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ABSTRACT

The report describes a study conducted to evaluate Device 2B24, which simulates the UH-1 helicopter and an instrument flight environment, and to determine its suitability for cost-effectively accomplishing the instrument phase of Army rotary wing flight training and facilitating UH-1 helicopter transition training, aviator proficiency evaluation, standardization, and flight training quality control. The three-phase mission suitability test involved examining the 2B24's advanced features in a training context, developing a new instrument training program for use with the device, and administering that training to 16 volunteer officers who had completed Army primary rotary wing training (100 hours) but had no helicopter or instrument flight experience. Results confirmed the device's mission suitability regarding both cost (per-student saving of over $4,000) and transfer of training (instrument training concluded in an average of 6.5 flight hours, as opposed to 60 flight hours for students in the existing program). Findings also indicated that the standardization, evaluation, and quality control goals had been partially met, and that the device's design is such that their fuller achievement is likely in the future. Four appendixes include: suitability test Army participants, course outline for UH-1 instrument and transition training, maneuver performance record forms, and reference material study guide. (Author)

Technical Report 75-12

HumRRO-TR-75-12

HumRRO

Mission Suitability Testing of an Aircraft Simulator

Paul W. Caro, Robert N. Isley, and Oran B. Jolley

HUMAN RESOURCES RESEARCH ORGANIZATION
300 North Washington Street • Alexandria, Virginia 22314

June 1975

Prepared for

U.S. Army Research Institute for the
Behavioral and Social Sciences
1300 Wilson Boulevard
Arlington, Virginia 22209

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The Human Resources Research Organization (HumRRO) is a nonprofit corporation established in 1969 to conduct research in the field of training and education. It is a continuation of The George Washington University Human Resources Research Office. HumRRO's general purpose is to improve human performance, particularly in organizational settings, through behavioral and social science research, development, and consultation. HumRRO's mission in work performed under Contract DAHC19-73-C-0004 with the Department of the Army is to conduct research in the fields of training, motivation, and leadership.

The findings and conclusions of this report are not to be construed as an official Department of the Army acceptance or position. The report does not necessarily reflect the official position of the U.S. Army Aviation Center. Its contents reflect the views of the Human Resources Research Organization which is responsible for its accuracy.

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Device 2B24, the first subsystem of the U.S. Army's Synthetic Flight Training System (SFTS), was evaluated to determine its suitability for cost-effectively accomplishing the instrument phase of Army rotary wing flight training and facilitating UH-1 transition training, aviator proficiency evaluation, standardization, and flight training quality control. The device, which simulates the UH-1 helicopter and an instrument flight

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environment, was designed for these training-related purposes. The three-phase mission suitability test involved examining the 2B24's advanced features in a training context, developing a new instrument training program for use with the device, and administering that training to 16 volunteer officers who had completed Army primary rotary wing training (100 hours) but had no helicopter or instrument flight experience. Results confirmed the device's mission suitability regarding both cost (per-student saving of over $4,000) and transfer of training (instrument training concluded in an average of 6.5 flight hours, as opposed to 60 flight hours for students in the existing program). Findings also indicated that the standardization, evaluation, and quality control goals had been partially met, and that the device's design is such that their fuller achievement is likely in the future.

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U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
1300 WILSON BOULEVARD
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PERI-P

June 24, 1975

SUBJECT: Mission Suitablity Testing of an Aircraft Simulator (SYNTRAIN)

TO:

1. This report presents the results of a study conducted to evaluate Device 2B24, the first subsystem of the U.S. Army's Synthetic Flight Training System (SFTS), and to determine its suitability for cost-effectively accomplishing the instrument phase of Army rotary wing flight training and facilitating UH-I transition training, aviator proficiency evaluation, standardization, and flight training quality control.

2. The device simulates the UH-I helicopter and an instrument flight environment. A three-phase mission suitability test conducted in 1971 and 1972 examined the 2B24's advanced features in a training context, developed a new instrument training program for use with the device, and administered that training to 16 volunteer officers who had completed Army primary rotary wing training (100 hours) but had no previous helicopter or instrument flight experience. Results confirmed the device's mission suitability regarding both cost, in terms of per-student savings, and transfer of training (instrument training was concluded in an average of 6.5 flight hours, as opposed to 60 flight hours for students in the existing program).

3. This report will be of interest to those concerned with rotary wing training or with the development and evaluation of training devices and their associated training programs.

Arthur J. Drucker
ARTHUR J. DRUCKER
Chief, Plans and Operations

MILITARY PROBLEM

In the mid-1960s, the U.S. Army's overriding concern regarding its rotary wing aviator training program was to maintain and improve its quality despite problems of increasingly complex aircraft and rising costs. The then-available training devices, while possibly lessening slightly the number of aircraft training hours required to achieve stated performance goals, had produced no real training cost reduction, nor were they suitable for use in many portions of the training program. Further, they contributed little toward the kind of program the Army wanted. One which would result in all Army aviators receiving standardized flight instruction to a predetermined level of proficiency, one with objective evaluation of aviator performance, and one in which aviator performance could be maintained on a continuing basis through periodic retraining.

The development of the Synthetic Flight Training System (SFTS), with its advanced training features and component high-fidelity devices designed to simulate specific aircraft, was initiated as a means of achieving some of these objectives. The first subsystem of the SFTS, Device 2B24, simulates the UH-1H, the Army's primary operational helicopter. It was designed (a) to provide cost-effective instrument and emergency procedures training, (b) to aid UH-1 transition training, (c) to contribute to aviator standardization and proficiency evaluation, and (d) to provide a tool for more effective quality control of the flight training program.

RESEARCH PROBLEM

After in-plant acceptance testing at the manufacturer's facilities, Device 2B24 was delivered to Fort Rucker, Alabama, to undergo an Expanded Service Test conducted by the U.S. Army Aviation Test Board. The principal objective of the test was to determine the device's mission suitability—that is, its appropriateness for training use. The Test Board asked HumRRO to undertake this determination of the device's mission suitability.

Since Device 2B24 was unique in terms of Army training capability, there were no other training devices with which to compare it as a basis for evaluating suitability. The 2B24's advanced training features included the following. (a) partial automation of instructor functions such as demonstrating maneuvers, sequencing instruction, varying tasks, and monitoring the trainee, (b) augmentation of trainee feedback (knowledge of results) through playbacks of recorded performance and hard copy printouts of performance summaries; (c) a degree of trainee control over training exercises to facilitate self-instruction; and (d) provision for the instructor to reprogram training situations on-line. These advanced training features were largely developmental rather than proven training design features, and a training program had to be developed for use with the 2B24 which would exploit as many of these training features as were workable at the time of the test. Had an attempt been made simply to adapt the existing training program to the device, or the device to the program, the capabilities of the device would have been rendered less effective.

In addition to evaluating the suitability of Device 2B24 for training use, the test staff also had to determine whether it could perform its mission in cost-effective fashion, in order to satisfy the Army's other major concern regarding its flight training program.

APPROACH

A three-phase test was planned to determine Device 2B24's mission suitability.

Phase I activities were devoted to evaluating the workability of the device, with emphasis on its design-for-training features, as opposed to mere affirmation of its mechanical functioning. The fidelity of the UH-1 simulation was assessed by personnel who were UH-1 qualified. Training activities were developed so as to determine the proper functioning of each component and feature in a training context, and mock training was conducted in the device using test personnel as device operators, instructors, and students.

During Phase II, an instrument flight training program was devised for use with the device. The program was based upon current training technology and was designed to make optimum use of the device's features found usable during Phase I, taking into account any deficiencies that had been noted. Flight instructors were then trained in the proper administration of this program. Thus, Phase II developmental efforts were twofold: (a) to produce a program designed for the exploitation of the device's training features and (b) to provide training for the instructors who would be administering the new program, to ensure its proper use.

Phase III operations were aimed at determining the training effectiveness of the device through an empirical transfer-of-training study and a study of the cost of conducting training in the device versus cost in the aircraft.

The transfer-of-training study was accomplished by training a group of student pilots in Device 2B24, using the training program developed for it, so that data could be collected to ascertain the extent to which their skills transferred to the UH-1 aircraft. Sixteen officer test subjects were selected from among a large group of volunteers. All of the volunteers had completed the primary phase of Army helicopter flight training (100 flight hours). Some of them had received small amounts of fixed wing training prior to entering the Army, but none had had any instrument flight experience or had piloted a helicopter prior to their Army training. When they attained, and could demonstrate in the device, the skills necessary to pass a Standard Instrument Rating checkride administered by Army flight examiners, they were "transitioned" to the aircraft for a brief period of familiarization and an instrument checkride, also administered by Army flight examiners. After successfully completing the instrument checkride in the aircraft, they then completed the advanced contact phase of flight training and were administered a contact checkride. Records of training time requirements and checkride grades were maintained. Subsequent to the advanced contact training, all trainees underwent the standard tactics phase of rotary wing training.

The other Phase III objective, to determine cost effectiveness, was accomplished by comparing Army cost data reflecting the costs of conducting training in Device 2B24 with the costs pertaining to the then-current training vehicles. Analysis of these costs made possible the calculation of a per-student training cost for both the existing program and a projected 2B24 program.

RESULTS

Phase I activities involved examining the 2B24 as an integrated system with respect to its suitability in training. During this process, it was found that some of the device's features were not functioning in the intended manner and consequently could not be used in a training program. It was necessary during this phase for the test staff, representatives of the U.S. Army Aviation School and other Army agencies, and manufacturer's personnel to identify and solve a number of design problems, deficiencies, and malfunctions. In some cases the proposed training program could work around them; in others, modifications had to be accomplished before suitability testing could continue.

Despite frequent delays due to these problems, complete examination of Device 2B24 did occur, and most of its automatic and advanced training features were made suitable for use by the beginning of Phase III. The automatic exercises and automatic checkride, which required modification not possible within the time available, were not usable during the test period, but the lack of these—although disappointing—did not prevent proceeding with development of a training program. The test staff concluded that the device's continuing deficiencies were correctable, and that the design features of Device 2B24 were such that it could be considered as being capable of performing its intended mission.

The training program developed during Phase II incorporated concepts and methods to take advantage of Device 2B24's training features that were operable at the time. Some of the major features of the training program were: (a) individualized training; (b) proficiency-based advancement through the training, (c) functional-context (or mission-concept) training; (d) peer and crew training; (e) programmed texts to replace conventional classroom instruction; (f) a diagnostic checkride in the device for purposes of identifying either weaknesses or already-attained proficiency prior to the end of training; (g) incentive awards; and (h) the use of an instructor-manager concept, with each instructor assuming complete responsibility for carrying his students through both the instrument and the advanced contact phases—in Device 2B24, in the aircraft, and academically. A training program for these instructor-managers in the proper application of the new program was developed and administered as part of the project.[1]

The Phase III transfer-of-training study revealed that the 16 test subjects did exhibit a high transfer of training from device to aircraft. The subjects required an approximate mean time of only four hours for aircraft familiarization before taking the Standard Instrument Rating checkride in the UH-1 aircraft, on which they received checkride grades comparable to those of conventionally trained students. They successfully completed the instrument phase with considerably less aircraft time (6.5 hours on the average versus 60 hours) and also in less calendar time (7 to 8 weeks versus 12 weeks). In addition, in the subsequent contact flight training there was a further average saving of 5 flight hours, which was considered by the research staff to be attributable to the 2B24 training program.

The cost-effectiveness of the program was demonstrated in the training-cost study, which compared the relative costs of instrument and advanced contact training using Device 2B24 and the UH-1 helicopter with the then-current practice of using the TH-13T, the 1-CA-1 (a general instrument training device), and the UH-1 aircraft. The per-student savings of the 2B24 program were substantial ($4,439), thereby allowing amortization of the capital acquisition costs of the device within a relatively short period. Device 2B24 was thus evaluated as a cost-effective vehicle for use in Army undergraduate rotary wing flight training.

[1] In reviewing this report, the U.S. Army Aviation Center made note of reservations about the instructor-manager concept, questioning its feasibility for day-to-day use as a part of the Army's ongoing undergraduate training activities at the Aviation Center.

CONCLUSIONS

The overall Mission Suitability Test objective was to determine whether Device 2B24 was capable of performing its training mission—more specifically, whether it could cost-effectively provide instrument and emergency procedures training, and facilitate UH-1 transition training, standardization, proficiency evaluation, and flight-training quality control. The following may be concluded as a result of the test:

(1) The training features of Device 2B24 provide superior and cost-effective flight training. Students participating in the experimental training reached the required levels of proficiency in significantly less time and at substantially less cost than did conventionally trained students.

(2) Emergency procedures training, while difficult to evaluate empirically, was considered to be safer and more comprehensive than would be possible in an aircraft or in a training device lacking the realistic simulation of aircraft malfunctions which the 2B24 exhibits.

(3) Aviator UH-1 training, standardization, performance evaluation, and quality control of the flight training process can be facilitated by the device, but further technological development of already-incorporated features will be required to accomplish fully the standardization, evaluation, and quality control functions.

PREFACE

This report describes the conduct of a test to determine the suitability for undergraduate instrument pilot training of a simulator for an Army rotary wing aircraft. The test was performed by the Human Resources Research Organization under Work Unit SYNTRAIN, Modernization of Synthetic Training in Army Aviation, and represents the culmination of HumRRO efforts related to the development of an advanced-technology pilot training system. The test itself was performed at the request of the U.S. Army Aviation Test Board in conjunction with that agency's Expanded Service Test of the simulator. The test was performed in 1971 and 1972.

A report of the HumRRO-conducted test was published by the U.S. Army Aviation Test Board as an appendix to its Final Report of the Expanded Service Test. In addition, portions of the findings reported here were reported in HumRRO Professional Paper 7-72, *Transfer of Instrument Training and the Synthetic Flight Training System.* Related publications in the SYNTRAIN series are HumRRO Technical Reports 70-10, *Device-Task Fidelity and Transfer of Training. Aircraft Cockpit Procedures Training,* 70-6, *A Determination of Selected Costs of Flight and Synthetic Flight Training,* 72-11, *Determining Training Device Requirements in Fixed Wing Aviator Training,* and 73-20, *Research on Synthetic Training. Device Evaluation and Training Program Development,* and HumRRO Professional Paper 6-74, *Aircraft Simulators and Pilot Training.*

Work Unit SYNTRAIN is a part of the device research program of HumRRO Central Division (Dothan, Alabama Office), formerly HumRRO Division No. 6 (Aviation). Dr. Wallace W. Prophet is Director of the Division, and Dr. Paul W. Caro is Dothan Office Director. Dr. Caro was the Work Unit Leader for Work Unit SYNTRAIN at the time of the work reported here. Mr. Robert N. Isley is the current Work Unit Leader.

Military support for the study was provided by the U.S. Army Research Institute Human Research Unit, Fort Rucker, Alabama. LTC Robert O. Carter was the Unit Chief at the time of the research reported here. In addition, personnel assigned to the U.S. Army Aviation Test Board and U.S. Army Aviation School participated in and contributed to the research. The authors wish to express particular appreciation for the contributions of MAJ Luther Smith, CPT Clarence Davis, CW3 Richard Rehn, Mr. Donald Hickman, Mr. Albert Cooper, and Mr. Eddie Ewell.

HumRRO research for the Department of the Army under Work Unit SYNTRAIN was conducted under Contract DAHC19-73-C-0004. Army Training Research is performed under Army Project 2Q062107A745. The SYNTRAIN work was conducted under the sponsorship of the U.S. Army Research Institute for the Behavioral and Social Sciences, with Dr. Aaron Hyman serving as the technical monitor.

Meredith P. Crawford
President
Human Resources Research Organization

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INTRODUCTION

BACKGROUND

A new item of training equipment which has had a major impact upon Army aviator training in recent years is Device 2B24, the first subsystem of the Synthetic Flight Training System (SFTS). Unique in the Army's history of pilot training device development, the 2B24 is a high-fidelity simulator designed to train pilots to fly a particular operational Army helicopter, the UH-1H, rather than a non-specific instrument trainer designed to develop skills for general transfer to a wider class of aircraft. Its primary intended uses are undergraduate-level instrument training and training in the operation of the UH-1H helicopter. The SFTS, including its Device 2B24 and other subsystems, will be employed in undergraduate pilot training, graduate-level training, tactics and weapons delivery training, and proficiency or combat readiness training for Army aviators—active, reserve, and National Guard.[1]

The SFTS design conception was developed in 1965 by HumRRO, in coordination with the U.S. Army Aviation School and the U.S. Army Combat Developments Command Aviation Agency. The SFTS is a comprehensive, but flexible, training system. The design was based primarily upon the Army's pilot training requirements and upon research in training technology, design considerations also included the training of experienced instructor pilots and of program administrators at the Aviation School and at Army aviation field units. Engineering technology relevant to simulator design also played an important role in SFTS design considerations, but the emphasis was upon training.

The U.S. Army Training Device Agency was responsible for the management of the procurement of Device 2B24. Engineering and contracting support was provided by the U.S. Naval Training Device Center. HumRRO personnel worked closely with these organizations during the implementation of the SFTS design conceptualization into the design of Device 2B24.

Device 2B24 was delivered to Fort Rucker, Alabama, in December 1970. In accordance with existing Army practice, it was necessary for the device to undergo an Expanded Service Test.[2] The U.S. Army Aviation Test Board was responsible for the conduct of this test, a principal objective of which was the determination of the device's mission suitability—that is, the appropriateness of its design for training use by the Army. At the request of the Aviation Test Board, HumRRO undertook this determination, and this report describes that portion of the test devoted to ascertaining the 2B24's training mission suitability. Other service test results are presented elsewhere.[3]

[1] Other SFTS subsystems under development at the time of publication of this Technical Report were Device 2B31, which simulates the CH-47, and Device 2B33, which simulates the AH-1.

[2] U.S. Army Aviation Test Board. "Test Plan, Service Test of UH-1H Field Unit Subsystem of Synthetic Flight Training System (SFTS)," April 1971.

[3] Luther S. Smith and Willie H. Sasser. "Final Report, Expanded Service of UH-1H Field Unit Subsystem of Synthetic Flight Training System (SFTS) (Device 2B24)," U.S. Army Aviation Test Board, April 1972.

DESCRIPTION OF DEVICE 2B24

With reference to the simulation of the UH-1H and its flight characteristics, Device 2B24 is comparable to the most complex training aircraft and spacecraft simulators. It contains (Figures 1 and 2) four independently operating helicopter cockpits, each with its own motion and sound systems, a sophisticated centralized operator console, and three general-purpose digital computers. It does not include extra-cockpit visual displays, as do some other simulators, because simulation of the visual world was not required for the 2B24's training mission projected at the time the simulator was designed. However, some planned future SFTS subsystems will include such displays.[1]

Each of the four helicopter cockpits, or trainee stations, is modeled after the cockpit of the UH-1H helicopter (Figure 3). The area forward of the pilot and copilot seats is nearly an exact replica of the UH-1H cockpit, except for a few components that were added to enhance the training value. These components provide status and feedback information to the trainee (Trainee Information Panel) and allow him to control certain functions, such as trainer freeze, motion on or off, and automatic exercise selection (Auto Problem Control Panel).

Inside the cockpit enclosure, but behind the pilot and copilot seats, are an instructor pilot seat, a cathode ray tube (CRT) display that repeats selected information from the central operator console, and a closed-circuit television camera. Nearby are controls which permit the instructor to communicate with the trainees and/or with personnel outside the cockpit and to control the CRT display.

Each cockpit is mounted on a five-axis, hydraulically actuated motion system. The motion system is a cascading system with complete independence of movement among axes. The motion capabilities are up to 15° each in pitch, roll, and yaw; ±12 inches heave displacement; and ±11 inches lateral displacement. In addition to simulating the movement of the aircraft, the motion platform can simulate rough air disturbances up to a frequency of 5 hertz. Higher frequency vibrations experienced in the helicopter are simulated via actuators operating on a section of flooring beneath the pilot and copilot seats.

The central device operator console, which can be used as an instructor station when there is no instructor pilot inside one or more cockpits, consists of an extensive array of displays of information relative to the status and progress of training in each cockpit (Figure 4). All but one of the displays, a panel which permits the operator to study a selected trainee's flight and engine instrument readings, are CRTs. These displays include:

- Four graphic plotters, each of which displays a trainee's flight path on a problem-area map, along with airspeed and altitude histories and tabular information describing the status of the training under way.
- Two data displays used to exhibit training and simulation problem parameters and to permit their modification by the operator on-line.
- Two closed-circuit television monitors.

The controls at the operator station permit communications with personnel in each cockpit and with the computer and its various information display and printout devices. The controls also allow modification of the parameters of simulation and training activities.

The computer complex contains three general-purpose digital computers, display generation and buffer equipment, and the interface electronics necessary to achieve correlations between the computer and the other components of the device. Peripheral equipments associated with the computer include a high-speed paper tape In/Out device, three keyboard printers, and two rapid-access data files.

[1] Both the 2B31 and 2B33 subsystems, presently under procurement, will have visual display systems.

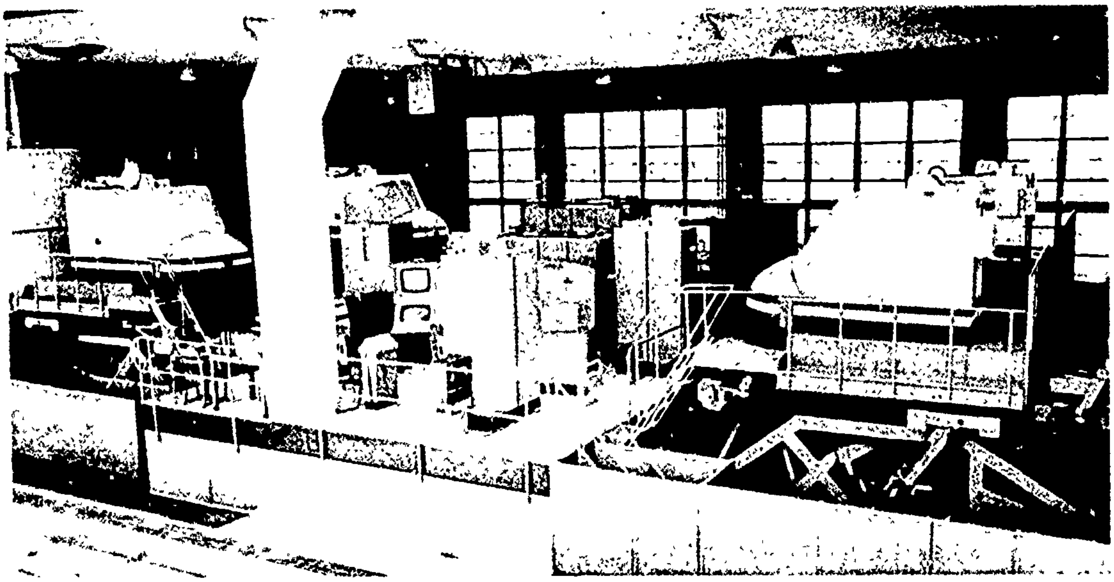

Figure 1. Device 2B24

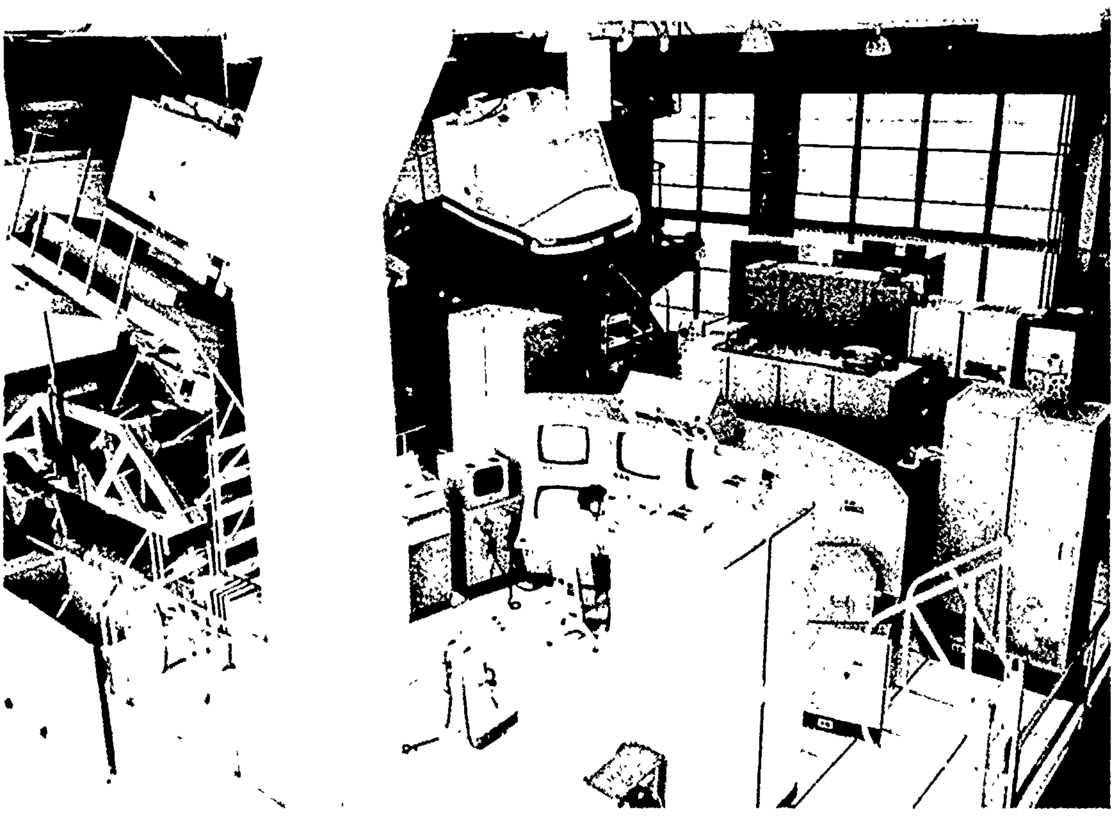

Figure 2. Device 2B24 Showing Cockpits 1 and 2
in Motion and the Device's Operator Station and Computer Complex.

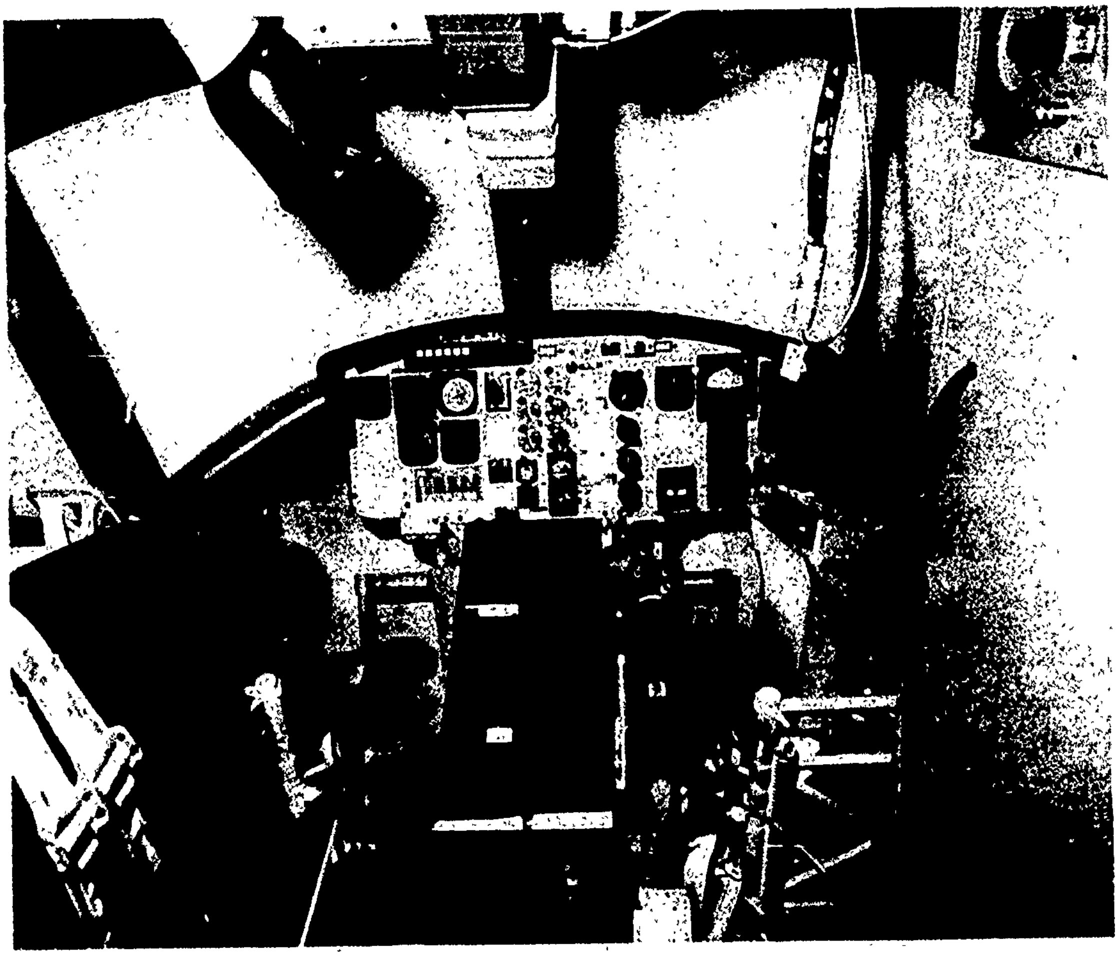

Figure 3. Device 2B24 Trainee Station

Other components of the device include sound and video recording and playback equipment, and a high-speed printer. A more detailed physical description of Device 2B24 and the SFTS can be obtained from the Army's design documents and from the Test Board *Final Report.*[1]

Device 2B24 does differ, in one important respect, from other high-fidelity simulators. In addition to providing the high-fidelity simulation of a specific aircraft, it includes many features designed solely to facilitate the learning of tasks the trainee must perform during operational flights. These characteristics resulted from a continuing emphasis during its design on the development of a training capability. The intent was to produce training equipment that would augment the instructor's capabilities and overcome his weaknesses. Device 2B24 is an aircraft simulator built primarily to specifications that are oriented to training requirements, rather than to specifications which emphasize reproduction of the rather poor learning environment of an operational aircraft.

The device's principal training design features include: (a) partial automation of instructor functions, such as demonstrating maneuvers, sequencing instruction, varying task difficulty, and monitoring trainee performance; (b) augmented feedback to the

[1] Smith and Sasser, *op. cit.*

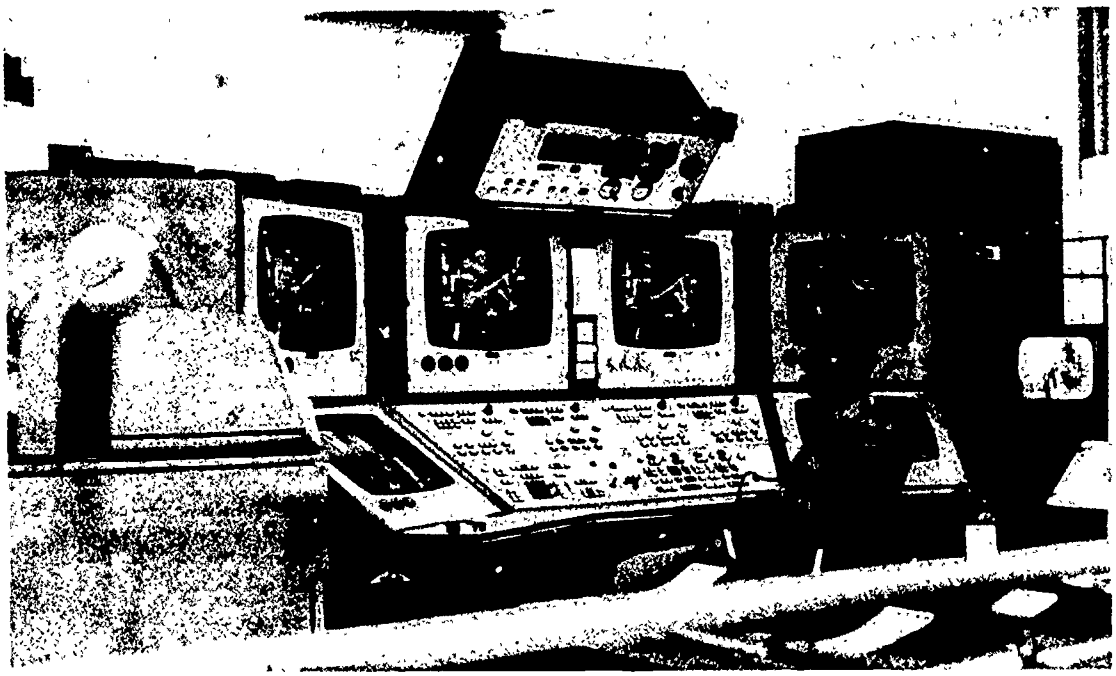

Figure 4. **Device 2B24 Operator Station.**

trainee during training through real-time and slow-time playbacks of recorded device performance, closed-circuit television,[1] video and audio recordings and playback systems, on-line displays summarizing trainee performance over time, and hard-copy printouts of trainee performance data, (c) aids to the instructor, such as automatically updated communications-problem scenarios and extensive on-line capabilities for reprogramming training situations, and (d) self-instructional features which enable pilots in the cockpits to exercise control over their own training, much as they might in a modern, multimedia learning laboratory.

MODES OF DEVICE OPERATION

For purposes of training and performance evaluation, Device 2B24 is designed to operate in three modes: Automatic, Semi-Automatic, and Checkride:

During Automatic Mode operation, instructor involvement is minimized, and much of the control of training activities is exercised by the system's computers. Instructor involvement during this mode is intended to be limited to training-problem selection and initiation, analyzing trainee difficulties, and dealing with unprogrammed contingencies.

During Semi-Automatic Mode operation, the device operates in more conventional fashion, that is, training activities are under direct instructor control, and instructor interaction with the trainee and with the device controls is required.

[1] The closed circuit television subsystem of Device 2B24 was not included in production models of the device.

During Checkride Mode operation, the device administers a standardized instrument checkride under standardized conditions and records data describing trainee performance for subsequent analysis. Instructor involvement during Checkride Mode operation is precluded, except that the instructor initiates it, can terminate it at any point, and must provide the simulation of ground controller voices necessary to complete the automatically administered checkride. The voice scenario to be followed, however, is under device program control.

The Automatic Mode is a developmental feature of the device. At the time the 2B24 was designed, it was recognized that experience with computer-controlled flight training was very limited, and there was no expectation that the Army would be able to implement a fully automatic pilot training program upon delivery of the 2B24. In fact, only nine short automatic training exercises were required to be developed for use with the device when it was delivered. Until automatic pilot training techniques could be developed further, a 2B24 training program was envisioned which could involve predominately Semi-Automatic Mode operation. It was intended that there would be increasing use of the Automatic Mode as appropriate training exercises were developed. The long-range developmental goal with respect to Automatic Mode training is for a significant amount of training in the device to be under computer control.

There are a number of "automatic" features of the 2B24, that is, features which operate under computer control and are considered important to training during Semi-Automatic Mode operation. These include automatic recording of selected trainee performance data, audio alerts to the trainee when specified flight tolerances are exceeded, audio coaching messages which recommend certain actions to students and are intended to improve their performance, position initialization and flight parameter set-up programs, and certain automatic scheduling and sequencing programs. While these features are employed in the exercises developed for Automatic Mode operation, they are also available to the instructor, should he elect to use them, during Semi-Automatic Mode training.

The Checkride Mode, also a developmental feature of the 2B24, was designed to provide a means of determining instrument flight proficiency of trainees and of previously rated pilots under standardized conditions. It was also designed to provide data for quality control of training.

SUITABILITY TEST CONSIDERATIONS

Background

The fact that Device 2B24 is unique made its suitability testing difficult. It was not developed as a replacement for existing training devices, and much of the training made possible through its use had never been available to the Army even when using operational aircraft. Consequently, previous approaches to training device suitability testing–approaches which have basically compared one device with others, or have been based solely upon a transfer of training paradigm—were considered to be inappropriate models for 2B24 testing.

It was decided that an appropriately designed mission suitability test for the device would have to build upon its unique design-for-training features if its potential for use in Army aviation training was to be tested. Further, since the operational mission of the 2B24 is training, its suitability could be evaluated only within the context of a training program. Thus, it appeared that a test was required which would exploit the uniqueness of the 2B24 in a specific training situation, with the goal of determining its cost-effectiveness in that situation. It was anticipated that this type of test would lead to quite different results and conclusions about the 2B24 than one in which the device might simply be compared to older, existing devices whose contributions to training are unclear.

Since the device incorporated a relatively large number of untested features, it was recognized that, upon delivery to the Aviation School, the 2B24 would probably not meet all the automatic training and performance evaluation goals stated for it in the SFTS Qualitative Materiel Requirement (QMR).[1] While it would have the *potential* for providing largely automatic training, only a token number of automatic training exercises would have been prepared by the manufacturer. A completely automatic training program was not procured with the device, and the Army had no program suitable for use with it. In this respect, the 2B24 was considered to be a training system undergoing development, rather than solely an implementation of proven device design features.

For practical reasons, it was decided not to delay mission suitability testing until all of the automatic training and evaluation features could be fully developed. More than one 2B24 was needed to meet known training requirements, but procurement of additional devices was dependent upon favorable suitability test findings. Before further investment in the system could be justified, it was necessary to determine whether substantive changes in the programming concepts or in hardware would be required in order for the device to achieve its training mission. To make this determination, it was assumed that enough of the system development had been completed to enable test personnel to obtain objective evidence reflecting on the workability of the equipment, the suitability of trainee station and operator console design, the contractor's approach to automatic training, the acceptability of the device's mission suitability, and the manageability of the developmental work remaining to be performed.

There were two principal developmental areas of concern in making this determination: hardware and software. A finding that the device was unsuitable for its training mission without extensive substantive changes to hardware might well preclude its further use. However, changes that might be accomplished through minor equipment adjustment could be identified and made prior to procurement of subsequent models of the device. Corresponding concerns existed with respect to the software area. It was desired that deficiencies relating to computer programs and models upon which the simulator programming was based be identified and corrected before the device was made available for operational use.

The Mission Suitability Test which evolved took into account these various considerations. It was structured to permit the identification and correction, where possible, of equipment and software deficiencies on a basis that would permit a determination of the device's suitability for training. The workability of the various automatic and semi-automatic training features of the 2B24 was to be investigated first. Then its potential training value and cost-effectiveness were to be determined through the use of the device in a training program which would be developed specifically for suitability test purposes.

Test Objectives

The overall objective of the Mission Suitability Test was to determine whether Device 2B24 could cost-effectively achieve the purposes stated for it in the SFTS QMR. There were six such objectives:

(1) To provide basic and advanced instrument training
(2) To provide UH-1 emergency procedures training
(3) To facilitate UH-1 transition training

[1] Department of the Army. "Approved Qualitative Materiel Requirement (QMR) for a Synthetic Flight Training System (SFTS) (Rotary Wing/VTOL)," 10 July 1967.

(4) To facilitate aviator proficiency evaluation
(5) To facilitate flight training standardization
(6) To process flight training quality control data

Approach

A three-phase Mission Suitability Test was employed to determine whether Device 2B24 could meet the SFTS QMR objectives.

During Phase I, primary test emphasis was on determining the workability of the various instructor station, automatic training, and automatic checkride features of the device. This phase also provided an opportunity for assigned HumRRO and Army personnel to learn about device capabilities and permitted identification of specific design deficiencies.

During Phase II, a training program designed to exploit the training potential of the device was developed. It was intended that this program incorporate manufacturer-produced automatic training and performance evaluation programs to the extent that they were found usable during Phase I. If they were found to be deficient, the training program was to be planned around the limitations to permit a fair evaluation of the device's potential. As is evident in the subsequent discussion of the test, the program developed during Phase II made only limited use of the 2B24's automatic training features.

During the final stage, Phase III, a transfer-of-training study was conducted to determine the value of the device in preparing students to fly the UH-1 aircraft under both instrument and contact flight conditions (Objectives 1-3). The relative costs of the 2B24 training program and the existing training program for Army rotary wing aviators were determined. Also, data reflecting the device's ability to meet Objectives 4, 5, and 6 were sought during Phase III.

The activities and findings of the three Suitability Test phases are described in Chapters 2, 3, and 4.

Chapter 2

PHASE I: WORKABILITY OF TRAINING FEATURES

OBJECTIVES

The principal objective of the first phase of the 2B24 Mission Suitability Test was to determine the workability of various training features of the device. All hardware and software features, as they interfaced directly with training personnel and with the training functions of the device, were examined. This examination included a determination of the perceived fidelity of simulation of the UH-1H helicopter and of its various on-board subsystems; a determination of the adequacy of controls and displays involved in the conduct of training in the device; and an examination of the device's various automatic and non-automatic training and performance evaluation features.[1]

It should be noted that the emphasis during these Phase I determinations was upon the use of the device within a training context. The 2B24 had already been subjected to, and passed, an acceptance test which had addressed similar questions within an engineering test context. For example, it had already been determined that the controls and displays functioned in accordance with acceptance test specifications. During those tests, however, each item had been checked more or less in isolation from other functions. By contrast, the Phase I activities addressed the device as an integrated operational entity, and the controls and displays were examined in terms of their adequacy when training was being conducted (or simulated) in the device.

A secondary purpose of Phase I was to permit the Suitability Test staff[2] to become sufficiently familiar with the 2B24 for them to develop a pilot training program during Phase II that would exploit its workable training features.

APPROACH

The test plan for Phase I called for a period of time devoted exclusively to staff familiarization with the equipment and its operation, a period during which mock training and performance assessment activities would be conducted in several cockpits simultaneously, and a period during which a relatively large number of aviators from Fort Rucker would be invited to fly the device and respond via questionnaire and interview to questions concerning its simulation fidelity and acceptability. This plan could not be followed. During the initial device familiarization activities, it was found that the device was not totally satisfactory, even for mock training activities, because many of its major subsystems would not work simultaneously and because its programming had not been completely debugged. Had it been necessary to adhere strictly to the intended test plan, the device probably would have been rejected as unsuitable for its intended training mission.

[1] Other human factors considerations (e.g., ambient noise level) were assessed separately during other portions of the Expanded Service Test and are reported elsewhere (Smith and Sasser, *op. cit.*).

[2] Army personnel who assisted the HumRRO staff in the conduct of the Suitability Test are identified in Appendix A.

Instead, the procedure adopted and undertaken jointly by the test staff, Aviation School, Aviation Test Board, procurement agency, and device manufacturer personnel, became one of identifying deficiencies and effecting corrections so that the device might *become* suitable for training. Thus, Phase I activities became a continuation of the device adjustment and refinement process which had been initiated during the 2B24's manufacturing process. During this process the device was constantly being rechecked as each deficiency was corrected.

It was not possible to correct all of the deficiencies within the time available for the Suitability Test. Therefore, as the various deficiencies were detected, decisions were made by test personnel as to their probable impact upon the conduct and outcome of the test itself. In some cases it was decided that the discrepancies were minor, and that the planned training program could either work around them, or the discrepant features could be "simulated" in some fashion (e.g., certain automatic features could be simulated through manual intervention). In others, correction would have to take place before suitability testing could be completed. In most cases, correction of high-priority deficiencies was initiated shortly after they were detected, thus making possible continuation of the test with interruptions only for necessary work to be performed.

Because of the continuing modifications being made to the device and the limited availability of the device during many of those modifications, test activities typically could not be reliably predicted even one hour in advance. Methodologically, Phase I testing became an *ad hoc* activity, except that the requirement for testing within a training context was maintained. It was not practical to schedule non-test staff personnel to fly the device as had been planned, so all of the data concerning fidelity of simulation and device acceptability were obtained from participating HumRRO staff members and assigned Army personnel of the Aviation Test Board and the Aviation School.

All data collected during Phase I were opinion data, and because of the circumstances, those data were collected informally. Where differences of opinion existed among test personnel, a consensus was obtained by joint review of the device's features that were in question and the differences were then resolved. The questionnaire and structured interviews which were planned were not used.

In spite of the delays encountered during Phase I, a comprehensive, examination of Device 2B24 did take place. Mock training activities were conducted in the device, using test personnel as device operators, instructors, and trainees. Training activities that required use of each component and training feature of the device were developed for this purpose. These activities were thought to be typical of those subsequently to be used in student training (Phase III). Test personnel thus were able to determine whether each relevant component of the device "worked," and, if it did not, to identify the nature of the deficiency. These activities also permitted test personnel to examine each automatic training and performance evaluation feature of the device within a simulated training context. In some instances, device features were examined many times as various "fixes" were attempted.

The fidelity of the UH-1H simulation, including each of the aircraft malfunction programs, was assessed by requiring at least two test staff members who were UH-1 qualified pilots to identify, while flying the simulator, any discrepancies between the simulation provided by the device and the real-world model for that simulation. Where discrepancies were detected, judgments were made jointly by the pilots and by the HumRRO staff as to their probable significance for training.

The 2B24 had undergone both in-plant and on-site acceptance testing by the procurement agency prior to the beginning of the Expanded Service Test. As is frequently the case with complex new systems, there were deficiencies which had not been detected during acceptance testing. This resulted in acceptance of a device that, in addition to being less than fully satisfactory when employed in a mission context, had features which did not reflect the requirements of the QMR or other design requirements documents,[1] as these documents were interpreted by the Suitability Test staff.

For example, a computer program editing routine which would permit easy modification of automated training and evaluation programs had not been developed, thus precluding even minor adjustments in those programs by on-site personnel. Additionally, documentation procured with the device did not enable test personnel to evaluate some device subsystems at all, and, in some instances, questions about device operation could not be answered. Some of the trainee performance generated by the device could not be decoded, and the information appearing on the score panel in the cockpit during automatic training exercises did not agree with documented descriptions.[2] These and similar problems are discussed in more detail in the Test Board report.[3]

Because of deficiencies such as these and the initial unpredictability of the device's performance, a considerable amount of time was spent during Phase I identifying system problems and correcting them where possible. While it was anticipated that a number of adjustments, modifications, and debugging operations would be necessary in order to determine the device's mission suitability—as would be the case with any new, highly complex system—the scope of essential changes and the time required to accomplish these changes were underestimated. Three calendar months had been scheduled for Phase I activities. Because of the problems encountered, however, the device was not available to test personnel on a full-time basis for much of this time. Additionally, device maintenance and operator training courses were conducted during the first ten weeks of the Suitability Test. These courses required at least limited access to the equipment half of each workday.

In view of these difficulties, rather than ending after a three-month period as had been planned, Phase I activities continued, on a time/device available basis, throughout Phases II and III. During the two months scheduled for Phase II, the equipment was unavailable for further testing for approximately five weeks while solutions were sought for priority problems which had been identified up to that time.

RESULTS

The deficiencies detected during Phase I more often than not were attributable to software (i.e., computer programs) although in some instances the software deficiences induced hardware malfunctions. In fact, it generally was felt by those involved in Phase I testing that Device 2B24's software was the source of its major problems, and this was attributable, at least in part, to insufficient communication among the eventual device user (i.e., the Aviation School), the procurement agency, and the device manufacturer throughout the device's development phases. A result of this situation was that the

[1] The documents referred to are the manufacturer's Final Reports for the Instructor Station, Trainee Station, and Adaptive Training. NAVTRADEVCEN Technical Reports 69-C-0200-03, 69-C-0200-04, and 69-C-0200 15, respectively. See also "Technical Proposal for Synthetic Flight Training System Engineering Development Model, Device 2B24, Vol. 1, Technical Approach," Link Group/ Singer-General Precision, Inc.

[2] Due to these and other problems detected in Phase I, extensive changes were made in the computer program associated with the device, and the manufacturer conducted a special two-week training course on the automatic training system. The full cooperation of the manufacturer in the correction of deficiencies detected during the Suitability Test, as well as the assistance of manufacturer personnel during test activities, was very helpful and contributed to the eventual success of the test.

[3] Smith and Sasser, *op. cit.*

manufacturer's computer programmers had not been made sufficiently aware of all of the interactions between device subsystems that would occur during typical use of the 2B24 for training. Therefore, no provisions had been made during programming for some of the interactions later found to be significant. In most instances, deficiencies of this nature were eventually corrected, although not all of them were corrected prior to termination of the Suitability Test.

The deficiencies were not all related to software. There were hardware malfunctions and design problems as well. There was, for example, interference in communications between trainee stations, and the performance playback system was designed in such fashion that its use during training was inherently inefficient. Some of these problems were easily corrected, but others involved major design changes that could be overcome only through expensive device modifications that were judged not likely to be cost-effective.

The Aviation Test Board's report of the results of the Expanded Service Test,[1] of which the Suitability Test is a part, deals in detail with the deficiencies of the device which could not be corrected prior to the end of the test. The reader is referred to that report for their identification. The remaining portion of this chapter will discuss the workability of Device 2B24 in more general terms. This discussion will be in terms of the workability of the three modes of device operation described in Chapter 1. It must be noted that the teamwork among the military and civilian personnel, including the manufacturer, was exemplary. The attitude throughout was to obtain an effective training system for the Army. As discussed in subsequent sections of this report, those efforts resulted in solutions to most of the major problems and delivery to the Army of a highly effective system.

Automatic Mode

The developmental nature of the Automatic Mode training features of Device 2B24 was described in Chapter 1. Inspection of the manufacturer-developed automatic training exercises indicated that the initial developmental goals had been met. It was apparent, however, that additional development of each exercise, as well as the general approach adopted by the manufacturer, would be required.

Automatic training exercises, such as those developed for the 2B24, are analogous to computer-administered instruction (CAI) programs, in that a number of revisions should be planned before they can be considered appropriate for routine training use. CAI programs initially are prepared in draft form, and then one or more "students" attempt to "use" them. On this initial attempt, the chief question is whether it is possible to proceed through the programs from the entry point to the exit point, and little attention is paid to the specific didactic efficiency of the program. This latter consideration becomes important only after the program has been revised to assure that students can proceed through it.

As delivered, the SFTS automatic training exercises could be considered to be untested, initial-draft instructional programs. Consequently, the first step in determining their workability was to determine whether students could proceed through them from entry to exit points. Each of the programs was thus "tested," with test personnel serving as students.

The results were generally as might be expected. While it was possible to proceed through most of the exercises, it was typically done with difficulty, and further editing clearly was indicated in all cases. It had been intended that at least one editorial rewrite of each exercise would be undertaken as part of the Suitability Test in order to include

[1] Smith and Sasser, *op. cit.*

Automatic Mode training activities in the test results, but this was not possible because the required edit program had not been developed at that time. Further work with the Automatic Mode has taken place since the edit program became available, and some training can now be conducted with the automatic training exercises.

During Phase I a number of specific problems were identified which subsequently have been corrected. The problems ranged from relatively simple to major, some requiring overhaul of an entire exercise. A few of the problems are cited below for purposes of illustration.

(1) One exercise was programmed for an altitude of 6000 feet. However, the CRT display of altitude was programmed to operate only in the range of 0-4000 feet. An obvious solution was to change the programmed flight altitude for the exercise to a value less than 4000 feet. To make this relatively simple change without the edit program, complex reprogramming had to be accomplished.

(2) Initially, it was found that the difficulty levels associated with the adaptive training exercises were such that even highly experienced aviators could not fly the problems. Extensive reprogramming was necessary before these could be evaluated. After the changes were made, it was determined that sample students could progress through the exercises.

(3) An automatic training exercise containing inappropriate procedures should not be used for pilot training. All of the nine automatic training exercises were found to be deficient in this regard in one respect or another. Some of the problems encountered were due to program inadequacies. There were other problems, however, that were beyond the control of the program developers. For instance, training procedures in use at the Aviation School changed slightly between design freeze (a date specified in the contract between the manufacturer and the government beyond which changes occurring in the design models would not be reflected in the design of the device) and device delivery. For example, the "School solution" for the method of intercepting airways changed; consequently, the technique programmed into the computer autopilot, although technically acceptable, was no longer used for training at the Aviation School.

Detailed study of trainer operation in the Automatic Mode was postponed because of the relatively long lead time necessary to correct the problems associated with the automatic training exercises without the required edit program and the press of other Suitability Test activities. As the reprogramming was accomplished, automatic training was considered on a time-available basis during subsequent test activites. The extent of effort expended in this manner was low, and the Automatic Mode was not considered fully workable for purposes of the Suitability Test.

Semi-Automatic Mode

The Semi-Automatic Mode of operation of Device 2B24 was designed to permit instruction to be conducted under positive instructor or operator control. The distinction between this and the Automatic Mode is that the instructional process itself is not automated in the Semi-Automatic Mode. All of the automatic and advanced training features of the device except the automatic exercises and checkride are available for use, but the instructor must make a conscious decision concerning their employment.

Initially, the 2B24 was found to be unsatisfactory in the Semi-Automatic Mode, because so few of the device's subsystems would work simultaneously and because the computer programming necessary to operation in this mode was so deficient that device performance was unpredictable. A number of the problems were corrected relatively rapidly through replacement of defective hardware or patches to the computer program. Others required extensive study before the basis for the deficiency could be identified. An example of the latter involved the data display CRTs at the operator and trainee stations which went blank while mock training was being attempted in what, for several months, appeared to be random fashion. A minor programming error was eventually found to be the cause.

Many of the problems identified were minor in themselves, but in interaction with other deficiences they became very difficult to correct. Some of these were not corrected until well after the Suitability Test was completed. For example, during the period between the device-design freeze and the device's delivery to Fort Rucker, certain navigational fixes in the training area were changed. Such changes were anticipated and will continue to occur from time to time. Provision was made to effect such changes in the 2B24 through the previously discussed edit program. Since that program had not been developed at the time of the Suitability Test, this otherwise simple correction could not be made with the resources available.

Initially, there were a few aircraft maneuvers in which the 2B24's performance was judged unrealistic by test personnel, but these were corrected. Simulated turbulence and buffet effects also required extensive modification in order to obtain acceptable motion cues and instrument indications. Some modifications also were required to assure that malfunction simulation produced the same cues in the device as did malfunctions in the aircraft. With some exceptions—the most notable being simulation during hovering flight—the simulation of the UH-1H aircraft and of the environmental effects was quite good.

Likewise, the 2B24's advanced training features needed modification before they were considered usable in the planned training program. Many of the deficiencies in these features were relatively minor, but could not be corrected in some cases prior to completion of the Suitability Test. For example, the frequency of occurrence of audio alerts, a relatively minor problem, could not be adjusted until after the Suitability Test was completed. Other deficiencies were of greater concern, and the available effort was devoted to their correction. For example, although recall of plots of aircraft ground tracks was considered a desirable feedback technique to include in the planned training program, its use initially resulted in loss of all stored data.

Correction of the major Semi-Automatic Mode deficiencies received the highest priorities. By the time it was necessary to begin development of a training program, it could be predicted which features of the device would be workable during Phase III. Since the test staff was confident at that point that enough of the 2B24's features would be available during Phase III, or could be simulated in some fashion to permit meaningful training, Phase II training program development activities were initiated on schedule, although the device itself was down—and remained down for five weeks—for corrective actions at that time.

Checkride Mode

Like the automatic exercises, the automatic checkride was considered a developmental feature of Device 2B24. It is similar in concept and format to several of the automatic exercises except that during its administration certain performance data are recorded automatically for display to the check pilot and for off-line quality control data analysis purposes.

Initial attempts to fly the automatic checkride during Phase I were unsuccessful. Typical problems encountered were failure of the computer program's "maneuver detector" to detect that a maneuver change had occurred. Thus, it would not advance to the next segment. Performance data also were not available on the hard-copy printer as required. Problems such as these were almost entirely associated with computer programming.

Like the automatic training exercise problems already described, such deficiencies were considered correctable but the necessary changes could not be made within the time available for the Suitability Test. Consequently, evaluation of the automatic checkride was not completed during the time scheduled for Phase I. When a functioning automatic checkride could be flown during later phases of the test, it was examined, but complete evaluation could not be made, and the Checkride Mode was not considered to be a workable feature of the device for purposes of the Suitability Test.

The device was expected to have a computer program that would process data recorded during Checkride Mode operation to provide training quality-control information. Since the Checkride Mode was found unworkable, data could not be generated to test the quality-control data processing program. However, inspection of the program by test personnel led them to conclude that the program would not yield information useful to the Army for quality-control purposes. Inspection of other device features associated with Checkride Mode operation, such as the Card Reader, revealed additional inadequacies. In the case of the Card Reader, test personnel were unable to determine that the 2B24's computer programs permitted this component to perform any of the functions expected of it during any mode of device operation.

Summary of Phase I Results

During Phase I, enough workable features of the device were identified to proceed with the Suitability Test on the understanding that certain discrepancies would be corrected prior to the beginning of Phase III. The training program to be developed during Phase II, however, would have to involve Semi-Automatic Mode operation only, since the other two modes were found to require further development before they could be used for student training.

Chapter 3

PHASE II: TRAINING PROGRAM DEVELOPMENT

OBJECTIVE

During Phase I a number of the 2B24's unique training features were found to be workable. In addition to having these features, the device is significantly more comprehensive in its simulation of the training aircraft than are any other training devices used in an undergraduate-level pilot training program. It might be expected, then, that the device would be suitable for training. Research has shown, however, that the training value of a device such as the 2B24 is a function of the manner in which the device is used, not just the design of the device itself.[1] The objective of Phase II of the Suitability Test, therefore, was to develop a training program for use with the 2B24 that would take advantage of its capabilities in the training of Army undergraduate pilot trainees.

APPROACH

Training Program Objectives

An appropriately designed training program is one that is responsive to specific training objectives and is effective in accomplishing those objectives. Since the 2B24 was intended by the Army for use at the Aviation School primarily as an Instrument Phase training device, the objectives of that phase of the undergraduate pilot training program became the objectives for the 2B24 training program under development. These objectives consist of: (a) conduct of flight under the Instrument Flight Rules (IFR) specified in an applicable Department of Defense and Federal Aviation Administration Regulations; (b) conformity to the requirements of applicable U.S. Army Regulations concerning flight in the Army aircraft; and (c) operation of the aircraft in accordance with the requirements of the aircraft operator's manual.

The Army has established techniques and procedures for the determination of whether trainees meet these training objectives. They consist of oral examination and performance tests (checkrides) administered by aviators who have been awarded the designation of Instrument Examiner. For the purposes of the Suitability Test, the objective of 2B24 training was to enable a trainee to demonstrate to an examiner that the trainee had mastered the skill and knowledge requirements related to (a), (b), and (c) noted above (i.e., to pass an instrument checkride in the aircraft). In addition, it was expected that the instrument training received in the device would also have a positive effect upon a trainee's performance during visual flight maneuvers because many of the aircraft-specific skills acquired in the device (actually a UH-1H simulator) would transfer to the UH-1H aircraft in a visual as well as an instrument flight environment.

[1] For example:

G.S. Micheli. *Analysis of the Transfer of Training, Substitution, and Fidelity of Simulation of Training Equipment*, NAVTRAEQUIPCEN TAEG Report 2. U.S. Naval Equipment Center, Orlando, Florida, 1972.

Paul W. Caro, Robert N. Isley, and Oran B. Jolley. *Research on Synthetic Training: Device Evaluation and Training Program Development*, HumRRO Technical Report 73-20, September 1973.

Overview of Existing Training

At the time of the study reported here, Army undergraduate pilot training consisted of four phases: Primary, Instrument, Advanced Contact, and Tactics. The Primary Phase consisted of 100 hours of dual instruction and solo practice in a light, reciprocating engine helicopter, the TH-55. The TH-55 is not equipped for instrument flight, and no instrument training was provided to Primary Phase trainees.

The Instrument Phase consisted of 60 hours of dual instruction in another light, reciprocating engine helicopter, the TH-13T, and 26 hours' instruction in an existing instrument training device, Device 1-CA-1. The 1-CA-1 is a fixed-wing device developed during the late 1940s and modified by the Army to a rotary wing configuration.[1] Trainees successfully completing this phase had met all requirements for award of a Standard Instrument Rating.[2] That award is made upon completion of undergraduate pilot training, when the trainees are designated Army Aviators.

The Advanced Contact Phase and the Tactics Phase (given subsequent to the Instrument Phase) each consisted of 25 hours of flight instruction, most of which was dual, in the UH-1 B, D, or H model helicopter. The Advanced Contact Phase training was, essentially, a 25-hour UH-1 transition course. The Tactics Phase prepared the trainee to employ the UH-1 in representative tactical situations such as he might encounter should he be assigned to Southeast Asia.[3] The UH-1 is the primary operational aircraft for the newly graduated Army Aviator, his initial assignment, typically, is as pilot or copilot of that aircraft.[4]

Program Features

At the time of delivery of Device 2B24 to Fort Rucker, the Aviation School was conducting a comprehensive review of its pilot training programs, using the systems engineering approach. Very little change in the content of Instrument Phase training occurred as a result of the review. In anticipation of this result, the program development activities of Phase II did not include major revision of the objectives or content of the program. Instead, the Phase II effort concentrated upon the methodology of training. A discussion of that methodology as it applied to the development of flight simulator training programs is available elsewhere.[5]

The training program developed for the 2B24 was an advanced adaptation of a program previously developed and tested for use with a fixed-wing instrument device.[6] The primary distinguishing features of the training program developed for Device 2B24 are listed on the following page.

[1] The modified 1-CA-1 is described in more detail in Paul W. Caro, *Equipment-Device Task Commonality Analysis and Transfer of Training,* HumRRO Technical Report 70-7, June 1970.

[2] An earlier version of this training led to the award of an Army Technical Instrument Rating. For a discussion of that program and of the use of the modified 1 CA-1 in it, see Robert N. Isley, Paul W. Caro, and Oran B. Jolley, *Evaluation of Synthetic Instrument Flight Training in the Officer/Warrant Officer Rotary Wing Aviator Course,* HumRRO Technical Report 68-14, November 1968.

[3] At the time of the test reported here, the Vietnam conflict was in progress, and Army aviator training was oriented principally toward Southeast Asia operations.

[4] In January 1974, the IERW course was completely restructured. The Primary Phase was reduced to 85 hours, the Instrument Phase was changed to 20 hours in the 2B24, followed by 30 hours in the UH-1, and the Contact and Tactics Phases were modified to 20 hours of contact and 45 hours of tactics. The tactical instruction is designed around a mid intensity, high anti-aircraft threat environment such as might be expected in Europe.

[5] Paul W. Caro. "Aircraft Simulators and Pilot Training," *Human Factors Journal,* vol. 15, no. 6, December 1973; issued as HumRRO Professional Paper 6-74, May 1974.

[6] Micheli, *op. cit.*

Conduct of training in the device. On the basis of information obtained about Device 2B24 during Phase I and information from the flight training research literature, it was decided that full qualification, so far as pilot performance is concerned, for a Standard Instrument Rating could be acquired in the device. Therefore, the 2B24 replaced both the TH-13T and the 1-CA-1 as the instrument training vehicles. Trainees were not permitted to fly any aircraft during the instrument Phase (they had successfully completed Primary Phase training in the TH-55) until they could demonstrate in the device attainment of all of the Instrument Phase training objectives specified by the Aviation School. At that point in their training, they would go to the aircraft, where their instrument flight skills could be verified and where they could complete all remaining UH-1 transition training, or Advanced Contact Phase, requirements.

Individualized training. The pace and redundancy of all aspects of training (including "academic" instruction) were adapted to the learning rate of each student. Advancement of each student from one instructional activity to another was independent of the progress of all other students and was determined on the basis of objective evidence of his mastery of the performance requirements associated with each activity. The training time devoted to an activity was restricted to that required to bring a trainee to a specified skill level and no more. Overtraining was not permitted.

Functional context training. The training activities centered around simulated instrument flight missions, rather than abstract exercises designed to develop part-task skills. Contextual meaning of training activities was stressed, even during early training periods. For example, the training activity for the initial instructional period in the 2B24 included a simulated IFR mission, beginning with an instrument take-off and terminating with a ground-controlled radar approach (GCA). So-called basic or attitude instrument flying tasks, traditionally practiced during early instrument training periods, were omitted from the program. The skills developed during such practice in traditional instrument training programs were acquired by trainees in the present program as they practiced simulated instrument flight missions, rather than through practice of abstract aircraft control exercises.

Instructor-manager concept. Traditionally, instruction in flight simulators and training devices has been administered by non-rated enlisted personnel. In the program for the 2B24, all instruction in the Instrument Phase was administered by flight instructors who were qualified to provide both instrument and transition training in the UH-1H aircraft. All these instructors were officers, warrant officers, or Department of the Army civilian instructor pilots. Each instructor was assigned two trainees and charged with the responsibility to carry them through both instrument and UH-1 transition training (i.e., the Instrument and Advanced Contact Phases).[1] In accomplishing this training, he had to manage the resources available to him—the device, the aircraft, academic material, and supporting personnel—in accordance with the guidelines provided. His task, thus, was defined in terms of the acquisition by his students of the necessary skills with the least expenditure of resources.

Incentive awards. Both instructor motivation and student motivation were considered in this program. Behavior-change techniques developed in psychological research laboratories were employed to manipulate motivation in the training program developed during Phase II. This was done through use of incentives, such as free time, in exchange for above-average achievement by both instructors and students. For the trainee, above-average achievement consisted of reaching specified proficiency goals in less time than his peers or in less time than had been expected of him. For the instructor, it consisted of more efficient use of the instructional resources available to him.

[1] At the time of this study, there was a different instructor pilot staff for each phase of training in the existing program.

Crew and peer training. The 2B24 permits three people inside the cockpit—a pilot trainee, a copilot trainee, and an instructor pilot. The training program developed during Phase II consisted of simultaneous training of both trainees in the skills appropriate to the seat they occupied. The division of their time between the two trainee seats was at the discretion of the instructor and was based upon their respective learning rates. During the first few instructional periods, the instructor occupied the copilot position in order to demonstrate certain maneuvers (the automated maneuver demonstrations expected to be available during Automatic Mode operation of the 2B24 were found during Phase I to be unworkable without further development). During these periods, the second trainee occupied the instructor's position inside the cockpit and participated in the instruction only as an observer. During some training periods, the instructor pilot remained outside the cockpit and monitored the trainees from the centralized device operator console. In these cases, the trainees served as their own instructor and engaged quite effectively in problem-solving behaviors that typically did not occur when the instructor was present inside the cockpit.

Course Outline

The traditional format for documenting a flight training program involves specification of maneuvers to be performed during each hour of scheduled training. This format is unsatisfactory for documenting an individualized course in which the rate of progress through the required exercises is a function of the trainee's rate of mastery of the maneuvers involved. Even when a traditionally formatted document is intended to suggest only the hour level at which a maneuver may be introduced, the effect of that guidance typically is to produce training in which all students progress at the same rate, or very nearly so, rather than individually. In contrast, the data from human performance and learning research consistently lend support to the design of flight training programs in which trainees progress at individual rates rather than at the same rate.

The traditional course documentation format was rejected for the training program under development during Phase II, since it would not facilitate individualized training. Instead, a format was devised which would lend itself more readily to the requirement for student progression to be based upon student achievement, a program feature considered likely to yield more consistently satisfactory student performance at less total cost. The chief requirement for the new course documentation format was that it lead to standardization of training while permitting individual progression, dependent only upon student learning rates. It also had to be compatible with the features desired of the planned training programs previously indicated.

The document derived to meet these requirements is a Course Outline for UH-1 Transition and Instrument Training (Appendix B). It is designed for use with Maneuver Performance Record Forms (MPRFs), an example of which is in Appendix C. The Course Outline lists all of the activities and maneuvers for which training is to be provided in the device (Part A) and in the aircraft (Part B), in the sequence in which they are to be introduced and initially practiced by each trainee.

The Course Outline was used in the following manner: On the first training day, the instructor took his two trainees to the 2B24 and began the period of instruction for one of them by accomplishing Item I, 2B24 Orientation. He then proceeded through the Outline as far down the list of items, in sequence, as time would permit that day, attempting to reach Item 10. That is, the training period consisted of the demonstration and discussion, with student involvement in all tasks, of the performance of a simulated instrument flight beginning with cockpit procedures, an ITO, a straight climb to altitude, level off, a brief period of level flight ending with a 90° level turn, a GCA to a landing with appropriate prelanding aircraft checks, and engine shutdown. After a break, the same instruction was repeated for the second student, who had been observing the first student's performance and participating in the discussion with the instructor.

During the second period, each student in turn began with Item 2 and proceeded as far through the Course Outline as time would permit. The second and subsequent periods, except as is indicated below, ended with execution of an approach and completion of Items 9 and 10. The approach selected depended upon how far through the Outline the student had progressed. Initially, the approaches were GCAs.

The first time each item was introduced to a student, it was demonstrated by the instructor. The second time, if the Course Outline included the instruction "Practice using MPRF," the trainee was required to perform the maneuver as best he could, and his performance was scored using the MPRF developed for that maneuver. This procedure was repeated during each subsequent practice period until that item was performed without error, that is, no errors noted on the MPRF. It was omitted during the next period, and was replaced by a subsequent item in the Course Outline.

Following this Course Outline, all training activities were introduced in like manner and sequence to each trainee, and each instructional period consisted of at least a portion of a simulated instrument mission. On all such missions, applicable instrument flight regulations were followed, and all maneuvers were performed to existing Aviation School Standardization Manual[1] requirements. While later training periods often began in the middle of a simulated instrument mission (e.g., at Item 12), most periods ended with the practice of an approach. To allow better utilization of 2B24 time, practice on procedural Items 2, 9, and 10 was discontinued after the student demonstrated proficiency on them. Additional practice of these procedures during the last few training periods in the 2B24 allowed the student to regain proficiency prior to beginning training in the aircraft. Additional practice on other items was provided during the last few training periods in those cases where the instructor judged such practice to be needed before his trainees took their instrument checkride.

Diagnostic Progress Check

In previous training program development research, it has been noted that instructors tend to underestimate the achievement of their flight trainees. Although they can often estimate accurately the grade that a given student will receive on an independently administered checkride, instructor pilots may retain students beyond the time that they can pass that checkride in order to increase their overall proficiency beyond that level required for course graduates. This is an almost inevitable consequence of fixed-schedule training programs. If the course completion requirements accurately reflect desired performance standards, as they are assumed to do in proficiency-based training programs such as that developed during Phase II, retaining a student in training beyond the time that he can meet course-completion performance requirements amounts to overtraining that student and adds unnecessary costs to the training program.

As an aid to overcoming this tendency to overtrain students, a diagnostic progress check was used. This check consisted of a period of instruction administered to each trainee by an instructor other than his own. The purpose of the check was to obtain a relatively independent indication of the progress being made by the trainee, to identify skills/maneuvers on which additional practice should be concentrated prior to administration of the end-of-phase checkride, and to estimate the amount of training time that would be required prior to that checkride.

The check was given each trainee when his own instructor estimated that he was approximately two-thirds to three-fourths through with the required Instrument Phase training. This independent evaluation of student progress in the new program served several purposes. First, it tended to verify for an individual instructor and his students

[1] U.S. Army Aviation School Instrument Flight Training Guide, dated October 1970.

those training activities on which they should concentrate during the remainder of the device training program. Second, it tended to reduce overtraining, since some students were judged capable, at that point in time, of passing an instrument checkride. In such cases, the checkride was scheduled for the next training period. Third, the test staff used the information generated during the progress rides to schedule remaining test activities.

Maneuver Performance Record Forms (MPRFs)

The MPRF was designed to serve three principal functions, and reference to the sample MPRFs in Appendix C will illustrate these. The first purpose was to provide the instructor an objective score form on which he could represent graphically the daily progress of each student on each maneuver. This purpose was achieved by requiring that he use the MPRF to score the student's *first* performance of a maneuver each training period. While observing the trainee perform the required maneuver, the instructor would check each maneuver element performed correctly (i.e., within the tolerances specified).

The second purpose was to provide performance-specific, objectively recorded and reported feedback to the trainee concerning his performance on each maneuver he practiced each day, and to enable him to evaluate his progress with respect to that maneuver by comparing that day's performance with previous days' performances. The MPRF became a very effective communications tool between trainees and instructors and was judged by the test staff to have contributed to trainee motivation in the course.

The third purpose was to limit the amount of training the trainee received on each maneuver before proceeding to another. By requiring instructors to move on to other items as soon as the criterion of one errorless trial was achieved on a particular item on the Course Outline, the tendency of many instructors to overtrain on some maneuvers was reduced. Any trainee who, in the judgment of his instructor, needed additional practice on a previously completed maneuver, could and did return to that maneuver for further work prior to being recommended by his instructor for an instrument checkride.

No MPRFs were prepared for use during the portion of training conducted in the UH-1 Aircraft because of the limited time available for the conduct of Phase II. Since the principal interest during the Suitability Test was upon instrument training in the 2B24, the available time was devoted to preparation of material for instrument training in the device. For those activities and maneuvers for which no MPRFs had been prepared, the instructor exercised his own judgment as to the amount of practice his trainees might require.

Academic Training

The classroom instruction that normally was a part of a graduate aviator rotary-wing instrument training program had been converted to a self-instructional format by the Aviation School (i.e., programmed textbooks) prior to the 2B24 Suitability Test. Although not necessarily viewed as optimally suited for undergraduate students or for the program developed during Phase II, the programmed texts were judged adequate and were incorporated into it.

The trainees were provided sets of the relevant programmed texts and a Reference Material Study Guide (a copy is in Appendix D), and a study area was provided for their use during the half-days that they were not receiving instruction in the 2B24. An instructor pilot was available to respond to questions any individual trainee might have during much of this study time, but the flight instructor to whom each trainee was assigned was responsible for his trainee's timely mastery of the content of these texts to the extent he might require. Thus, each trainee had only one instructor throughout the instrument training program developed during Phase II, and that instructor was responsible for all the training he received.

Since self-instructional material was not available covering the subject matter of the UH-1 transition portion of the course, trainees were scheduled to receive conventionally administered training in that area from classroom instructors following completion of the instrument programmed textbooks. It was stressed with each flight instructor participating in the Suitability Test that he was responsible for identifying and compensating for any deficiencies that might exist in his students due to the fact that the classroom instruction his trainees received relating to the UH-1 aircraft did not precede their training in the UH-1 simulator. It was found that the instructors had no difficulty giving their students all the information they needed about the UH-1 while simultaneously conducting instrument flight training in Device 2B24.

Instructor Pilot Training

The final Phase II activity was the initiation of training of instructor pilots to administer the newly developed programs. Several of these pilots had assisted the HumRRO staff in its development; others, when assigned to the project, were completely unfamiliar with many of the features that have been described. Each pilot was qualified, so far as the Aviation School's proficiency requirements were concerned, to conduct both Instrument and Advanced Contact Phase training in the UH-1H prior to his assignment to the project.

To accomplish the necessary training, an instructor training program was developed which enabled the participating flight instructors to learn to conduct training in the manner required. A brief description of that training is provided below. It should be noted that the information contained in this Technical Report is intended only to provide a general description of the training techniques employed during the Suitability Test, rather than to enable otherwise untrained personnel to replicate that training.

Instructor pilot training consisted of two activities. During the first, the instructors were thoroughly briefed on the new training programs and their features, were trained to operate the 2B24, and conducted mock training periods under the guidance of the HumRRO staff, using each other as trainees. The second activity consisted of the supervised administration of the training program to Army trainees. This second activity, which was the conduct of Phase III, was monitored closely from the centralized device operator station by the HumRRO staff, and the instructors were debriefed after each instructional period, as needed, to assure that the new program was being administered in the manner prescribed. The instructors were not considered to have completed their training until they had completed the supervised training of the two trainees assigned to them.

Emphasis during the training the instructors received during Phase II was upon the procedures involved in administering the device training program. Most of these procedures were new to the instructors, and in some cases were contrary to well-established military pilot training practices and tradition. Some of the instructors initially did not believe that the new program could be successful and privately disclaimed responsibility for the failure they expected of their students if the new procedures were followed. Fortunately, the instructors—while not necessarily convinced that the new procedures were either workable or improvements over more traditional training procedures—were generally receptive to the demands of the test and were fully cooperative in the administration of the new program.

In the view of the HumRRO staff, the training received by the instructors in the administration of this program was critical to its subsequent success in Phase III. Previous efforts with and without such training—to include the supervised administration of the training to students—as well as the subsequent experiences of the Aviation School, have confirmed the view that thorough instructor training and monitoring are essential to the successful introduction of training techniques and procedures that differ from those previously established.

Phase II Summary

During Phase II, a Device 2B24 training program was developed. The program was designed to take advantage of the device's capabilities that were found workable during Phase I. The program was an advanced adaptation of a program previously developed and tested in another Army undergraduate pilot instrument training program. Primary distinguishing features of the program were the conduct of training in the device rather than in the aircraft, the individualization of training, training in a functional context, employment of an instructor-manager concept and incentive awards, and crew and peer training. The course documentation was designed to facilitate these features and did not conform to conventional format, and the need for conventional classroom instruction was significantly reduced. Phase II concluded with the initial training of the flight instructor pilots who would administer the newly developed training program during Phase III.

Chapter 4

PHASE III: TRANSFER-OF-TRAINING AND TRAINING-COSTS STUDIES

OBJECTIVE

The objective of the third and final phase of the Suitability Test was to determine the cost-effectiveness of Device 2B24 training in the Army undergraduate pilot training program. This objective was met through the conduct of two studies: a transfer-of-training study, in which the effectiveness of training received in the 2B24 was determined on the basis of subsequent trainee performance in the UH-1 helicopter; and a training-costs study, in which the relative costs of training in the 2B24 were compared with those of training in the existing training program.

The study plan called for the administration of the 2B24 training program developed during Phase II to Army pilot trainees who had just completed the Primary Phase of undergraduate training. Since the 2B24 training program was a proficiency-based program, a training program length, either in "flight" hours or in calendar time, was not specified. Instead, each trainee's flight instructor was required to proceed through the course at a pace he judged appropriate to his trainee's performance and to indicate when the trainee was prepared to pass a Standard Instrument Rating checkride. When that indication was given, the trainee was then administered such a checkride in the 2B24. If he passed that checkride, he was taken to the UH-1H aircraft and administered a second Standard Instrument Rating checkride, usually by the same examiner. Since the student had never flown the UH-1 helicopter, he was permitted several familiarization flights in it prior to administration of the second checkride. The familiarization flights were, in effect, periods of dual instruction administered by each trainee's instructor, but the chief purpose of the flight was to demonstrate to the trainees that they were, in fact, instrument-qualified in a helicopter as well as in a simulator, prior to facing the examiner a second time.

TRANSFER-OF-TRAINING STUDY

Subjects

Sixteen test subjects participated in the study. They were selected, using a table of random numbers, from among the members of an Officer Rotary Wing Aviator Course who volunteered for the training. Only those trainees who had less than 60 hours of flight experience, none of which was instrument flight, and were members of the active Army were permitted to volunteer. Thirty-four of the 39 officers who met the eligibility requirements volunteered. All had completed the Primary Phase of training (100 hours of contact training in the TH-55) before Device 2B24 training began. The amount of prior flight experience of those selected varied from 0 hours (seven of the test subjects) to 60 hours (one subject). Most of the others had received 35 to 40 hours of pilot training in an ROTC fixed wing private pilot training program prior to entering the Army.

Instructors

Nine instructor pilots (IPs) participated in the study (see Appendix A). The group was made up of Army officers, warrant officers, and Department of the Army civilians. Eight instructors were assigned two test subjects each. The ninth instructor was used as a spare in instances when one of the other instructors was absent. Prior to the test, each instructor was either an Instrument Phase IP or a Contact Phase IP. Consequently, it was necessary to qualify the former as IPs in the UH-1 aircraft and to qualify the latter as instrument instructors. This was done by the Aviation School. The instrument training experience of these IPs, thus, varied considerably, ranging from no prior instrument instructing experience to extensive IP experience and qualification as an Army instrument examiner.

Before the beginning of Phase III, each IP was trained by the test staff in the administration of the experimental training program, as described in Chapter 3. Additionally, performance was closely monitored by the test staff throughout training to encourage compliance with the training program design and to promote standardization. These steps were necessary because the experimental training program required numerous significant deviations from training practices to which these IPs were accustomed.

During training, the Device 2B24 operator console was manned by non-rated personnel, who assisted the flight instructors when they were conducting training inside the cockpits. The chief functions performed by these device operators related to problem set-up and simulation of ground station communications.

Academic Instruction

Necessary flight-related academic instruction was conducted under the IPs' supervision, as described in Chapter 3. The test trainees received other required academic instruction (e.g., aeromedical lectures) with comparable students who were not participating in this study.

Results

The amount of training received by each trainee in Device 2B24, and the time required for the checkride and the checkride grade, are shown in Table 1. Two trainees did not pass the checkride the first time it was administered. Both returned to their assigned IP for additional training and then were given a second checkride. Both students passed on the second attempt.

Table 1 includes all training and checkride time required by these students. Army Aviation School policy dictates that a grade of 70 be assigned when any checkride is passed after having once been failed, regardless the quality of the student's performance on the recheck. The grades of students #5 and #13 reflect this policy.

The mean total time required for these students to complete 2B24 training and to pass the required instrument checkride was 42 hours, 50 minutes. Of this, an average of 40 hours, 28 minutes was devoted to training, and 2 hours, 22 minutes was given to evaluating performance during checkrides. This compares with the total training and evaluation time of 86 hours (60 hours in the TH-13T, plus 26 hours training time in the modified 1-CA-1 device) scheduled for all conventionally trained students.

Upon passing the instrument checkride in the 2B24, these experimental trainees were judged qualified, as far as proficiency was concerned, for award of a Standard Instrument Rating. Present Army regulations, however, require that such an award be made only upon the basis of performance during a checkride conducted in an aircraft. Consequently, the test could not be concluded until these trainees had been examined in the aircraft itself.

Table 1

Training and Checkride Time Requirements and Checkride Grades of Trainees in Device 2B24

Student Number	Training Time	Checkride Time	Total Time	Checkride Grade
1	33:15	2:15	35:30	89
2	35:00	2:00	37:00	82
3	35:00	2:00	37:00	84
4	37:30	2:00	39:30	73
5[a]	39:00	4:15	43:15	70
6	40:00	2:15	42:15	85
7	40:30	2:15	42:45	90
8	40:45	2:00	42:45	91
9	41:00	2:15	43:15	90
10	42:00	2:00	44:00	94
11	42:15	2:45	45:00	89
12	43:00	2:00	45:00	92
13[a]	43:45	3:30	47:15	70
14	44:00	2:15	46:15	80
15	45:00	2:00	47:00	82
16	43:35	2:00	47:35	86
Mean	40:28	2:22	42:50	84.2
S.D.	3:41	:38	3:47	7.6

[a]Students 5 and 13 did not pass the checkride in the 2B24 the first time it was administered. Their performance was satisfactory on a subsequent recheck.

Each IP "transitioned" his assigned trainees from the 2B24 to an instrument-equipped UH-1H. This aircraft familiarization training activity was conducted under the hood (under simulated instrument conditions), and none of the trainees had prior experience flying the UH-1. Transition training was restricted to familiarization with the aircraft under simulated or actual instrument conditions, since it was presumed that all necessary instrument training had been conducted in the 2B24. Table 2 indicates the amount of time devoted to this activity.

The aircraft time required for this aircraft familiarization ranged from 2 hours, 45 minutes to 6 hours, 45 minutes. This mean time was 4 hours, 12 minutes. It should be noted that a portion of the range of aircraft training times was attributed to the IPs' judgment that some students needed more aircraft familiarization than others. Some of the range, however, was a function of difficulties experienced in the scheduling of instrument-equipped aircraft and qualified Army instrument examiners. The latter was a particular problem, since the timing of this test conflicted with the scheduling of these personnel for other duties. It was found necessary to have three of the aircraft checkrides administered by qualified instrument examiners assigned to the test as IPs instead of using independent evaluator personnel exclusively. In no case, however, did the assigned examiners check their own students.

Table 2

Aircraft Familiarization and Checkride Time Requirements and Checkride Grades of Trainees in the UH-1

Student Number	Training Time	Checkride Time	Total Time	Checkride Grade
1	3:00	2:00	5:00	87
2	3:00	2:45	5:45	88
3	6:15	2:00	8:15	88
4	4:45	2:00	6:45	84
5[a]	6:15	3:15	9:30	70
6	5:00	2:00	7:00	85
7	6:45	2:00	8:45	84
8	3:00	1:30	4:30	91
9	3:00	2:00	5:00	83
10	4:00	2:00	6:00	82
11	3:30	2:00	5:30	85
12	3:45	2:00	5:45	80
13	3:30	2:45	6:15	83
14	5:30	3:00	8:30	78
15	3:15	1:45	5:00	74
16	2:45	3:00	5:45	70
Mean	4:12	2:15	6:27	82.0
S.D.	1:21	:30	1:31	6.2

[a]Student 5 did not pass the checkride in the UH-1 the first time it was administered. His performance was satisfactory on a subsequent recheck.

The aircraft checkride times and grades[1] are also listed in Table 2. One trainee (#5) failed to pass the inflight checkride on his first attempt. Unknown to test personnel at the time, this trainee's mother had died, and he was awaiting a flight home when he took the checkride. Upon returning from emergency leave, he was given one additional familiarization flight and then successfully completed the required checkride. This additional time is included in Table 2. It may also be noted in Table 1 that trainee #5 experienced unexpected difficulty with the final check in the 2B24 (his total time in the 2B24, including the repeat checkride, was less than the mean value for all students).

The total calendar time required for the conduct of the experimental training in the 2B24 and the familiarization flights and instrument checkrides in the aircraft for the trainees was seven to eight weeks, excluding the one individual whose recheck was delayed by emergency leave. The conventional schedule in effect at the time of the test programmed 12 weeks for the Instrument Phase of training.

Upon completion of the instrument checkride, students entered the Advanced Contact Phase of training with their instructors. This training was also conducted on a proficiency progression basis for the 2B24-trained students. The end-of-phase proficiency checkrides were conducted in accordance with procedures then in use at the Aviation School for that phase of training.

[1]The mean Instrument Phase checkride grade for students in the existing course was approximately 80.5, as opposed to the mean of 82.0 for the test subjects.

Since it was assumed that training in the 2B24 in normal and emergency procedures, as well as the aircraft control skills developed in the device, would be helpful to students in their Advanced Contact Phase training, it was anticipated tha the device-trained students would be able to complete their UH-1 transition training in somewhat less than the 25 hours normally required. Some flight time savings were achieved. (See Table 3.) However, the flight hours reported in Table 3 are inflated by a number of adminis' ative constraints and do not accurately reflect the savings that could result from a fully integrated instrument/contact flight training program.[1]

Table 3 shows the Advanced Contact Phase, or UH-1 transition training time, total time, and checkride grade.[2] The mean total contact training time of 20 hours, 11 minutes required by the 2B24-trained students compares with the 25 hours that was normally programmed for Aviation School trainees in this phase of the course.

Table 3

UH-1 Transition Training and Checkride Time Requirements and Checkride Grades of Device 2B24 Trainees

Student Number	Time to Contact Checkride	Checkride Time	Total Time	Checkride Grade
1	15:00	1:30	16:30	88
2	15:00	1:30	16:30	89
3	16:00	1:30	17:30	88
4	17:15	1:45	19:00	82
5	19:30	1:30	21:00	84
6	19:30	1:30	21:00	80
7	21:00	2:15	23:15	78
8	21:00	1:15	22:15	82
9	20:30	1:15	21:45	86
10	17:45	1:45	19:30	87
11	19:45	1:30	21:15	80
12	19:30	1:45	21:15	86
13	20:45	2:30	23:15	87
14	19:45	1:45	21:30	87
15	16:15	1:30	17:45	84
16	18:15	1:45	20:00	86
Mean	18:32	1:39	20:11	84.62
S.D.	2:05	:19	2:13	3.32

[1]The Aviation School required that all trainees receive a minimum of six hours of contact flight instruction prior to solo in the UH-1 helicopter. None of the approximately six hours of instrument flight time already accomplished in the UH-1 by each trainee participating in this study could be counted against this requirement. In addition, aircraft scheduling problems, stagefield non-availability, and inclement weather also served to inflate the time data.

[2]The mean Advanced Contact Phase checkride grade for students in the existing course was approximately 85.4 as opposed to the mean of 84.6 for the test subjects.

After their Advanced Contact Phase checkride, the 2B24-trained students were given an instrument recheck during their next flying period. These checkrides were administered by the same instrument examiners who had administered the earlier instrument checkrides to the same students. The purpose of the recheck was to generate data that could be used to compare the flight proficiency of 2B24 students with that of a comparable group of students who had completed the existing instrument training program (i.e., had received 60 hours training in the TH-13T and 26 hours in the 1-CA-1) and who were rechecked after the Advanced Contact phase.

The examiners conducting the checkrides reported that the 2B24-trained students, as a whole, performed as well as, or better than, the students in the control group. The examiners also reported that both groups displayed some loss of retention of instrument flight skills. The intervening period of contact training between the initial instrument checkrides and the rechecks may have contributed to this finding. However, the recheck was an upgraded flight as far as student records were concerned, and there was no reward or penalty associated with performance on it.

TRAINING-COSTS STUDY

The second Phase III activity was the collection and analysis of data relevant to the cost of conducting Army undergraduate pilot training utilizing Device 2B24 and the UH-1, versus using the TH-13T, the 1-CA-1, and the UH-1. The model used to compute training costs was that developed in earlier HumRRO research.[1]

The materials and services included in the cost comparison are shown in Table 4. Indirect costs associated with the conduct of training, such as costs of the administration of the U.S. Army Aviation Center (USAAVNC), the conduct of academic instruction, and trainee salaries and allowances, are not included.

The costs associated with the conduct of flight training in the TH-13T, the 1-CA-1, the UH-1, and the 2B24 are shown in Table 5. All data are based upon actual costs experienced by the U.S. Army Aviation School during October 1971, and the table presents a comparable cost-per-training-hour figure for each training vehicle. The figures presented for the TH-13T and the 1-CA-1 represent actual training hours flown and actual costs associated with Army undergraduate instrument training during October 1971. Figures presented for the UH-1 are

Table 4

Materials and Services Included In the Cost Comparisons

(1) Aircraft/Trainer
(2) Buildings and Facilities
    (a) Depreciation
    (b) Utilities
    (c) Janitorial Service
    (d) Maintenance
(3) Salaries: Training Personnel
(4) Contractor Fee
(5) Office Equipment
(6) Aircraft/Trainer Maintenance
    (a) Personnel
    (b) Maintenance Equipment
    (c) Spare Parts
(7) Trainee Transportation
    (a) Equipment Operation
    (b) Drivers' Wages
    (c) Equipment Depreciation
(8) Flight Clothing and Equipment
(9) Aircraft Petroleum, Oil and Lubricants
(10) Aircraft Refueling Services
(11) Navigation Facilities
    (a) Buildings
    (b) Equipment and Furnishings
    (c) Controllers
    (d) Transportation

[1] Oran B. Jolley and Paul W. Caro, Jr. *A Determination of Selected Costs of Flight and Synthetic Flight Training*, HumRRO Technical Report 70-6, April 1970.

projected figures, based upon data from the same time period. They represent an approximation of what training would have cost if undergraduate instrument training had been conducted in the UH-1 instead of in the TH-13T during that period.[1] As reflected in the table, many cost items for the TH-13T (e.g., buildings and facilities, training personnel) are assumed to be the same for the UH-1. Others, such as aircraft depreciation and aircraft maintenance, are UH-1 specific.

Table 5

Relative Flight Training Costs for Each Type Training Vehicle

Cost Item	Training Vehicle				
	TH-13T	1-CA-1	UH-1	2B24 Single Shift	2B24 Double Shift
1. Depreciation					
Aircraft/Trainer	$ 80,465.00	$ 7,623.76	$ 310,827.18	$ 170,301.00	$ 170,301.00
2. Buildings and Facilities					
Depreciation	10,314.12	451.40	10,314.12	1,872.43	1,872.43
Utilities	1,917.16	378.84	1,917.16	585.48	1,036.34
Janitorial services	748.95	300.68	748.95	202.50	202.50
Maintenance	2,712.28	220.55	2,712.28	589.62	589.62
3. Salaries: Training Personnel	369,406.15	44,751.99	369,406.15	105,025.39	204,120.04
4. Training Contractor Fee	3,550.17	619.28	3,550.17	N/A	N/A
5. Office Equipment	334.65	17.60	334.65	17.60	17.60
6. Aircraft/Trainer Maintenance					
Personnel	298,431.96	2,389.00	729,360.54	7,997.18	9,967.10
Maintenance Equipment	3,155.09	19.49	12,081.38	85.00	85.00
Spare Parts	225,731.41	132.46	1,108,248.06	12,080.00	24,160.00
7. Transportation		N/A		N/A	N/A
Equipment Operation	1,607.07		1,607.07		
Drivers' Wages	1,724.48		1,724.48		
Equipment Depreciation	114.57		114.57		
8. Flight Clothing and Equipment	3,982.23	N/A	3,982.23	N/A	N/A
9. Aircraft Petroleum, Oil Lubricants and Electricity	41,024.64	41.31	76,242.84	4,409.60	5,785.60
10. Aircraft Refueling Services	5,016.60	N/A	15,577.60	N/A	N/A
11. Navigation Facilities		N/A		N/A	N/A
Buildings	1,573.20		1,573.20		
Equipment and Furnishings	23,161.19		23,161.19		
Controllers	68,274.00		68,274.00		
Transportation	2,943.46		2,943.46		
Total	$1,146,188.38	$ 56,946.36	$2,744,701.28	$ 303,165.80	$ 418,197.23
Training Hours	10,899	5,164	10,899	5,120	10,240
Cost Per Training Hour	$ 105.16	$ 11.02	$ 251.83	$ 59.21	$ 40.83

[1] Subsequent to the test reported here, the U.S. Army Aviation Center has changed the program so that all inflight instrument training is given in the UH-1 aircraft.

The figures in Table 5 for Device 2B24 represent a projected monthly cost for eight of the devices, or 32 cockpits. These projections are based on the actual costs encountered in operating the one device during October 1971. They also reflect the material and servicesanticipated to be required for the operation of the 32-cockpit complex envisioned for the Aviation School by the SFTS QMR.[1]

The "Cost Per Training Hour" in Table 5 reflects the direct costs associated with providing one cockpit hour of flight instruction. As would be expected, double-shift operations with the 2B24 further reduce training costs. Many commercial airlines operate their simulators 24 hours a day, and the Aviation School is cognizant of the advantages of multiple-shift operation with Device 2B24.[2]

Tables 6 and 7 provide examples of the per-student savings which would accrue to the Aviation School if eight Device 2B24s were used (i.e., if they were used as in the study reported here) in place of the then-current training vehicles. Table 6 compares the cost of providing an undergraduate trainee with a Standard Instrument Rating in the existing program an, in a projected 2B24-based program. Also indicated in Table 6 is the projected costs of instrument training under the then-existing program if the UH-1 were substituted for the TH-13T. Substantial per-student savings would be realized through appropriate use of Device 2B24 in the instrument training program. The device's contribution to trainee proficiency during the Advanced Contact Phase of flight training appears to have enabled an additional reduction of approximately five hours of flight time. Table 7 illustrates the cost comparison between the present flight training program and one using the 2B24 in both the Instrument and Advanced Contact Phases.

It should be noted that the cost data cited relate to the operation of training vehicles and supporting personnel, facilities, and activities only. These figures do not take into account the savings which could result from a four-week reduction in the length of time trainees are in residence at the Aviation School or for the total elimination of an aircraft type (the TH-13T) from the Army inventory. Such cost savings would be in addition to the savings indicated in Tables 6 and 7.

Table 6

Existing and Projected Flight Training Costs for a Rotary Wing Standard Instrument Rating

Training Program	Training Vehicle		Program Hours		Program Cost Per Student
	Aircraft	Device	Aircraft	Device	
Existing undergraduate training	TH-13T	1-CA-1	60	26	$ 6,596.12
Projected undergraduate training	UH-1	2B24	6½	42½	$ 3,372.17[a]
Existing undergraduate training using UH-1 in place of TH-13T	UH-1	1-CA-1	60	26	$15,396.32

[a] Assumes double shift in 2B24.

[1] At the time of preparation of this report, six of the Device 2B24s (24 cockpits) had been delivered to Fort Rucker. Additional devices were scheduled for delivery to Army aviation field units.

[2] In early March 1975, the Aviation School was scheduling Device 2B24 training in two shifts (i.e., 15 hours of training) each training day.

Table 7

Existing and Projected Flight Training Costs for Instrument and Advanced Contact Phases of Training

Training Program	Program Hours and Vehicle	Cost
Existing undergraduate training	60 hours in TH-13T	$ 6,309.60
	26 hours in 1-CA-1	286.52
	25 hours in UH-1	6,075.50[a]
		$12,671.62
Projected undergraduate training	42½ hours in 2B24	$ 1,735.27[b]
	6½ hours in UH-1	1,636.89
	20 hours in UH-1	4,860.40[a]
		$ 8,232.56

[a]Since navigation facilities would not be required for the conduct of Advanced Contact Phase training the costs associated with those facilities in Table 5 (Item 9) are not included here. The UH-1 hourly operating costs for *contact* flight training thus are estimated to be approximately $243.02

[b]Assumes double shift in 2B24.

Student training inputs are, of course, subject to change with the needs of the Army; however, based on a projected annual input of approximately 1,500 trainees, utilization of the 2B24 in a manner similar to that described here could lead to an annual savings of at least $6,658,590.00 ($12,671.62 - $8,232.56 x 1,500) compared to the program that existed at the time of the Suitability Test. As can be seen, the per-student saving is $4,439.06. The reader can easily calculate total annual savings for any yearly graduate output figure. Utilizing this per-student savings figure, the total annual cost reduction (based upon October 1971 cost computation) during the peak output periods of the late 1960s (approximately 7,500 graduates per year) would have amounted to $33,292,950.00.

With respect to the costs of training, it should be noted that the data cited were developed for a particular purpose: To determine the relative costs of training to a fixed performance standard using several combinations of devices and training aircraft. This purpose dictated which cost information was relevant. These data should be interpreted with caution, since they may not be equally relevant to other training cost determinations. Further, the specific data cited are, in many instances, perishable. Fuel and personnel costs, for example, have undergone large changes between the development of the information and publication of this report.

Chapter 5

DISCUSSION

2B24 MISSION SUITABILITY

The Army has moved vigorously in recent years and has made great advances in the area of pilot training through simulation, perhaps the greatest of all the military services. It is anticipated that simulation will have an increasingly large and important role in the Army aviation training mission and in the maintenance of aviator operational readiness. The question is no longer whether simulation is feasible, the question is how to best design, procure, test, and utilize simulators. Therefore, in addition to describing the experiences encountered during the Suitability Test of Device 2B24, this report has sought to highlight the procedures employed in the testing of the device and the implications of test findings for the benefit of future training device programs.

The overall objective of the Mission Suitability Test was to determine whether Device 2B24 was capable of cost-effectively fulfilling the objectives of the SFTS QMR as set forth in Chapter 1. With respect to these objectives, the research staff reached the following conclusions:

(1) A high level of transfer of training to the UH-1 aircraft resulted from the combined use of the 2B24 and the training program developed for it, with a considerable saving in costly actual flight time.

(2) Although the value of emergency procedure training cannot be readily judged, it was the opinion of the test staff and participating instructor pilots that the malfunction effects in the device so accurately reflect those which might be experienced in the aircraft that they are very useful training aids.

(3) Device-trained students transitioned satisfactorily to the UH-1 aircraft, completing the Contact Phase of training in less time than that allocated for students receiving the regular course of instruction.

(4) Several device features were found to facilitate the evaluation of aviator proficiency. The monitoring and performance assessment capabilities of the device provided the instructor or the examiner with information he would not have available if he were performing this function in an actual aircraft. The Automatic Checkride feature, intended to facilitate aviator proficiency evaluation, was not fully functional during the test, but present indications are that this feature will make such evaluation easier and more objective.

(5) The cockpit monitoring capabilities of the 2B24 make it an excellent vehicle for Instructor Pilot training and standardization,[1] and can thus lead to greater standardization of student training. In addition, certain automatic features of the device, designed specifically to enhance the standardization of flight training, will facilitate this objective.

(6) Although further development is necessary in the quality control area, the 2B24 has the hardware design characteristics needed to meet its quality control purposes.

[1] Because of other cockpit monitoring features of the 2B24, this conclusion is not affected by the elimination (see p. 14) of the closed circuit TV cockpit monitoring capability of the prototype.

In the process of reaching these conclusions, some areas of concern important to future Army aviation training were identified. The Army aviation device procurement system made available to the Aviation School, in the 2B24, a device and a training program which have placed the School at the forefront in military undergraduate training. However, a number of lessons were learned which should be considered in the future in order to avoid problems similar to those encountered with the 2B24. The Army has committed itself to sizable capital investments in simulation for years to come, and a careful analysis of the difficulties experienced during 2B24 testing should be helpful in obtaining maximum benefit from those investments.

Since each of the Mission Suitability Test phases focused on different requirements, and each presented particular problems, the three phases will be considered in separate sections of this discussion.

PHASE I

Acceptance Testing Procedures

Perhaps the most important conclusion to be drawn from Phase I activities was the need to review the training device acceptance testing procedures which existed at the time. The 2B24 was accepted for the Army in accordance with acceptance testing practices and procedures which had been established for relatively simple training devices. Later, the discovery was made that the 2B24 would not function as a wholly integrated system within the situational context for which it was designed (i.e., simultaneous, but independent, operation of all four cockpits for purposes of training).

Had the acceptance test procedure been oriented around the use of this complex device as an integrated training system, in contrast solely to a determination of whether each subsystem—in relative isolation from all others—would function in accordance with engineering data, it is likely that some of the device's deficiencies would have been detected and corrected more quickly, and perhaps at less cost to the Army and the manfuacturer. It would have been desirable that such deficiencies be detected in-plant where the manufacturer's in-plant resources were more readily available than they were after the device was delivered to Fort Rucker.[1] For example, if the acceptance test procedures had included exercise of the off-line computer programs required for delivery with the 2B24, even if it were necessary to do so with hypothetical data, the absence of an edit program and the inadequacy of the quality-control data processing program might have been detected sooner.

Personnel involved in the acceptance and suitability testing of Device 2B24 learned a great deal from those experiences that has already been of benefit with respect to procurement of subsequent Army training devices. Largely in response to lessons learned by the Army and the manufacturer during acceptance and suitability testing of this device, the procedures involved in accepting subsequent models of Device 2B24 were modified, and further changes in acceptance testing criteria and procedures are planned for other devices currently in production.

[1] The U.S. Coast Guard benefited from some of the lessons learned during Phase I of this test. Working with the Coast Guard, HumRRO developed a plan of acceptance testing for the Variable Cockpit Training System (VCTS) simulators which that service recently procured for the H-3 and H-52 helicopters used for search and rescue missions. The test plan included the simulation of several representative training periods with the device. As a result of preparations made for that particular test activity by the manufacturer, and information generated during the test itself, the Coast Guard simulators presented only minor problems during their first full year of use.

Device Development Procedures

Device 2B24 was built by a manufacturer unfamiliar with Army training practices and training goals, in response to a set of specifications prepared by the procurement agency. These specifications documented the agency's understanding of the needs of the eventual user of the device user—principally the U.S. Army Aviation School. A number of the training features of the 2B24 had never before been incorporated into simulator design, so the specifications represented an attempt to describe device features that were innovative in nature. As a consequence, some of those features were not uniformly understood by all parties concerned, and communication of their intent was difficult. Both Aviation School and HumRRO personnel had provided assistance in the preparation of the specifications, but a degree of ambiguity apparently remained, since the device, when delivered, was not completely responsive to intended requirements.

Specific attempts were made to resolve such ambiguities. After a manufacturer was selected to build Device 2B24, design review conferences were held approximately quarterly between the manufacturer and personnel from the procurement agency, the Aviation School, HumRRO, and other interested Army groups. During these conferences, many differences in interpretation of individual specification requirements were identified and resolved, thus enabling the manufacturer to be more responsive to the Army's training requirements as reflected in the intent of the specifications.

During Phase I a number of device design deficiencies were noted that could only have resulted from misinterpretation or lack of clarity of the specifications, or from lack of understanding of the intended use of some of the device's advanced design features. Several of these were mentioned in Chapter 2: (a) the design of the performance playback feature made its routine use undesirable because of the time consumed in accessing it and (b) the design of the quality-control data processing program was based upon assumptions which rendered it unusable in the context of Army undergraduate training. During the development of new equipment and programs, it clearly must be the *user's* responsibility to identify areas of potential ambiguity or lack of understanding and to take the initiative, in interacting with the procuring agency, and through that agency with the manufacturer, to resolve such problems in timely fashion.

It is likely that these and other deficiencies of Device 2B24 would not have occurred had there been sufficient interaction between the manufacturer and the Army user representatives at the time the specifications were being interpreted by the manufacturer's engineering staff. The quarterly reviews that were held with the Army were helpful, but they were insufficient to provide the needed assistance to the manufacturer in interpreting the specifications.

Benefit from review conferences can be enhanced by ensuring that representatives of involved Army agencies attending such conferences are well-informed as to the purpose of the proposed device and of the state of the training and simulation arts related to it. Continuity of representation at these conferences can be very important, since an agency's representative must be well-informed concerning actions taken at preceding conferences if he is to be an effective representative.

The Army must ensure that its training device procurement procedures effectively provide for *continuing* and *appropriately informed* interaction between the manufacturer and the agencies involved in the initiation of the requirement for a particular device and the determination of its various features. In the case of Device 2B24, these agencies included the procurement agency, the Aviation School, the Combat Developments Command Aviation Agency, and HumRRO. An increase in such continuing interaction would probably have made a significant difference in the overall suitability of Device 2B24. More importantly, an increase in such interactions in the future will be beneficial as the Army procures other innovative training equipment.

Automated Training

It had been recognized prior to the beginning of the Mission Suitability Test that the 2B24 was still a system under development. Because of the innovative nature of the automated training and performance measurement features of the device—the fact that they had not before been implemented in a flight simulator—it was anticipated that they would not function optimally at the time of first use. It was expected that considerable time in the actual training context would be required to make necessary adjustments to the software programs that provide the automatic control of training. Thus, the finding that the initial training programs developed for the device could not include Automatic and Checkride Mode operations, although disappointing, cannot be accepted as *prima facie* evidence of the unworkability of the underlying concepts.

When it was discovered that such features did not work as well as had been intended, attention was directed to the software program structure and to the mechanics of implementation of the instructor functions. Detailed analysis of these programs suggests that the program structure is acceptable and that the operating programs will, in fact, permit at least a partial implementation of automatic training in the future. The chief limitation seems to be with respect to the data that the operating programs use in modeling and implementing the functions (items such as commands to move a stick to a certain position, to increase pitch to a certain value and at a given rate, and the like). While there are also problems with the general approach in some instances, the principal initial problems are in the data that the operating programs use to perform their functions. This is demonstrated by the fact that changes to the data base have been made for an automatic instrument take-off (ITO), and an improved ITO has been obtained.

Had the off-line edit capability been provided and fully functional during the testing period, a great many changes could have been easily made to the data base. This might have rendered some of the automatic training exercises usable during the Suitability Test. Those few changes that were made during the test required an expert programmer and were time-consuming and difficult to make.

The problem of data will remain with the 2B24 for some time, and the Army should consider the fact that effort must be devoted to further defining the data required. The forms in which it must be expressed to fully capitalize on the 2B24's capabilities must also be considered. Thus, additional development will be required before automatic training can be implemented. The expected benefits appear to be well worth the necessary effort.[1]

Additional effort will also be needed to develop a usable off-line quality-control system. Although less progress has been made to date toward debugging the quality-control system than for automatic training in general, it is the consensus of test personnel that Device 2B24 has the capability for quality-control data processing, but that a new computer program will have to be developed. The work remaining to be done in this area includes defining more precisely which data should be processed and how they should be processed.

Other Comments on Phase I

A great many adjustments and modifications were made to Device 2B24 during Phases I and II. As a result of these changes, the device was judged in the Aviation Test

[1] Based upon experiences with the 2B24, a different approach to the development of automatic training exercises and checkrides is being tested in future SFTS subsystems. The new approach will simplify the data requirements.

Board report[1] to be generally compliant with the requirements of the SFTS QMR and with the intents of the performance xspecifications. To be fully compliant, particularly with respect to the automatic training and performance measurement features of the device, a great deal of additional developmental work will be required.

Test personnel generally considered that representation of the performance and flying qualities of the UH-1H aircraft in Device 2B24 were excellent. The fact that its characteristics do promote high transfer of training was established during the Phase III activities.

PHASE II

It was noted in Chapter 3 that the training program developed during Phase II was an advanced adaptation of a fixed wing program previously developed and tested by HumRRO.[2] In the fixed wing program, a relatively low-fidelity, generalized instrument trainer was used in the Instrument Phase of the Army's fixed wing undergraduate pilot training program. Initially, it was used with an adaptation of an existing training program, and modest gains in trainee performance in the aircraft were obtained. When the device was used in conjunction with a training program developed for it, major gains in trainee performance were obtained. Specifically, use of the device with the new program resulted in a 40% reduction in the number of flight hours required to attain the phase objectives.

The Suitability Test training program yielded significantly better transfer-of-training results than did the earlier fixed wing training program for two reasons: (a) the device involved in the Suitability Test provided more extensive simulation of the training aircraft and contained a number of features designed specifically to enhance its training value and (b) the knowledge gained during the fixed wing research was applied during Phase II to design a training program that made better use of training technology.

Had it not been for the fact that the Suitability Test training program was based upon training features and techniques that already had been proved effective in an Army-undergraduate pilot-training setting, it may not have been possible to produce an effective program for the 2B24 in the limited time that was available for this activity. Because of the previous work, however, it was possible to build a training program around workable features of Device 2B24, to train the assigned instructors in its administration, and to initiate Phase III activities on schedule with a high degree of confidence that valid test results would be obtained.

Training during the Suitability Test was conducted on an individualized basis, with the amount of training received by each trainee being determined by the amount required for him to attain stated performance goals. It is perhaps easier to manage an individualized, proficiency-progression training program for only 16 trainees than it would be for classes many times that size. It is possibly for this reason that individualized training is the exception rather than the rule in all military pilot-training programs. The cost benefits of individualized training, however, would appear to justify the effort required. Had all of the Suitability Test trainees been given the approximately 47 hours required by the slower trainees, the savings realized would have been significantly less than that obtained. The Army needs the benefits of early graduation of the more able students, particularly in a flight training program as expensive as the one under study.

An interesting aspect of the Phase II training program was the manner in which trainees acquired needed information about the UH-1 aircraft and its various systems. It will be recalled that the existing course provided UH-1 transition training, including UH-1

[1] Smith and Sasser, *op. cit.*

[2] Caro, Isley, and Jolley, *op. cit.*

ground school, following instrument training in the TH-13T. Consequently, none of the test subjects received formal ground school instruction in the UH-1 prior to learning to fly the UH-1 simulator (i.e., Device 2B24), nor did they receive such instruction prior to beginning to fly the UH-1 aircraft during their Instrument Phase training. Instead, it was the responsibility of the participating instructor pilots to provide such information as was needed to support their cockpit instruction.

The instructors provided the required information within the context of a specific need for it during a simulated flight in the 2B24. This occurred typically at a time and within a context that permitted the information to be applied immediately. The instructors thus were able to provide the needed information in conjunction with their other instructional duties without apparent additional effort. Before the trainees completed the Advanced Contact Phase of their training, they did attend ground school classes, where they received formal instruction in UH-1 specific subject matter by qualified classroom instructors, but a number of them reported on their course critique sheets that the additional ground school was superflous, since they already possessed most of the information disseminated there.

Because of this experience during the Suitability Test, the HumRRO staff developed a training program, for use with the previously mentioned Coast Guard helicopter simulators, which omitted formal ground school classes. Coast Guard instructor pilots, instructing in their devices very much in the manner described in this report, provide their students with relevant and required aircraft systems information within the context of the tasks these students perform during simulator training. The Coast Guard program has been both successful and well-received by instructors and students, and significant savings have resulted from the elimination of classroom instruction for these students.[1]

The present Suitability Test did not address gains in performance or cost reductions that could result from elimination of classroom instruction through adoption of a similar instructional model in Army undergraduate pilot training. It would appear, however, that such savings might be worth exploration. At a minimum, this particular instructional model would facilitate individualized instruction which permits students to progress at their own rates. Conducting instruction in the cockpit instead of in the classroom would greatly reduce the problems associated with making timely the instruction provided through different and difficult-to-coordinate training media (such as aircraft, simulation, and classrooms).

The program developed in Phase II cannot be considered as being optimal for Device 2B24. Even without any substantive changes, further Army experience in the administration of the program can doubtless lead to increased effectiveness in its administration. Better standardization of instructors, for example, might reduce the range of training time required for course completion, thus facilitating the scheduling of both personnel and equipment. More substantive changes (such as the incorporation of automatic training exercises) could lead to other benefits, possibly even to a reduction in the number of instructional personnel required. Program changes based upon advances in the technology of training and further modification of some of the features of the 2B24 could lead to greater transfer-of-training and cost benefits. Even with the device deficiencies identified during Phase II, modification of the present training program to include greater emphasis upon the transfer of skills to the visual flight environment would be likely to yield more cost-effective training.

Possibly the most important activity during Phase II was the training of the participating instructor pilots in the administration of the newly developed training programs. In retrospect, it is concluded that additional effort should have been planned

[1] Robert N. Isley, Winon E. Corley, and Paul W. Caro. *The Development of U.S. Coast Guard Aviation Synthetic Training Equipment and Training Programs*, HumRRO Final Report FR-D6-74-4, October 1974.

for this task. Some of the traditions associated with flight training—such as lock-step instruction and extensive overtraining for the more apt students—were difficult to overcome in such a short instructor training period. If a program such as that used during the Suitability Test is to be successful, it must be assured that the instructors are able to apply properly the instructional techniques involved *and* are favorably disposed toward those techniques. More extensive preparations of the instructors who participated in the Suitability Test would probably have reduced the need for monitoring and debriefing those instructors during Phase III and might also have led to reduction in both simulator and aircraft training time.

PHASE III

The device training conducted during the Suitability Test was cost-effective. The aircraft time in the Instrument Phase alone was approximately 6 1/2 hours for the test group versus 60 hours for the conventionally trained students. The total aircraft and device time also was less, approximately 49 hours for the test group (including two checkrides) versus 86 programmed hours for the conventional trainees. Further, calendar time in the Instrument Phase was only 8 weeks versus 12 weeks for the conventional program. A decrease in flight time during the Advanced Contact Phase represented additional cost savings.

The fact that training in Device 2B24 transfers to the aircraft is not surprising since the device is a high-fidelity simulator of the training aircraft. The major commercial airlines experiences in transitioning pilots to large jet transport aircraft have shown that such high-fidelity simulators can provide effective training, thereby reducing the reliance upon aircraft for training.

It has been proposed that the airlines have been able to use simulators effectively only because their pilots are quite skillful and experienced before they enter transition training programs; the commercial pilots, thus, must only learn in a transition program how to operate another aircraft, often of the same general type they have been flying for many years. That proposition would imply the training of the military undergraduate aviator must be conducted in the air because he is not well-qualified and has not yet acquired the "air sense" that characterizes more experienced pilots. However, the Suitability Test provides evidence that simulators *can* be used effectively with undergraduate Army trainees.

Certainly, the extensive simulation of the training aircraft and the unique design-for-training features of the 2B24 contributed to the transfer of training. However, the manner in which the device was used contributed to these results perhaps as much as the equipment itself. Undoubtedly, had any pre-existing synthetic training program been used, much of the potential effectiveness of Device 2B24 would have been lost. The freedom to innovate provided by the Army in this program was a significant factor in allowing the development of new ways of utilizing devices, a factor critical to the program's success. As noted earlier, an appropriately designed training device can make transfer of training possible, but device design alone does not assure effective training.

Student training was conducted on a proficiency basis, and the amount of time required by each trainee to reach the required performance criteria in both the 2B24 and the aircraft varied considerably. Thus, the range of times reported in Tables 1 and 2 of Chapter 4 reflects the times required to bring all students to essentially the same skill level. The product moment correlation coefficient between training time in the device and device checkride grade is +.04, and the corresponding correlation between familiarization time in the aircraft and aircraft checkride grade is - .09. Since these correlations are not significantly different from zero, and are, in fact, essentially zero, they tend to confirm the fact that the trainees receiving the most training time needed that time to attain the required proficiency, rather than to attain higher-than-required proficiency.

A large part of the range in times required to reach criteria probably should be attributed to differences in the instructing skills of the participating IPs. Some of them were more proficient in their administration of the training program developed for this test than were others. It is believed that more efficiency can be obtained in subsequent administration of Device 2B24 training through instructor training. This should lead to reductions in the amount of training time required by students of the less proficient IPs to reach stated criterion performance levels.

POSTSCRIPT

There is an understandable tendency on the part of all large organizations—and the Army is no exception—to proceed cautiously with respect to introducing major changes in established practices. The replacement of a major portion of the aircraft time devoted to the instrument training of undergraduate pilots would constitute a very major change in an established Army practice. The possibility of a reduction in aircraft training time of the magnitude described in these results was beyond the pre-Suitability Test expectations of most Army aviation personnel. Even if there had been sufficient numbers of Device 2B24s available to replace the existing training program with that developed for the 2B24, it is unlikely that the Army would have elected to do so without further verification of the generality of the results. Fortunately, an opportunity to verify the Suitability Test findings was soon available.

At approximately the time of the Suitability Test, the Army was conducting a series of tests of the feasibility of replacing the Primary Phase training aircraft, the TH-55, with a turbine-powered aircraft, the OH-58. These activities were known as the Turbine Trainer Tests.[1] In the second of the Turbine Trainer Tests, the Instrument Phase consisted of a replication of the Device 2B24 Suitability Test, using the 2B24 and the UH-1 as the training vehicles. Because of fortuitous timing following completion of the Suitability Test, two of the instructor pilots who had participated in the Suitability Test also participated in the second Turbine Trainer Test and trained the other participating instructors in the training techniques described in Chapter 3.

The Turbine Trainer Test was conducted by the Aviation School without HumRRO participation, except that HumRRO technical assistance was provided during test planning activities. Thus, the test provided an opportunity for the Army to verify the results of the earlier Suitability Test without outside assistance but with two of the instructional personnel who had participated in the development and use of the HumRRO training program.

The conditions of the Turbine Trainer Test were essentially the same as those described for the Suitability Test. There were two exceptions: the Turbine Trainer Test students had undergone Primary Phase training on a proficiency basis in a turbine aircraft, the OH-58, rather than the then-existing Primary Phase training in the TH-55; and the performance criteria associated with completing training in Device 2B24 before going to the aircraft were not as rigidly enforced (i.e., checkrides in the device were not administered by instrument examiners). The training program developed for the Suitability Test, including its use of proficiency advancement techniques and the

[1] U.S. Army Aviation School. Letter to United States Continental Army Command, Subject: Turbine Trainer Test (Phase II), dated 19 December 1972.

instructor-manager concept, was employed in the Turbine Trainer Test. Sixteen officer and warrant officer students participated in this test. One was grounded for medical reasons early in the test and was subsequently medically eliminated from flight training.[1]

The 15 Turbine Trainer Test subjects completed training in Device 2B24 in an average of 36 hours, 24 minutes (range 29 hours, 12 minutes to 43 hours, 12 minutes), or approximately 6 hours, 26 minutes sooner than had the students participating in the Suitability Test. In the aircraft, these students required more time to pass the checkride administered by the instrument examiner. They required an average of 13 hours (range 7 hours to 29 hours, 24 minutes), while the Suitability Test subjects required 6 hours, 23 minutes less. On the basis of this comparison, it appears that the Turbine Trainer Test students might have benefited from additional time in the 2B24 before going to the aircraft.

The differences in training time between these two tests are relatively minor and possibly reflect variations among student and instructor groups that can be expected to occur in the future if both device and aircraft times are allowed to vary. Of more interest is the observation that the total time of 49 hours, 24 minutes (36 hours, 24 minutes in the device plus 13 hours in the aircraft) required by the Turbine Trainer Test group was almost identical with the time of 49 hours, 17 minutes (42 hours, 50 minutes in the device plus 6 hours, 27 minutes in the aircraft) required by the Suitability Test group. It appears that a total time of about 50 hours is required for attainment of Instrument Phase objectives. Further, it appears that perhaps as much as 40 hours of that time can be accomplished in Device 2B24, leaving approximately 10 hours of UH-1 familiarization to be accomplished in the aircraft. Because of the apparent hour-for-hour tradeoff of time between these two training vehicles, the exact ratio of device to aircraft time can vary, at least around the times observed in these two tests, without sacrificing student proficiency. There would be a cost benefit, however, of conducting greater amounts of training in the device instead of in the aircraft.

[1] The trainees involved in the Turbine Trainer Test included warrant officer candidates, whereas the trainees who participated in the Mission Suitability Test were all officers.

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Appendix A

SUITABILITY TEST ARMY PARTICIPANTS

The U.S. Army and Department of the Army civilian personnel who participated in the Device 2B24 Suitability Test and the dates of their participation are listed below.

U. S. Army Aviation Test Board

Name	Rank	Dates of Participation
Expanded Service Test Project Officers		
Smith, Luther	MAJ	5 Apr 71 - 5 Mar 72
Sasser, Willie H.	CW3	5 Apr 71 - 5 Mar 72
Instrument Examiner		
Quisenberry, H. L.	LTC	8 Nov 71 - 12 Nov 71

U. S. Army Aviation School

Name	Rank	Dates of Participation
Project Officers		
Miller, Edward J.	MAJ	5 Apr 71 - 5 Mar 72
Cunningham, Adrian D.	DAC	5 Apr 71 - 5 Mar 72
Instructor Pilots		
Davis, Clarence	CPT	5 Apr 71 - 5 Mar 72
Rehn, Richard	CW3	6 Sep 71 - 5 Mar 72
Moon, D. W.	CW2	5 Apr 71 - 5 Mar 72
Nesselroade, Robert	CW2	6 Sep 71 - 22 Dec 72
Voisine, A. E.	CW2	6 Sep 71 - 10 Dec 71
Cooper, Al	DAC	5 Apr 71 - 5 Mar 72
Hickman, Don	DAC	6 Sep 71 - 22 Dec 72
McGuire, Everett	DAC	6 Sep 71 - 22 Dec 72
Ridgeway, Paul	DAC	6 Sep 71 - 22 Dec 72
Instrument Examiners		
Piety, Richard L.	CW4	8 Nov 71 - 20 Jan 72
York, John	CW4	8 Nov 71 - 20 Jan 72
Dvorak, Donald W.	DAC	8 Nov 71 - 20 Jan 72
Ketchum, Clark	DAC	8 Nov 71 - 20 Jan 72
Witt, Larry R.	DAC	8 Nov 71 - 20 Jan 72

Name	Rank	Dates of Participation
Console Operators		
Hall, Luther	E7	5 Apr 71 - 5 Mar 72
Enfinger, Robert	E6	5 Mar 71 - 5 Apr 71
Whitlock, Robert	E6	5 Apr 71 - 5 Mar 72
Ewell, Eddie	DAC	5 Mar 71 - 5 Mar 72
Programmer		
Stephenson, Mike	DAC	5 May 71 - 5 Mar 72
Mathematician		
Harwell, William	DAC	5 Apr 71 - 5 Mar 72
Supply		
Ingram, Floyd	E6	Apr 71 - Mar 72
Cobia, Roger	SP4	Apr 71 - Mar 72
Test Subjects		
Campbell, Michael H.	CPT	20 Sep 71 - 22 Dec 72
Wallace, Don W.	CPT	20 Sep 71 - 22 Dec 72
Thiel, Brian P.	1LT	20 Sep 71 - 22 Dec 72
Thole, Alexander	1LT	20 Sep 71 - 22 Dec 72
Albert, Wayne J.	2LT	20 Sep 71 - 22 Dec 72
Coolidge, Douglas E.	2LT	20 Sep 71 - 22 Dec 72
Eaton, Clark J.	2LT	20 Sep 71 - 22 Dec 72
Foster, William B.	2LT	20 Sep 71 - 22 Dec 72
Goodwin, Chester	2LT	20 Sep 71 - 22 Dec 72
Krause, Michael D.	2LT	20 Sep 71 - 22 Dec 72
Luck, Lee E.	2LT	20 Sep 71 - 22 Dec 72
Miller, Barry W.	2LT	20 Sep 71 - 22 Dec 72
Ray, Gregory L.	2LT	20 Sep 71 - 22 Dec 72
Ristow, Larry W.	2LT	20 Sep 71 - 22 Dec 72
Shallcross, Richard A.	2LT	20 Sep 71 - 22 Dec 72
Williams, Thomas H.	2LT	20 Sep 71 - 22 Dec 72

Appendix B

COURSE OUTLINE FOR UH-1 INSTRUMENT AND TRANSITION TRAINING

A. Activity/Maneuver to be Performed in the 2B24:

1. 2B24 Orientation
    a. Starting
    b. Shutdown
    c. Standard Operating Procedures
2. Execute cockpit procedures using checklist
    a. Interior check
    b. Before starting engine
    c. Starting engine
    d. Engine run-up
    e. Prior to instrument take-off
    f. Before take-off
3. Instrument take-off
    a. Demonstrate and discuss
    b. Practice using MPRF
    c. Additional practice if required
4. Climb (straight)
    a. Demonstrate and discuss
    b. Practice using MPRF
    c. Additional practice if required
5. Level off
    a. Demonstrate and discuss
    b. Practice using MPRF
    c. Additional practice if required
6. Straight and level flight
    a. Demonstrate and discuss
    b. Practice using MPRF
    c. Additional practice if required
7. 90° level turn
    a. Demonstrate and discuss
    b. Practice using MPRF
    c. Additional practice if required
8. GCA
    a. Demonstrate and discuss
    b. Practice using MPRF
    c. Additional practice if required
9. Before-landing check
10. Engine shutdown and aircraft security
11. VOR/RMI
    a. Tuning radios, orientation, and track interception
        (1) Demonstrate and discuss
        (2) Practice using MPRF
        (3) Additional practice if required

b. Track bracketing and following
   (1) Demonstrate and discuss
   (2) Practice using MPRF
   (3) Additional practice if required
c. Accelerations and decelerations (90 kts to 100, 100 to 70 kts, 70 to 90 kts)
   (1) Demonstrate and discuss
   (2) Practice using MPRF
   (3) Additional practice if required
d. Station passage and changing track
e. Changing altitude—(climb 80 kts, 500 FPM)
   (1) Demonstrate and discuss
   (2) Practice using MPRF
   (3) Additional practice if required
f. Changing altitude—(descend 90 kts, 500 FPM)
   (1) Demonstrate and discuss
   (2) Practice using MPRF
   (3) Additional practice if required
g. Holding at station
   (1) Demonstrate and discuss
   (2) Practice
h. Holding at VOR intersection
   (1) Demonstrate and discuss
   (2) Practice
i. Changing altitude and heading (climbing turns)
   (1) Demonstrate and discuss
   (2) Practice using MPRF
   (3) Additional practice if required
j. Changing altitude and heading (descending turns)
   (1) Demonstrate and discuss
   (2) Practice using MPRF
   (3) Additional practice if required
k. VOR approach and missed approach
   (1) Demonstrate and discuss
   (2) Practice

12. Recovery from unusual attitudes (partial panel)
   a. Steep climbing turns
      (1) Demonstrate and discuss
      (2) Practice using MPRF
      (3) Additional practice if required
   b. Steep descending turns
      (1) Demonstrate and discuss
      (2) Practice using MPRF
      (3) Additional practice if required
13. Engine failure during flight (instrument autorotation)
   a. Demonstrate and discuss
   b. Practice using MPRF
   c. Additional practice if required
14. Engine restart during flight
   a. Demonstrate and discuss
   b. Practice using MPRF
   c. Additional practice if required

15. Standard instrument departures
    a. Demonstrate and discuss
    b. Practice
16. Flight planning
17. ARTC enroute procedures
18. Lost radio communication procedures
19. DF steer
20. Emergency flight panel
    a. Demonstrate and discuss
    b. Practice
21. ADF/RMI
    a. Tuning radio, orientation, and track interception
        (1) Demonstrate and discuss
        (2) Practice
    b. Track bracketing and following
        (1) Demonstrate and discuss
        (2) Practice
    c. Station passage and changing track
    d. Holding at station
        (1) Demonstrate and discuss
        (2) Practice
    e. Holding at VOR/ADF intersection
        (1) Demonstrate and discuss
        (2) Practice
    f. Holding at ADF intersection
        (1) Demonstrate and discuss
        (2) Practice
    g. ADF approach and missed approach
        (1) Demonstrate and discuss
22. ILS
    a. Tuning radio, and transition
        (1) Demonstrate and discuss
        (2) Practice using MPRF
        (3) Additional practice if required
    b. Holding at the outer marker
        (1) Demonstrate and discuss
        (2) Practice using MPRF
        (3) Additional practice if required
    c. Track bracketing and following
        (1) Demonstrate and discuss
        (2) Practice using MPRF
        (3) Additional practice if required
    d. ILS approach and missed approach
        (1) Demonstrate and discuss
        (2) Practice using MPRF
        (3) Additional practice if required
23. Engine fire in flight
    a. Demonstrate and discuss
    b. Practice using MPRF
    c. Additional practice if required

24. Fuel boost pump failure
    a. Demonstrate and discuss
    b. Practice using MPRF
    c. Additional practice if required
25. Instrument cross-country
    a. VOR
        (1) Demonstrate and discuss
        (2) Practice using MPRF
        (3) Additional practice if required
    b. ADF
        (1) Demonstrate and discuss
        (2) Practice using MPRF
        (3) Additional practice if required
26. Governor failure (high side)
    a. Demonstrate and discuss
    b. Practice using MPRF
    c. Additional practice if required
27. Governor failure (low side)
    a. Demonstrate and discuss
    b. Practice using MPRF
    c. Additional practice if required
28. Hydraulic power failure
    a. Demonstrate and discuss
    b. Practice using MPRF
    c. Additional practice if required
29. Instrument and indicator failures, engine/transmission failures, in-flight malfunctions, electrical system malfunctions
    a. Demonstrate as appropriate
    b. Additional practice if required
30. Circuit breakers for instruments and indicators, navigation and communication radios, illumination and miscellaneous
    a. Demonstrate as appropriate
    b. Additional practice if required
31. Progress check
32. Review and additional practice
33. Instrument checkride

B. Activity/Maneuver to be Performed in the UH-1 Helicopter:
1. Preflight inspection
2. Execute cockpit procedures using checklist
    a. Interior check
    b. Before starting engine
    c. Starting engine
    d. Engine run-up
    e. Prior to instrument take-off
    f. Before take-off
3. Two cross-country IFR flights to include practice of all appropriate normal and emergency procedures previously learned in the 2B24.
4. Instrument checkride
5. VFR maneuvers (pre-solo)
    a. Radio procedures (VFR)
    b. Traffic patterns
    c. Local area orientation

d. Hazards to low level flight
e. Hovering flight
f. Normal take-off
g. Normal climb
h. Normal descent
i. Normal approach
j. Decelerations
k. Steep turns
l. Forced landing procedures
m. Flight with max gross loads
n. Hovering autorotations
o. Standard autorotations
p. Servo off operations
q. Max performance take-off
r. Steep approach

*6. Pre-solo checkride

7. Solo practice of maneuvers designated by the instructor

8. Advanced contact
   a. Autorotation low level
   b. Autorotation sod touchdown
   c. Slope operation
   d. Night flight
      (1) Hovering flight
      (2) Take-off and landing
      (3) Autorotations
      (4) Forced landings
      (5) Parking procedures and use of lights
      (6) Use of instruments as an aid to night flying
      (7) Use of lights
   e. Confined area operations
      (1) High and low ground reconnaissance
      (2) Flight with max gross loads
      (3) Pinnacle operations
      (4) Ridgeline operations

9. Advance checkride

10. Instrument recheck

*Student pilots must satisfy the pre-solo checkpilot that they are safe in the following maneuvers/procedures prior to release for

1. Be familiar with Emergency Procedures as listed in -10
2. Cockpit procedures
3. Airwork
4. Forced landings
5. Standard autorotations
6. Hovering autorotations
7. Hovering flight
8. Normal take-off
9. Normal approach
10. Servo off operations

Appendix C

MANEUVER PERFORMANCE RECORD FORMS

Two Maneuver Performance Record Forms (MPRFs) are illustrated in this appendix. The MPRFs are for an Instrument Take-Off (ITO) maneuver and an Instrument Landing System (ILS) approach.

INSTRUMENT TAKE-OFF

Student ______________________ Sheet No. ____

Date					
Light on skids					
Power increase 5 lbs. (±1 lb.)					
Heading (±10°)					
Attitude level (±½ bar)					
Established positive climb (Altimeter moving clockwise)					
Attitude: 1 bar low (−0, +1 bar)					
No assistance required					
Heading to 200′ (±10°)					
INITIAL CLIMB (STRAIGHT) 2000′ AFTER 80 KTS ESTABLISHED					
Attitude: 80 kts (±10 kts)					
Power 500 FPM (±100FPM)					
Heading (±10°)					
Trim proper (±½ ball)					
Errors					

Total prior time: 1st trial ☐ Criteria reached ☐

Page 1

ILS

Student ______________________________ Sheet No.______

Date					
TRANSITION					
Tune radios and identify sta.					
Track (VOR ±5°) (ADF ±5°) Radar vector (±10°)					
Altitude (±100′)					
OUTER MARKER OR INITIAL APPROACH FIX					
Turn					
Report					
Altitude (±100′)					
HOLDING					
Entry					
Report					
Heading outbound (±10°)					
Track inbound (±1°)					
Timing					
Altitude (±100′)					
PROCEDURE TURN					
Pre-landing check completed					
Timing					
Procedure turn altitude					

067

ILS

TRACKING INBOUND					
Rolled out on course					
Track (±1°)					
Altitude (±100′)					
OUTER MARKER INBOUND					
Intercept altitude (±100′)					
Report					
Airspeed 90 kts (±10 kts)					
APPROACH					
Localizer (±1°)					
Glideslope (in the doughnut)					
Min. altitude (−0, +100′)					
MISSED APPROACH					
Time/DH					
Power as required					
Report					
Prescribed procedures					
Errors					

Total prior time: 1st trial ☐ Criteria reached ☐

Appendix D

REFERENCE MATERIAL STUDY GUIDE

Following is a list of the programmed texts applicable to the instrument flight activity/maneuver the student will perform in the 2B24. They are listed in the sequence in which they should be completed by the student.

Programmed Texts	Subject	Additional References
PT 100	Flight Instruments	TM 1-215
PT 101	Basic Instruments, R/W, Part I	
PT 102	Basic Instruments, R/W, Part II	
PT 103	Introduction to Instrument Flight	
PT 104	Radio Navigation	
PT 115	Introduction to RMI	TM 1-225, Ch. 12
PT 113	Introduction to ADF and VOR	TM 1-225, Ch. 10, 11
PT 122	VOR Tracking	
PT 119	VOR Airways	TM 1-225, Ch. 13, 14
PT 7	VOR Enroute	
PT 126	Holding	
PT 109	Airport Surveillance Radar	TM 1-225, Ch. 16
PT 112	Precision Approach Radar	
PT 147	Transponder	
PT 118	ADF Orientation and Tracking	
PT 131	ILS	TM 1-225, Ch. 15
PT 133	ILS Procedures	
PT 121	Approach Procedures	
PT 152	Holding Procedures	
PT 150	Instrument Autorotations	
PT 110	Regulations	
PT 151	Controlled Airspace	
PT 16	DoD FLIP	
PT 105	IFR Shorthand	
PT 114	DD 175 and DA 2283	
PT 129	FAA Form 7233-1	DoD FLIP
PT 116	Required Reports	
PT 127	NOTAM	
PT 135	Gyrocompass Failure	TM 1-225, App. III
PT 137	Communications Failure	DoD FLIP

(Continued)

Programmed Texts	Subject	Additional References
PT 138	Partial Panel	
PT 145	Altimeter Errors	
PT 13	Navigational Computer	
PT 70	Teletype Reports	
PT 139	Pressure and Winds	
PT 140	Clouds	
PT 141	Air Masses	
PT 142	Fronts	
PT 143	Station Models	
PT 144	Weather Maps	
PT 146	Hazards to Flight	
PT 108	Winds Aloft	
PT 106	VFR Review	
PT 148	Instrument Preflight	