EVALUATION OF AN AUTOMATED GCA FLIGHT TRAINING SYSTEM

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INTRODUCTION

Purpose

The principal objective of this evaluation is to measure the training effectiveness of an advanced training concept using an Automated Flight Training System (AFTS) GCA Module. This module, developed by Logicon, Inc., was installed at NAS Chase Field, Beeville, Texas for use with a TA-4J Operational Flight Trainer (Device 2F90).

In addition to training effectiveness, per se, curriculum design and its effect on cost-effectiveness of student training will be examined. As a result of the reset capability of the GCA module, it is possible to run a greater number of students and cover more material in a shorter period of time than with conventional methods. Substitution of trainer time for ground control approach flight training will also be investigated.

Comparisons of training with the GCA module and with conventional techniques will be made. In addition, a transfer of training evaluation will be made to determine how learning by the different techniques is carried over to the operational situation.

Background

The Naval Training Equipment Center has been involved in a continuing project of programmed and adaptive training. Digital computer technology and advances in performance measurement techniques have provided a means for implementing these training concepts.

The advantages of automated adaptive training include standardization of instruction, progress tailored to match the individual's abilities, and objective performance measurement. Additionally, costs could be decreased by reducing the number and required experience level of the instructors.

An exploratory study was conducted in 1971 to demonstrate the feasibility of implementing an automated adaptive training program (Charles and Johnson, 1972). Automated ground controlled approach and emergency procedures tasks were implemented on the NAVTRAEQUIPCEN Training Device Computer (TRADEC) and tested with operational pilots. The results demonstrated the feasibility of automated training and its acceptance by operational personnel.

What remains to be done is an evaluation of the GCA module in an operational flight trainer. trainer. The TRADEC facility uses a Xerox Data System Sigma 7 computer and peripherals. Since Device 2F90 also uses XDS equipment, the Sigma 5 and peripherals, it was a candidate for a transfer of the original TRADEC implementation.

Training Requirements Analysis

The ground controlled approach was analyzed in depth to determine the training tasks and support functions required. Standard terminology was collected and tapes of actual F-4 GCA's were recorded and reviewed. Handbooks on the F-4 and GCA systems including the SPN-35 and SPN-42 systems were studied. Additionally, human factors research on carrier landing system performance (Brictson, 1966-1971) was reviewed.

System Description

The trainer provides full support to student and instructor by performing all routine functions including syllabus and trainer configuration control automatically until overridden by instructor input or student needs.

The implementation requirements for the GCA module include the following hardware systems:

a. A stored training program
b. Voice generation system
c. Graphics display terminal
d. Printer terminal
e. Interface with the basic trainer.

Integration of the GCA module did not require modification of the design of the existing Device 2F90. The automated training hardware interfaces with the basic 2F90 simulation program as shown in figure 1.

The Cubic Corp. "DIGITALK" speech generation system assembles a fixed vocabulary into phrases and sentences under computer control. This equipment provides the GCA voice command input requirement. The voice system generates words and phrases and assembles them into the standard GCA

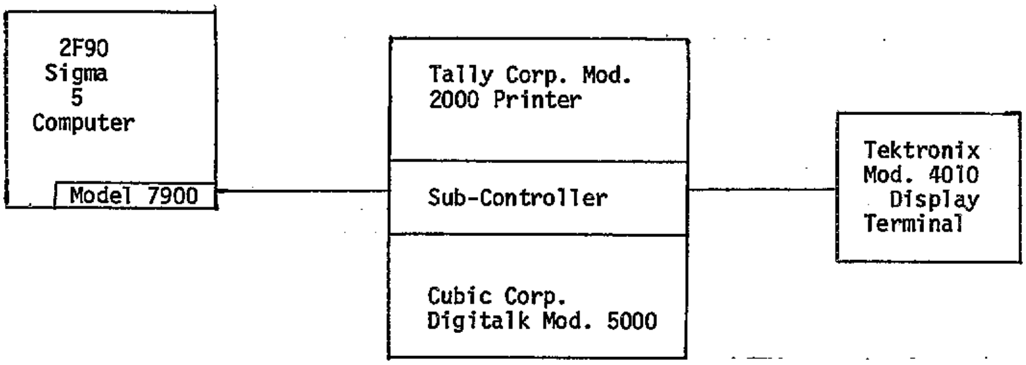

Figure 1. System Interface

phraseology for approach control. This system also provides the voice command input for feedback and diagnostic messages concerning student performance.

A graphics CRT (Tektronix Display Terminal Model 4010) and a line printer (Tally Corp. Model 2000) with keyboard are located near one of the instructor stations of Device 2F90. The results of each approach are output to this display subsystem. The CRT provides a time plot of each approach in the format of a GCA Precision Approach Radar (PAR) display, i.e., a vertical profile of aircraft position with respect to the glide slope, and a horizontal profile of aircraft position with respect to course. The printer provides a hard copy summary of conditions and performance for each approach.

PERFORMANCE MEASURES

As the GCA has very definitive performance requirements, measures related to operational performance appear feasible. Two separate scores are used. The first reflects performance during the run (path measures); the second reflects position relative to the runway at the end of the control phase of the PAR (gate measures).

Scoring

The performance measures include about 15 path measures and 5 gate measures. These are combined to provide a single score for the adaptive scheduling plan. Figure 2 illustrates the basic logic developed for final scoring. In effect, a path score is computed for all runs. If successful, a gate score is computed and combined with the path scores for a total run score. If the run terminates in a wave-off or a crash, the path score is adjusted to compensate for the position of run completed.

THE PRELIMINARY STUDY

An initial study was performed during installation, checkout, and preliminary evaluation of the system. This provided an opportunity to train instructors and check procedures. Procedures were modified as a result of this initial study and a better grasp of the variability within and between students was obtained. A rough estimate of these variances was helpful in estimating the number of subjects required in the groups being tested. A present estimate of the number of subjects in each group is 20. In essence, this study provided information upon which to refine the main experiment in a manner which will increase the probability of producing meaningful results with a minimum expenditure of time and money.

EXPERIMENTAL DESIGN

Experimental and Control Groups

The Trainer Experiment: One experimental and one control group is being used. The experimental group is being trained using the Automated GCA concept. The control group is being trained in the conventional manner (i.e., with instructor and present syllabus as per CNATRA Instruction 1542.20A, 6 July 1973). In each case, training is to proficiency, and the automatic performance measurement capabilities of the GCA module are used in addition to instructor scoring.

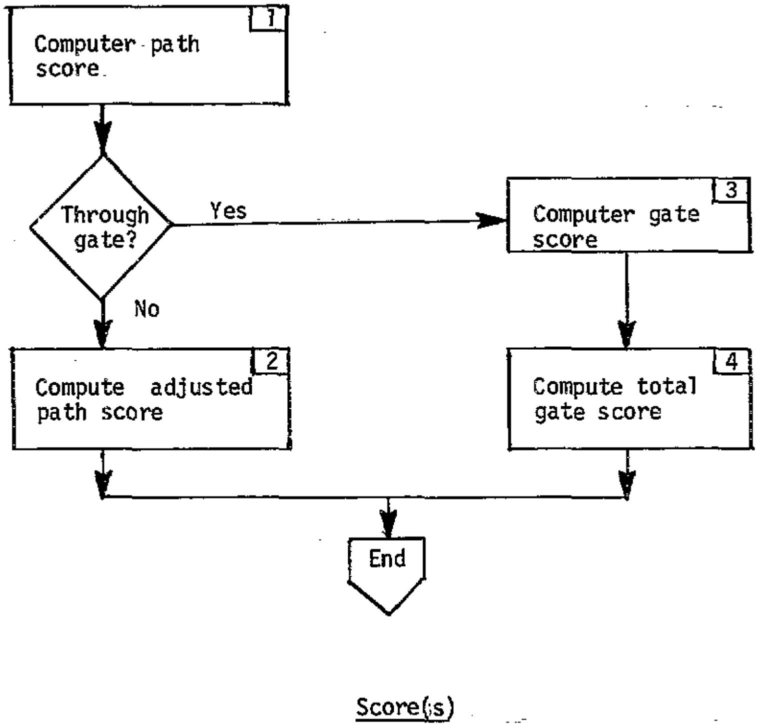

Figure 2. Scoring Logic Flow Chart

Two operation modes are available: a manual mode and an automatic mode. The automatic mode is implemented as the default mode; i.e., the automatic mode will appear as the selected mode when the system is energized. Both modes are similar in that they provide GCA training. However, the automatic mode provides for fully automated training with adaptive syllabus control and simulated GCA controller.

The manual mode requires that the instructor enter the conditions for each GCA approach and act as the GCA controller. In both modes, performance measurement is provided. Table 1 summarizes the two modes.

Since the primary purpose of the GCA training mode is to provide as much training as possible in the final approach phase, students are not required to fly a complete pattern for each approach. Instead, the aircraft is repositioned to base leg after completion of the approach or waveoff for all but minimum fuel approaches. For minimum fuel approaches, the aircraft is positioned to downwind leg after completion of approach or waveoff.

The GCA training mode is normally initiated from an 'in-flight' condition. When airborne and the 'in-flight' condition is attained, the student is 'cleared' (audio instructions) to a specific heading and altitude (200 feet, straight ahead). The program detects the aircraft reaching the specified altitude and repositions the aircraft to one of two geographical locations depending on whether the approach is to be normal or a minimum fuel approach. The initialization point for the normal GCA is on base leg, 5 miles from the turn to final and 9 miles from touchdown. Heading and altitude is initialized at 040 degrees and 2000 feet. It is assumed that the aircraft will be in a clean condition, although the aircraft configuration is not critical. The initialization point for the minimum fuel approach is 5 miles from touchdown and 4 miles offset on a heading of 310 degrees and an altitude of 2000 feet. Table 2 summarizes these initial conditions.

During both modes, the instructor is not permitted to view the AFTS Instructor's Terminal where the Tektronix Display is located, as this would provide pictorial information for student feedback and evaluation which would not normally be available to him. At the end of the run, in both manual and automatic modes, the experimenter takes a photograph of the display trace (figure 3) using a Tektronix C-10 oscilloscope camera.

TABLE 1. COMPARISON OF AUTOMATIC AND MANUAL MODES

Function	Automatic Mode	Manual Mode
Student file creation	Manual entry	Manual entry
Student file retrieval	Automatic	Automatic
Level select	Automated-adaptive	Enter each pass
Initialization	Automatic	Automatic on level select
Vector to final	Automatic	Manual
Final controller	Automated	Manual
Performance measurement	Automatic	Automatic
Performance feedback	Automatic	Manual
Hardcopy of performance	Automatic	Automatic
Student file maintenance	Automatic	Automatic

TABLE 2. INITIALIZATION LOCATION

Parameter	Normal GCA	Minimum Fuel GCA
Latitude	28^{o} 23' N	28^{o} 21' N
Longitude	97^{o} 50' W	97^{o} 45' W
Heading	040^{o}	310^{o}
Altitude	2000'	2000'

The Transfer Experiment: After completion of GCA training in the Device 2F90, the evaluation of the students who participated in the experiment is continued into the flight training phase in order to assess their performance in the operational situation (i.e., GCA field landing practice). An ATJ Addendum for GCA is filled out by the instructor pilot on a knee pad during flight in the TA-4J aircraft. The information contained in this form is similar to that which is on the ground trainer Tektronix display. This permits a direct comparison of ground trainer performance with flight performance. In addition, voice recordings of the GCA controllers are recorded on cassettes for analysis and correlation with the ATJ Addendum. Identification of a particular student flight tape recording for transcription to a cassette is made by noting the time of flight and communications channel number. Tapes are held for ten days at the GCA radar shack and identified by date, time, channel, and frequency.

The first GCA field landings made at the end of the BI Stage (BI-9, 10 and 11) are graded and cassette recordings made. The number of times the controller reports the student off course and off glide slope will be extracted from each tape. It is also possible to reconstruct the trend of the path by plotting the reported commands on profiles like the ones on the ATJ Addendum. However, if it is found that variations among ground

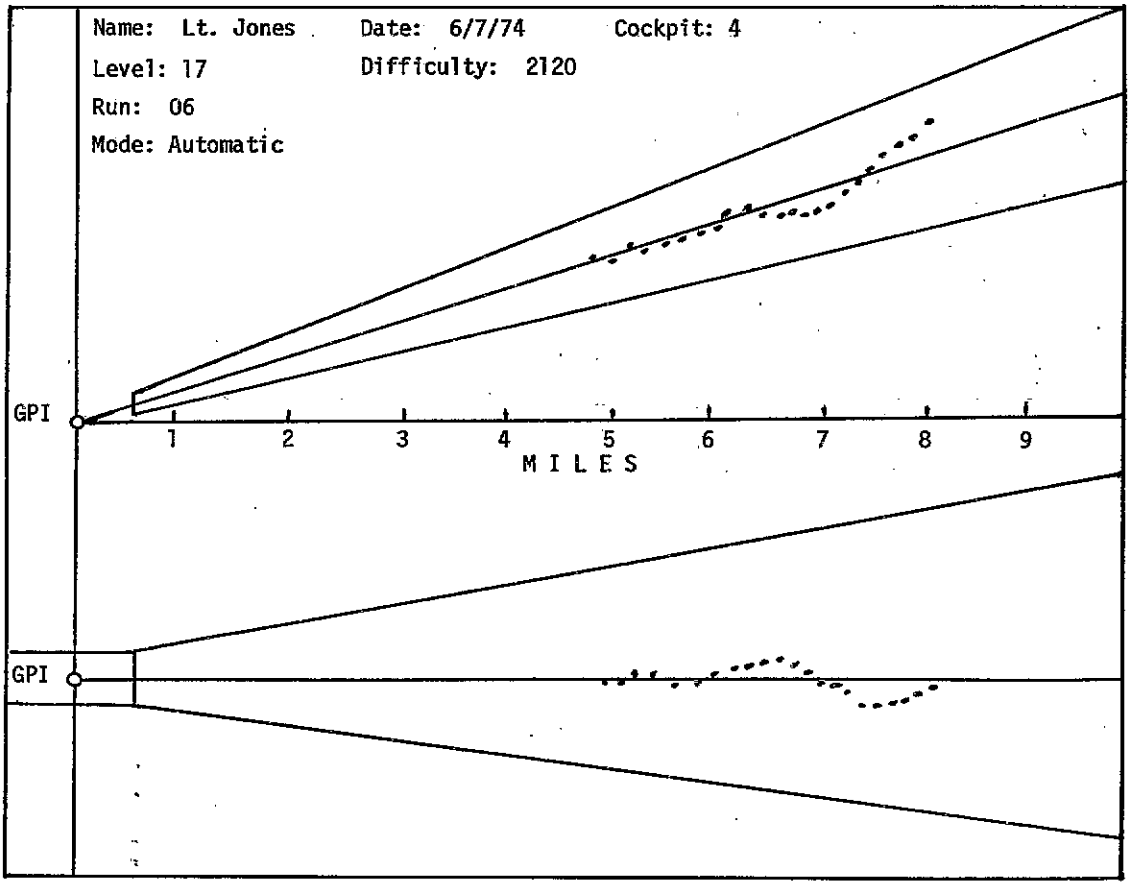

Figure 3. GCA Display Geometry

controllers are wide enough to make the reported deviations suspect as student performance data, this method will be discontinued. Photography of the scope traces at the GCA control tower is another approach that was investigated; however, interference with controller performance and administrative problems prevented the use of this method.

The best techniques derived from BI Stage scoring will also be applied to the GCA field landings at the end of the RI Stage (DI-12 through 17X) and possibly at the end of the AN Stage (AN-9 and 10X). However, it is expected that the effects of simulator training will "wash out" after the first few air trials. When the data indicates that this point has been reached, this part of the data collection effort may be discontinued.

Selection and Assignment of Subjects

It is anticipated that two matched groups of 20 students each will be required for the experiment. Matching on the basis of basic grades and previous flight experience is normally accomplished by selection of students from VT-26 (basic students) for assignment to squadrons VT-24 and VT-25. However, since only about 25% of the total student population coming into the program will be used, this smaller group must be matched. The four students selected are matched as closely as possible. As an added precaution in preventing a bias from the influence of individual squadron training, the students are assigned to the control group and experimental group from alternate squadrons each month, as shown in table 3.

One effect of the matched groups design is to reduce the extent to which experimental

TABLE 3. SQUADRON ASSIGNMENTS

Month	Control Group	Experimental Group
Group 1	VT-24 (2 students)	VT-25 (2 students)
Group 2	VT-25 "	VT-24 "
Group 3	VT-24 "	VT-25 "
Group 4	VT-25 "	VT-24 "
Group 5	VT-24 "	VT-25 "
Group 6	VT-25 "	VT-24 "
Group 7	VT-24 "	VT-25 "
Group 8	VT-25 "	VT-24 "
Group 9	VT-24 "	VT-25 "
Group 10	VT-25 "	VT-24 "

differences result from differences between groups. With ideal matching, each group would be alike and, therefore, an experimental effect, no matter how small, should be detected. In actual practice, of course, matching is never this accurate. Even if the students' basic grades were identical, other differences might make them perform differently to the experimental conditions.

Performance Evaluation

To assess the training value of the GCA Module on Device 2F90, the performance of the students in the experimental and control groups will be compared. Performance data on the simulator will be extracted from three sources: (1) the computer printout (in both manual and automatic modes); (2) instructor scoring (in both manual and automatic modes); and (3) Tektronix display photographs. These data will provide a basis for comparison of automated performance assessment with instructor subjective evaluation on the training device. A problem may arise at this point as to the validity of each type of data. Although it is hypothesized that correlations between measures and subjective ratings will be high, they may, in fact, turn out to be low.

The use of instructor ratings as initial guidelines in the development of measures is valuable, and a great deal of insight to the measurement problem can be gained by examination of subjective ratings. However, subjective ratings lack reliable standards and and rating-standardization. Another approach is to validate measures using within-subject sampling. With this approach, the assumption is that learning will be reflected by student advancement in difficulty level. Individual measures should show performance improvement through their trends from the first practice trial through the last training session for each student. If improvement is evident from the students' performance data, the validity of the measures will be substantiated despite any lack of subjective ratings.

Performance data of actual TA-4J GCA's of students in both the experimental and control groups will be used to compare in-flight performance of both groups. In addition, this data will provide a comparison of simulator performance with in-flight performance for the two groups.

A summary of the grading scheme is shown in table 4. Note that the experimental and control groups are treated alike in methods of scoring. Automatic grading and instructor grading are both used to evaluate student performance.

In figure 4, the relationship of the various data sources used in the study are shown.

Several statistical methods will be used to describe and compare the measurement data derived from the experiment. Tests will be

TABLE 4. GRADING SCHEME

	SIMULATOR		AIRCRAFT	
	Automatic Grading	Instructor Grading	Instructor Grading	Controller Voice Tapes
Exper. Group	X	X	X	X
Control Group	X	X	X	X

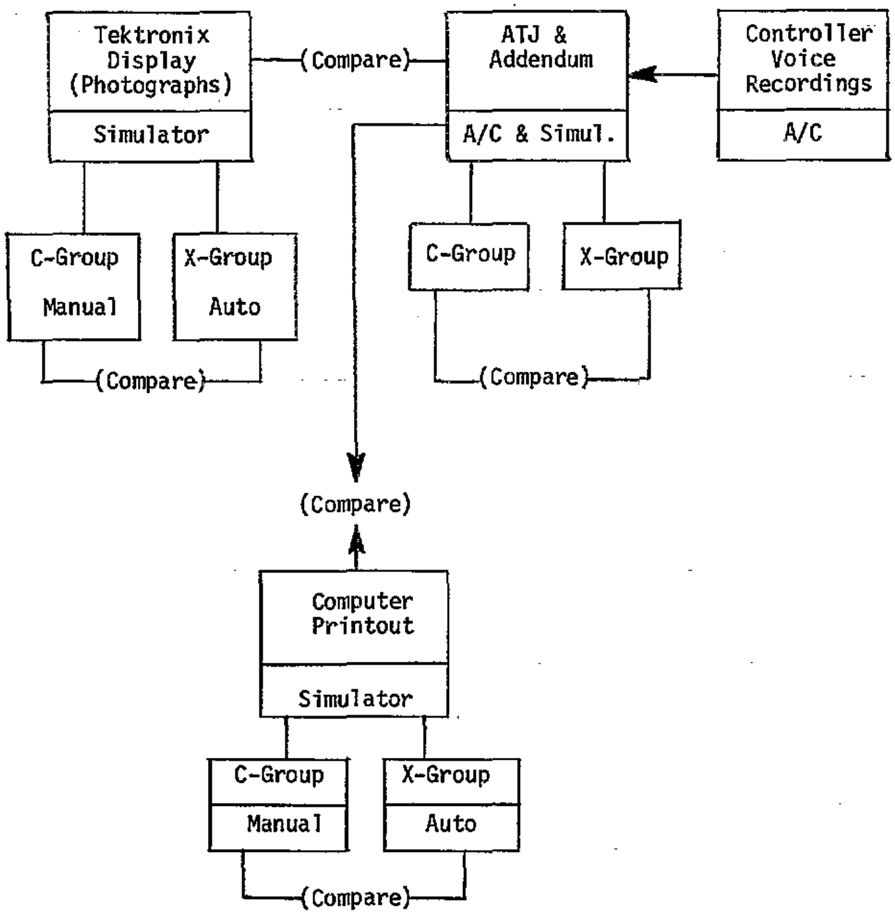

Figure 4. Use of Data Forms

made to determine significant differences among the group scores.

Another evaluation device, which will be used after completion of GCA training, is a questionnaire concerning the effectiveness of training with the automated GCA Module. The *opinion of instructors and students who have* been involved in the study will be solicited by means of this questionnaire.

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