THE JOY OF FLYING SIMULATORS

STANLEY N. ROSCOE
University of Illinois at Urbana-Champaign
and
ILLIANA Aviation Sciences Limited

INTRODUCTION

The problems of defining, designing, and developing flight training simulators and other synthetic ground-training devices are far exceeded by the problems encountered in their effective use. Their acceptance without pain by the entire aviation training and operating communities depends not only upon the further demonstration that they do work, but also that they can be integrated into a training program reasonably and painlessly. Indeed, it can and must be shown convincingly that they are the key to levels of operational effectiveness not attainable in training aircraft at any price, exposure to personal hazard, or potential equipment loss.

To do this, it will be necessary to sell "The Joy of Flying Simulators" that are defined and designed to teach and are not merely the products of the unfettered imaginations and budgets of simulator design engineers and marketing managers. The place for unfettered imaginations and budgets is in the development of new instructional technologies based upon the use of devices of unprecedented flexibility of programing and reliability of operation. Experiments recently completed at the University of Illinois for the Air Force Office of Scientific Research have demonstrated the economic and tutorial benefits of two innovative instructional technologies, interactive computer-assisted procedural training and automatically adaptive visual cue enhancement in the development of contact landing skills.

COMPUTER-ASSISTED PROCEDURAL TRAINING

Graduate student James P. Finnegan, supervised by Dr. Michael J. Kelly, measured the transfer of training of private pilots of limited instrument experience in flying holding patterns in varying wind conditions from the PLATO computer-based instructional system to the Piper Arrow airplane. Finnegan's CAI "simulator," originally developed by graduate student Stanley R. Trollip (1977), allows the student to "fly" a simulated airplane using a hand control with reference to dynamic instrument indications drawn by the computer on a plasma-matrix display screen.

Finnegan (1977) divided his 48 subjects into three equal groups who received the following training sequences: (1) CAI, then aircraft; (2) ground school, GAT-2, then aircraft; (3) ground school, then aircraft only, as a control basis for measuring transfer. CAI training proved comparable in transfer effectiveness to the analogous instruction in a Singer-Link GAT-2 general aviation trainer. In both cases there was reliable positive transfer, but at a big difference in cost, the interactive PLATO "simulator" being highly cost effective and the GAT-2 not being cost effective in this particular application. The applicability of CAI training, not only in flight procedures but also across the range of cognitive learning currently covered in ground school, warrants serious consideration.

ADAPTIVE PERCEPTUALMOTOR TRAINING

Gavan Lintern (1977), under my supervision, developed and demonstrated the transfer effectiveness of the substitution of automatic presentation and withdrawal of guidance cues in a simple skeletal computer-generated visual landing system in lieu of the verbal and manual assistance normally provided by the flight instructor during initial landing training. Lintern trained 48 flight-naive subjects to criterion landing performances in the Singer-Link GAT-2 without cockpit motion. Groups of 12 students each were trained under each of the following four conditions.

<u>Control Group</u>: All training by reference to a closed-loop, computer-generated skeletal airport scene consisting of a horizon, runway outline and centerline, and an aimpoint 500 feet from threshold, all TV-projected onto a spherical-section screen mounted in front of the pilot's cockpit.

<u>Continuous Augmentation Group</u>: Pretraining by reference to the same scene plus a visible representation of a desired flight path for the final approach, an extension of the runway centerline, and flare cues represented by inverted L-markers placed along either side of the runway starting 2,000 feet from threshold.

<u>Adaptive Augmentation Group</u>: Pretraining by reference to the same augmented visual scene, with the exception that all augmented guidance cues were automatically withdrawn whenever the simulated airplane was within specified tolerances relative to the desired flight path, thereby weaning the students of

the nonreal world assistance and comfort they afforded.

Transfer Control Group: An equal amount of pretraining by reference to a projected cross representing the airplane's actual flight path and a projected square representing the desired flight path, thereby creating a compensatory tracking task and controlling for the possible transfer of learning associated uniquely with practice in controlling the simulator.

Following their pretraining, each of the three transfer groups continued training to criterion performance levels under the control condition. All students in all groups reached the criterion of three successive landings within preestablished tolerances, and the transfer effectiveness of the three experimental pretraining strategies was in the predicted order: The group with automatically adaptive augmented visual feedback reached criterion most quickly; the group with continuous augmentation during pretraining was next; and the group that practiced making approaches without benefit of any representation of a dynamic airport scene showed little transfer, if any.

One subject from each of the four groups was given one preexperimental flight in a Piper Arrow during which he was allowed to attempt six approaches and landings. Of the total of 24 attempts, none was successful; in all cases the instructor had to take over control. Subsequent to the simulator training, 21 students drawn randomly from the remaining 44, in approximately equal numbers from the four groups, were similarly tested in flight, and 29 of the 126 attempted landings, an average of 1.38 per student, were made without assistance from the instructor and without any previous flight experience.

CONCLUSIONS

It is evident that continued training to a criterion of three successive unassisted landings in the airplane by students previously trained to criterion safely and painlessly in a relatively inexpensive simulator with a simple visual system would result in extremely high transfer of perceptual motor skills required in contact flight. Furthermore, it appears that more can be gained by imaginative, inexpensive, and enjoyable instructional strategies, such as automatically adaptive cue enhancement and performance feedback, than can be gained by any investment in visual systems of high literal image fidelity. Similarly, the application of computer-assistance to procedural training, regulatory currency, and cognitive refreshment is cost effective and more fun than ground school.

REFERENCES

Finnegan, J. P. Evaluation of the transfer and cost effectiveness of a complex computer-assisted flight procedures trainer. Savoy, IL: University of Illinois at Urbana-Champaign, Aviation Research Laboratory, TR ARL-77-7/AFOSR-77-6, 1977.

Lintern, G. Acquisition of landing skill with the aid of supplementary visual cues. Savoy, IL: University of Illinois at Urbana-Champaign, Aviation Research Laboratory, TR ARL-77-12/AFOSR-77-11, 1977.

Trollip, S. R. An evaluation of a complex computer-based flight procedures trainer. Savoy, IL: University of Illinois at Urbana-Champaign, Aviation Research Laboratory, TR ARL-77-1/AFOSR-77-1, 1977.

ABOUT THE AUTHOR

DR. STANLEY N. ROSCOE is the associate director for research of the Institute of Aviation and professor of aviation, aeronautical and astronautical engineering, and psychology, University of Illinois at Urbana-Champaign. He received his PH.D. in experimental (engineering) psychology from the University of Illinois in 1950. From 1943 to 1946 he served as a pilot instructor and transport pilot in the United States Army Air Corps. From 1946 to 1952 he was successively a research assistant, research associate, and assistant professor at the Aviation Psychology Laboratory, University of Illinois, where he conducted research on flight display principles. In 1952 he joined Hughes Aircraft Company where he established a human factors research and development program. He was manager of the display systems department at the time of his return to the University of Illinois in 1969. The Aviation Research Laboratory at the university airport now supports a research staff of approximately 50, including about 25 graduate research assistants, who perform contract research for the Air Force Office of Scientific Research, the Air Force Avionics Laboratory, the Office of Naval Research, the Federal Aviation Administration, and the Link Foundation. He is a past president of the Human Factors Society (1960-1961) and was a member of the executive council continuously between 1959 and 1971. He received the Society's Jerome H. Ely award for the best article published in Human Factors in 1968 and again in 1972. He also received the Society's Alexander C. Williams, Jr. award in 1973 for his contribution to the design of the Convair F-106/Hughes MA-1 aircraft and weapon control system. In 1969 he was cited by the Radio Technical Commission for Aeronautics for his contributions to the advancement of airborne area navigation as Chairman of RTCA Special Committee SC-116E. He is a technical advisor to that organization and to the National Aeronautics and Space Administration.