force versus position plots are generated for each control and compared against the aircraft data.

Sound System

As in an actual aircraft, students wear audio headsets to converse with fellow crew members, ground personnel and other aircrafts crew members. Rewritten communication models hosted by the sound system simulate operation of the C-130 intercom and radio equipment. A specific enhancement allows instructors to monitor transmissions and to provide instruction and role-play, such as providing air traffic control guidance. The sound system also hosts aural cue models that simulate C-130 flight deck ambient noise generated by the four turboprop engines, air turbulence and hydraulic pumps.

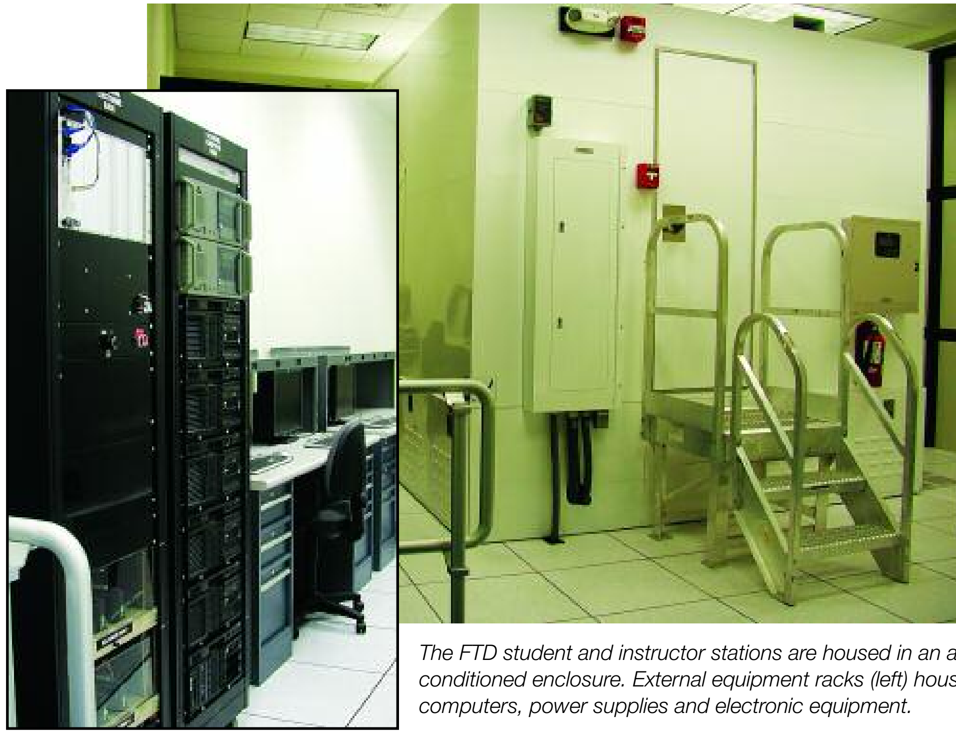


The instructor can monitor in-flight progress using mapping software at the IOS. The aircraft icon shows the aircraft's current position and heading. The instructor can change the aircraft position by using the mouse to drag/drop the icon anywhere on the map.

Instructor and Operator Stations

The graphical user interface at the instructor operation station (IOS) enables instructors to control and monitor the training environment. To start the student training session, an instructor selects an initial set of conditions that places the simulated aircraft in a predetermined location, such as on the parking ramp, engines off and the ground cart power connected; or on the runway with engines running, ready for takeoff. The latter initial condition set will be incorporated after the aircrew has mastered the engine start and taxi checklist procedures and has experienced numerous abnormal conditions associated with those procedures.

To start the training scenario, the instructor, acting as a traffic controller, uses a radio to direct the pilot. After the pilot reads back the departure instructions and confirms the aircraft is ready, the controller releases the aircraft for takeoff. If the instructor does nothing to speed up flight time, it may take a few hours to complete the flight plan and land at the destination airport. To reduce non-productive flight time, the graphical user interface allows the instructor to "drag and drop" the aircraft anywhere on the flight path map.



The FTD student and instructor stations are housed in an air conditioned enclosure. External equipment racks (left) house computers, power supplies and electronic equipment.

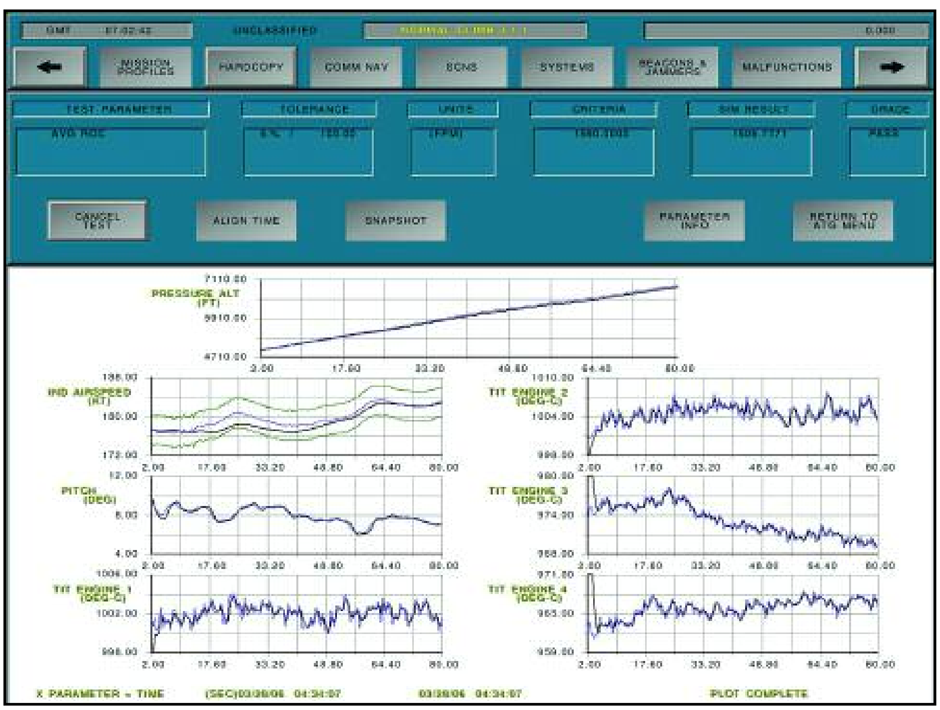
Conclusion

The flight training device received a conditional Level-6 certification in August 2006. Converting an existing training device saved the Air Force a considerable amount of money. To develop a brand new simulator would have cost approximately $12 million while the costs to reconfigure and certify an existing trainer were only about $5 million.

The primary goal, to reduce weapon system trainer workload and to increase the potential number of H2 students trained at Dobbins ARB, has been achieved.

A secondary goal of the trainer conversion effort was to pave the way for other simulator upgrades. Some aspects of the technical approach used to convert the unit level trainer could be used to upgrade other C-130 simulators. It is only a matter of time before spare parts for the weapon system trainer's early 1990s vintage minicomputer system become hard to find. Before that happens, work will begin to replace the simulation computers and replace proprietary software components. ❖

*Comments about this article? Contact Miller at (210) 522-3086 or kmiller@swri.org. To discuss this article, click on **www.swri.org/forums**.*



The certification process includes the comparison of recorded C-130 aircraft data with simulator data. The simulator pilot flies the same maneuver used in the aircraft; in this case, a normal climb after take off. Notice that the simulator airspeed (black line) stays within the tolerance bars.

Acknowledgments

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