ADVANCED INSTRUCTIONAL CONCEPTS IN FLYING TRAINING SIMULATION

DR. RONALD G. HUGHES
Air Force Human Resources Laboratory
Flying Training Division
Williams AFB, Arizona 85224

NOTE: The following material is the script portion of a sound/slide presentation entitled "Advanced Instructional Concepts in Flying Training Simulation." The presentation is unclassified, and is available upon request from AFHRL/FT, Williams Air Force Base, Arizona 85224.

Economic and resource constraints demand more cost-effective approaches to routine training needs. The impact of these constraints upon the Air Force is seen in the increased use of simulators at all levels of flying training.

While simulators offer the promise of greater training efficiencies, their primary importance lies not in the number of flying hours saved, but in their potential for achieving an increased level of combat readiness. Evidence already exists to show that the efficient use of simulators can bring about significant reductions in the physical resources necessary to accomplish routine training.

The real challenges in the years to come lie in developing simulators as training devices that are able to overcome the limitations and constraints of a real world training environment. No longer is it sufficient to work simply toward the development of high fidelity replicas of the aircraft we operate. The truly important task is the effective simulation of the tactical environment in which these aircraft are employed.

A legitimate concern exists over the extent to which instructional methods associated with the use of actual aircraft as training devices provide the most effective techniques for conducting training in simulators. While these methods are obviously valid for teaching persons to fly, they fail to capitalize upon the unique instructional capabilities of the simulator as a training device. It is this unique instructional capability that this presentation is all about.

Flight training simulators of the next decade are likely to contain provision for numerous instructional support features such as In-Flight Condition Store, Freeze, Rapid Reinitialization, and Record/Playback. Despite the presumed effectiveness of these features, little or no guidance exists as to their operational use . . . especially those applications which do not follow directly from use of the simulator as a "substitute" aircraft.

This research represents the beginning of an effort by the Flying Training Division of the Air Force Human Resources Laboratory to collect data upon which to base such guidance. The research approach involves studying the effects of a variety of instructional variables as measured by performance on representative "benchmark" tasks. Among the tasks which have been considered are carrier landings, aerial refueling and air-to-surface weapons delivery.

Considerations involved in the selection of the tasks are that they be discrete . . . capable of being acquired in a single simulator session . . . conducive to objective performance measurement . . . and above all, that they can be of operational significance to the user.

With one exception, instructor pilots assigned to Williams AFB have served as subjects. In these instances, the task selected for study has been an air-to-surface weapons delivery task. Training has been conducted in the T-37 configuration of the Advanced Simulator for Pilot Training. The one exception to the use of instructor pilots as subjects has been in the investigation of the Record/Playback feature, where Undergraduate Pilot Training students served as subjects in the acquisition of an aerobatic maneuver.

In one of the first studies to be completed, a continuously computed impact point cue was evaluated as an aid in the acquisition of a manual dive bombing task. The cue consisted of a spot of light which appeared to the pilot to move along the ground, indicating the point of impact for a bomb dropped at that moment. It was hypothesized that the addition of such a predictor cue to what is essentially a complex tracking task would reduce the number of trials required to learn the task. Although this was not found to be the case, the results of the study contained important implications for pilots' use of similar information when programmed as part of a head-up display.

In a second series of studies, the simulator's capability for establishing multiple initialization conditions was used to arrange for a backward chaining approach to the 30-degree dive bomb task. Under backward chaining, the last response in a response chain is acquired first. Learning then proceeds "backward" in the chain until all members of the chain are acquired. Outside of unpublished references to the Navy's use of a similar approach for teaching night carrier landings, no precedent for the use of backward chaining existed in the published flying training literature.

The results of the study showed that when training time for the two alternative methods was equated, pilots' accuracy under the backward chaining approach was significantly better than the accuracy of pilots who learned the task under a traditional whole-task approach. For example, in the time required for seven of ten pilots in the backward chaining group to reach criterion, only three of ten pilots under the whole task approach had done so. The findings are significant not only in that they have immediate training application, but that they support the utility of recognized, learning theory principles and techniques for flying training simulation.

One of the most widely recognized learning theory principles is that of immediate feedback. According to the principle, learning is facilitated when feedback is made to immediately follow a response. An attempt was made to evaluate the significance of this principle for the acquisition of a task such as the dive bombing task.

Pilots acquired the "final leg" component of a 30-degree dive bombing task under conditions where the feedback delay normally experienced between the time the bomb is released and the time the bomb strikes the ground was eliminated. Since the calculation of bomb impact is performed instantaneously in the simulator, such a condition is easily arranged for in the simulator by eliminating the delay portion of the program.

In addition to the use of immediate feedback, the capability for resetting the simulator back to the exact conditions occuring at the time of release was arranged through use of the systems in-flight condition store feature. The task thus became one where the pilot released the bomb . . . . . received immediate feedback as to its point of impact . . . . pulled off, and following a return to a wings level attitude was reset to the exact conditions at the time of release.

Through the joint use of immediate feedback and freeze, a significant reduction in the number of trials needed to acquire this portion of the overall task was achieved. Research is continuing to improve the efficiency of simulator approaches for teaching this and other flying performances consisting of response chains.

In a recently completed study, Undergraduate Pilot Training students acquired a complex, visual-motor flying task. The experimental task was the first two leaves of a clover leaf maneuver. The study compared periodic use of a performance playback with the use of an equivalent amount of training time for additional student practice. The results were interesting in that by the end of training, the group who had received the replays were performing no better than the "practice only" control group. The implication of these findings is that at least for some tasks, the provision for simple knowledge of results may be equally as effective as the provision for the replay of student performance.

In addition to the studies just described, work is also proceeding which is aimed at developing the capabilities of other less well recognized features of the Advanced Simulator for Pilot Training. One such feature is the General Electric Video Insetter.

The insetter provides the capability for inputting alphanumeric and graphic displays into a computer-generated visual scene. The capability is provided through use of a repeater graphics display, video camera, and visual processing unit. Displays available to the instructor at the instructor/operator console can now be presented to the pilot without modification or alteration of the interior of the cockpit. Such a display can be static as in the case where the insetter is used to generate a display of bomb impact points and release parameters or dynamic, as in the case of depicting glidepath and centerline deviation.

The significance of the video insetter is that it allows for the projection of objects into the pilot's visual scene without such objects having to be preprogrammed as part of the computer-generated visual data base. In doing so, it provides an "overlay" capability that might be used to "point out" the locations of objects in the visual scene. One might even envision the insetter as eventually providing an instructor, armed with a light pen, the capability for immediate and selective interaction with the pilot's visual environment.

The research which has been presented thus far has dealt with the development of training applications for instructional capabilities that currently exist on the Advanced Simulator for Pilot Training. One such capability is that for conducting formation flight. Consider the full range of possibilities associated with this training feature.

One of several ways of arranging for the conduct of formation flight is through the use of two separate cockpits, each flying interactively with the other through the presentation to each of a computer-generated image of the second aircraft. Two independent eyepoints are thus provided. Think now of what else this might allow one to accomplish.

First, consider a carrier landing and the two primary participants involved in a simulation of that task: the pilot of the aircraft performing the landing and the Landing Signal Officer or "LSO." The LSO is an individual positioned toward the end of the carrier's flight deck who communicates to the aircraft instructions for accomplishing a sucessful recovery. The two "eye points" are (1) the pilot's eye point, and (2) the eye point of the LSO.

The same capability that provides for the simulation of formation flight can also satisfy this requirement by having one "cockpit" provide for the simulation of the aircraft and the other provide for the simulation of the LSO's visual environment. Simulation for the LSO is in principle no different than simulation for a second aircraft flying in formation. The only difference is the eyepoint of the second participant . . . in this case, the LSO located in a static position on the flight deck.

Now to develop the concept one step further. If the second cockpit can be used to provide a simulation of the LSO's visual environment as seen from the flight deck of a carrier, then there exists no inherent reason why it could not also be used to provide a simulation of a weapon system located at ground level. All that would be required for such a simulation would be the provision for some type of sighting device and tracking apparatus. For the case of the A-10, the ground weapon system might provide for an enemy anti-aircraft site or surface-to-air missile site.

Such a simulation would provide the A-10 not only with a live interactive threat, but would also provide a playback capability where the A-10 could receive feedback as to the target that it presents to the ground weapon system. Such a capability would also lend itself to the development and evaluation of new and existing tactics for the A-10 in the ground attack role. Given that the primary mission of the A-10 is that of close ground support, an ideal tactical target would be a tank.

Currently, the US Army Armor School at Ft Knox, Kentucky is developing a full-crew interaction simulator for a tank weapon system. It is believed that the simulator is to employ a computer-generated visual data base, at least in some respects like that used with the Advanced Simulator for Pilot Training. It is also known that the tank simulator is to be capable of visual modeling of the same Central European environment in which the A-10 is to be operationally deployed.

By linking together an A-10 simulator and a tank simulator such as that being developed at Ft Knox, tactical scenarios like those envisioned for Central Europe could be conducted. Not only could integrated tactics employing A-10s and tanks against an armor threat be developed and evaluated, but A-10s could gain experience against tank type targets operated by live aggressor crews.

While the concept being developed here may sound futuristic, in principle it is identical to the situation presently possible in ASPT where two cockpits are flown interactively, with each presenting to the other, a computer-generated image of itself, the present example simply deals with the simulation of dissimilar weapon systems and extends the geographical distance between simulators. Given compatible visual data bases and the capability for establishing the physical link between systems, the concept is certainly within current state-of-the-art for training simulation.

The possibilities for broad range tactical simulation should now be apparent. Imagine the following scenario. At some predetermined time, members of A-10 squadrons located at different simulated airfields around the country become airborne and proceed together in tactical formation over common computer-generated terrain to some designated point. At the same time, naval air support is launched from carrier simulations. Before rendezvousing, naval and air force aircraft each conduct aerial refueling enroute. As A-10 and Naval aircraft proceed in formation to their target, aggressor aircraft flown from

Tactical Air Command simulator facilities engage the attack force. Once the target area is reached, a coordinated attack is launched against a simulated armor threat operated under the control of simulator aggressor crews at the Armor Center at Ft Knox.

Development of the concepts discussed above follow logically from an extension of ASPT's present capability for conducting formation flight. From that capability, it was discussed how a second cockpit could be used to provide a tactically different eyepoint. Consideration was then given to utilizing the second eyepoint as a ground weapon system (for example, a tank). Given that Ft Knox is currently developing a tank simulator with computer-generated visual data base, thought was given to accomplishing a physical link between the Ft Knox tank simulator and a flight simulator such as the A-10. Further thought was given to extending the link to include simulated carrier based aircraft and simulated aggressor aircraft.

This briefing has provided an overview of work done within the past year toward the operational employment of a flight simulator's advanced instructional features. While individual studies have emphasized the investigation of variables involved in the effective use of selected features, concepts which truly exercise the limits of the present state-of-the-art are also being pursued. Work to be conducted in the near future will continue these efforts both within the context of the A-10 and the soon to be developed F-16 flight simulator.

This presentation was prepared by the Flying Training Division of the Air Force Human Resources Laboratory, Williams Air Force Base, Arizona under work unit 1123-02-34 entitled Advanced Instructional Features and Methods in ASPT. The work unit supports Project 1123, Flying Training Development; Task 02, Instructional Innovations in Flying Training. These efforts further support AFHRL Planning Objective G03, Specific Goal 2, Training Methods and Media. Dr. Ronald G. Hughes was the Principal Investigator for the Laboratory.

ABOUT THE AUTHOR

DR. RONALD G. HUGHES is a Research Psychologist with the Flying Training Division of the Air Force Human Resources Laboratory located at Williams Air Force Base, Arizona, where his chief area of interest lies in the development and evaluation of advanced instructional concepts for training simulation. Dr. Hughes' efforts have not been restricted to flying training simulation. As an Army Reservist assigned to the Army Research Institute Fort Knox Field Unit, Dr. (Captain) Hughes has also contributed to the development of instructional concepts and methods for Armor combat crew simulation. Dr. Hughes' work for AFHRL in the near future will focus on the development of instructional concepts and strategies applicable to simulator training in hostile, threat environments. He holds a Ph.D. in experimental psychology from the University of North Carolina.