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ARMY TRAINING SIMULATOR RESEARCH, DEVELOPMENT AND PROCUREMENT:
FY 1976-1980 PROJECTS AND FUNDING SUMMARIES

Paul W. Caro
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Prepared for:

U. S. Army Training Device Agency
Orlando, Florida

June, 1974

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Final Report

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Human Resources Research Organization
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FOREWORD

This report summarizes work performed by HumRRO Division No. 6 (Aviation) under USNTEC Contract No. N61339-74-C-0133. The effort was sponsored by the U. S. Army Training Device Agency (USATDA) and is responsive to the needs of that agency and Department of the Army for a budget planning guide for Army aviation simulator research and procurement programs.

In developing the information for this report, it was necessary to rely on inputs from a substantial number of military and civilian agencies and personnel. The research team appreciates the excellent support and cooperation supplied by these sources. They are listed in the report. The authors would like to express special appreciation for the assistance provided by the contract technical monitor, Mr. Paul S. Walker, USATDA.

As is noted in the report, the general objective was to provide the Army with a considered basis on which budget programs for the FY 1976-1980 time period could be developed for simulator research and procurement programs. This report does not constitute a complete "Army plan for simulation," but it does provide a sound basis for the development of such a plan. The need for such a plan to govern the sizeable budget programs that would be necessitated by the increasing use of flight simulation in Army training is obvious. It should be noted that an adequate Army plan must contain a mechanism for updating itself over time due to changes that inevitably will occur in Army programs and in procurement costs. Therefore, the funding estimates contained in this report must be viewed as time bound to the situation as it exists in mid-1974.

The technical personnel involved in this effort are listed as authors of the report. Dr. Paul W. Caro was responsible for technical direction.

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SECTION I

INTRODUCTION

BACKGROUND AND SCOPE

Over the past decade simulation has increased in importance as a principal means of achieving Army aviation training goals. Recent developments such as the energy shortage and public concern over the environment have served to increase the already strong emphasis on simulation as an efficient and cost-effective means of improving training. It is likely that this emphasis will continue to increase. It is no longer a question as to whether Army aviation needs simulators in its aircrew training programs, or whether simulation can be afforded. It is generally accepted that simulation is a cost-effective approach to flight training, often the only feasible approach for some training requirements. Thus, the salient questions for Army aviation planners are *how much* and *what kind* of simulation is required and *when* must the requirement be met.

The Army has made significant and impressive advances in its flight simulation capabilities despite the fact that a formal DA-approved plan to govern training simulator research and procurement programs has not existed. The only sustained programs of research on Army aviation training simulator design and simulation training programs, with continuity over time, have been that supported by the U. S. Army Training Device Agency at the U. S. Naval Training Equipment Center and that conducted by HumRRO Division No. 6 for the Office of the Chief of Research and Development, DA. However, those programs

have necessarily been limited in scope and did not cover requirements for flight simulation on an Army-wide, long-range basis, nor did they address simulation research, procurement, and management considerations.

Lacking a comprehensive, DA-approved program, the Army has developed a number of reactive, ad hoc flight training simulation projects. One of these, the SFTS (Synthetic Flight Training System), has been effective and has produced significant advances of which the Army can justifiably be proud. Development of the SFTS has been governed by the DA-approved SFTS Training Device Requirement (TDR) and the SFTS Development Plan, and the success of the SFTS must be attributed in part to the existence of these documents. However, they are not sufficiently comprehensive to be considered as "the Army aviation simulation plan," since they address only procurement of SFTS subsystems, and not the management of simulators or research and funding related to future training requirements.

It is becoming increasingly important that there be an Army simulator plan. Two principal reasons are immediately apparent. First, the fiscal resources required in Army aviation simulation are changing from insignificant sums to major, highly visible budget items. Second, the Army is approaching the limits of implementation of existing simulation and training technologies and must place in motion major research initiative programs if Army aviation training and simulation problems are to be solved in effective, efficient, and timely fashion.

The immediate impetus for the present study was the need for information not available from the SFTS Development Plan, information on the basis of which budget programs for the FY 1976-1980 time period could be

established. Of particular concern was the initiation of budget programs for simulators to support training associated with major aircraft systems planned for future procurement, i.e., Utility Tactical Transport Aircraft System (UTTAS), Advanced Attack Helicopter (AAH), Heavy Lift Helicopter (HLH), and Aerial Scout Helicopter (ASH). Of additional concern was the identification of funding requirements associated with research and advanced development projects which, if conducted by the Army, would enhance the effectiveness of both present and future simulator training programs.

The Army recognizes the need for development of a comprehensive simulation management plan to guide future actions in this area. Establishment of the Project Management Office for Training Devices (P.M. TRADE) at Fort Benning is one evidence of this concern. Initiation of the present study by Department of the Army and the Army Training Device Agency provides further evidence. However, it should be recognized that the present study is not intended to produce a comprehensive simulation management plan. This report should be viewed as an interim plan which can provide a basis for short-range budget planning and for the initiation of certain high-priority simulation projects.

It should be noted that this report addresses only a portion of the Army's needs related to simulation. It concentrates on rotary wing training requirements and does not address requirements such as are understood to have been identified by the Army Security Agency for devices to support certain of its U-21 pilot training requirements.

Additionally, it does not address rotary wing simulation requirements unrelated to training, such as are understood to have been identified by the Army Missile Command for a UH-1 cockpit addition to the MICOM Advanced Simulation Facility. The scope of this report is limited to rotary wing training requirements of the present and foreseeable future.

REPORT ORGANIZATION

This report is divided into four sections. In addition to the introductory background information, Section I contains a general description of the study conducted by HumRRO Division No. 6.

Section II describes simulator design, development, testing, and procurement projects that are currently in existence or that will be required in the future. Estimates of the funding required for the conduct of each project, by funding category and by fiscal year, also may be found in this section.

Section III deals with research projects that can lead to more effective design and use of simulation in pilot training. Such projects include development of an expanded training research capability, as well as specific developments leading to solution of present and forecast training requirements and the development of techniques for more effective training with simulators. Also included is a project for miscellaneous studies in the areas of management and application of training devices in Army aviation. These include a study to expand the present report into a comprehensive plan for the development and management of simulator training projects and to keep that plan current in the future.

In section IV, the question of the cost-effectiveness of simulator training is addressed for the four "new" simulator projects discussed in Section II, i.e., simulators for the UTTAS, AAH, HLH, and ASH aircraft. The discussion is necessarily general, since the total savings resulting from procurement of these devices could not be determined. Nevertheless, it provides a basis for a conclusion that procuring simulators for the UTTAS, AAH, HLH, and ASH will result in reduced overall training costs. Included in this section is a summary recapitulation of the funding requirements forecast as necessary to support the various research and procurement projects described.

Summaries of each research and procurement project are contained in Appendix A. The Project Summaries are intended to be usable as "handouts" or "talking papers" to facilitate communication about the various projects during budget discussions. It is recommended, however, that those using the Project Summaries be familiar with the sections of this report to which they relate.

The mid-1974 materials and services cost data on which the funding estimates contained in this report are based are given in Appendix B. As noted, 1974 costs form the basis for estimates of funding levels required during the period FY 1976-1980.

Appendix C contains information related to the scheduling of the simulator projects described in Section II for the UTTAS, AAH, HLH, and ASH. Appendix C is classified CONFIDENTIAL. It is bound as a separate document and is not to be attached to this report.

DESCRIPTION OF STUDY

Objectives

The general goal of Army aviation with reference to simulation is to maximize the cost-effective use of simulators in the accomplishment of its training and operational objectives. Such use will result in increases in the proficiency of Army aviators with a reduction in required aircraft flying hours. The specific objectives of the study reported here are: (1) to identify current and required simulation projects related to that goal; and (2) to develop estimates of funding required to support those projects during the period from fiscal year 1976 through fiscal year 1980.

Approach

In order to achieve the study objectives, a team was assembled consisting of HumRRO personnel who had participated in the conduct of pilot training and simulation research at the U S Army Aviation School and the U. S. Coast Guard Training Center. The Study Team had an extensive background of experience in the design, development, procurement, and testing of aircrew training devices and simulators for the Army and Coast Guard. Because of their involvement in simulation research, development, and procurement activities over a period of up to approximately 15 years, members of the HumRRO team were already familiar with many on-going simulation projects and with areas in which further projects were needed to facilitate future Army use of aircraft simulators in aircrew training.

Rather than relying solely upon information it already possessed, however, the team contacted a number of organizations known to be active in the conduct of simulation-related R&D, as well as a number of organizations that could provide further definition with respect to future Army simulator development requirements. In the case of estimates of the costs associated with the various projects, the team contacted a number of additional organizations believed to be in positions to provide meaningful cost data.

This report, obviously, does not include all of the information obtained during these contacts. Some of that information, such as that describing future helicopter procurement projects, was used in order to define the scope of related training device projects. Portions of that information are summarized here. Some of the information that was used during the derivation of cost estimates was of such detailed nature that it would be of little interest to the readers of this report. However, an attempt has been made to give the reader a sufficiently detailed picture of current programs and future requirements to allow satisfaction of the two basic objectives of the study.

Organizations Contacted

The short period of time available for this study was a major constraint; therefore, it was not possible to contact all potential sources of information. Instead, attention was concentrated upon those which, in the opinion of the Project Director and the Contracting Officer's Technical Representative, were likely to yield the greatest amount of relevant information within the time available. A listing of the organizations contacted is as follows:

U. S. Army:

Army Aviation School, Fort Rucker, AL.

Army Aeromedical Research Laboratory, Fort Rucker, AL.

Army Agency for Aviation Safety, Fort Rucker, AL.

Project Management Office, UTTAS, AVSCOM, St. Louis, MO.

Project Management Office, AAH, AVSCOM, St. Louis, MO.

Project Management Office, HLH, AVSCOM, St. Louis, MO.

Project Management Office, ASH, AVSCOM, St. Louis, MO.

ASH Task Group, Fort Knox, KY.

Army Missile Command, Huntsville, AL.

Army Research Institute for the Behavioral and Social Sciences,
Arlington, VA.

U. S. Navy:

Naval Training Command, Pensacola, FL.

Naval Training Equipment Center, Orlando, FL.

Training Analysis and Engineering Group, Orlando, FL.

U. S. Air Force:

Air Force Human Resources Laboratory/ASD, Wright-Patterson AFB, OH.

Air Force Human Resources Laboratory/FT, Williams AFB, AZ.

Air Force System Project Office for Simulators, Wright-Patterson
AFB, OH.

1550 Aircrew Training and Test Wing, Hill AFB, UT.

Other U. S. Government:

U. S. Coast Guard Training Center, Mobile, AL

Aeronautical Man-Vehicle Technology Division, NASA, Washington, D. C.

Ames Research Center, Moffett Field, CA.

Industrial and Commercial Groups:

American Airlines Training Center, Fort Worth, TX.

Austin Electronics, Roselle, NJ.

Burtek, Inc., Tulsa, OK.

Flying Tigers Airlines, Los Angeles, CA.

Life Sciences, Inc., Hurst, TX.

McDonnell-Douglas Electronics Co., St. Charles, MO.

Redifon, Ft. Worth, TX.

Reflectone, Inc., Stamford, CT.

Simulation Engineering Corp., Fairfax, VA.

Singer, Simulation Products Division, Binghamton, NY.

Trainer Corporation of America, Buffalo, NY.

Project Definitions

The first task of the Study Team was to identify the various current and required simulator research, development and procurement projects. With reference to simulator research, it quickly became apparent that it would not be feasible to list all potential research projects or research hypotheses individually. Instead, it was decided to identify needed research in terms of problem areas, in some cases illustrated with example research tasks likely to lead to relief in those problem areas. A deliberate

attempt was made to eliminate efforts from the listing which, in the judgment of the Study Team, were in areas that are being covered adequately by on-going and already-funded research programs of the Air Force, Navy, or NASA. Further, it was accepted that sufficient funding would not be available to support all of the desirable research efforts, so some potential projects are not included. It was felt that the listing should identify the minimum amount of research needed to provide reasonable assurance that priority simulation technology areas would continue to advance.

In the area of simulator procurement, guidelines for project definition were more easily established. Several simulator development and procurement projects already have DA approval (e.g., Devices 2B24, 2B31, and 2B33), while others are expected to win approval because they parallel already-approved projects (e.g., simulators for the proposed Aerial Scout Helicopter and part-task trainers for several existing aircraft). Thus, projects were defined for both approved and yet-to-be-approved simulator requirements.

A word is needed in this regard about the use of simulators versus part-task trainers in meeting aircrew training requirements. This report has identified projects dealing with training devices for new aircraft as "simulator" projects. This was done because it is believed that simulators will be the most prominent of the training devices needed for training aircrews for the aircraft, and there is no intent to suggest that simulators should be used for training that could be done equally effectively in less expensive part-task devices such as

cockpit procedures trainers. In fact, it is considered essential that any project established to develop simulators for a particular aircraft requirement should also develop part-task trainers for use with it where part-task training is appropriate. Allocation of training goals among simulators, part-task trainers, and the aircraft itself is an essential consideration in defining the performance characteristics required in a simulator.

Estimation of Funding Requirements

Once the projects were defined, estimates were then developed of the level of funding that would be required for each. For research and studies projects, which involved principally manpower efforts, estimates were made of the level of manning that was judged to be required to achieve the project goals, and the cost of that manpower was estimated. For projects that involved principally the development of simulators and simulator components, funding estimates were based upon data provided by principal suppliers of comparable equipment in recent years. In no case are the estimates contained in this report those obtained from a single source. Rather, they represent the writers' best judgments and integration of data after reviewing the estimates provided by others.

All funding estimates are based upon 1974 dollars. Where funding levels are cited in this report for FY 1975, they are based upon those estimates, i.e., they represent the expected cost of a particular item or service if procured approximately 1 July 1974. To compensate for

expected cost rises in subsequent years, adjustments have been made in those estimates by increasing the mid-1974 price at the rate of 10% per year (compounded). It is believed that this rate of escalation in funding estimates will approximate the increased costs of labor and materials over the next six years.¹

¹Equipment suppliers contacted during this study indicated that they are experiencing annual cost escalation rates of from 7 to 11 per cent.

Section II

SIMULATOR ENGINEERING DEVELOPMENT AND PROCUREMENT PROJECTS

THE SIMULATOR DEVELOPMENT PROCESS

Development of simulators is a lengthy process. It requires not only a thorough knowledge of simulation technology, but also of training technology. Training requirements reflecting both the characteristics of the aircraft concerned and operational mission factors must be carefully specified. In the case of an aircraft in the development stage, there must be a constant interaction between the aircraft developer and the simulator developer.

There are five distinct steps which must be taken before a specific simulator can become available for the training of Army aviators. These steps and the estimated time requirements for each are discussed below. It should be noted that this discussion places primary emphasis on the development of simulators per se (i.e., full-task trainers), but it is also intended to cover the development of all training devices (e.g., CPT, OFT, WST, etc.) which would be required for the conduct of cost-effective aircrew training. The concentration upon the more complex devices is in recognition of the facts that the greater portion of the developmental effort must be devoted to them and that their development will be more time-consuming. The less complex devices can be developed within the times allocated to the development of the more complex simulators.

1. Engineering and Training Design Concept Definition

The first step is to design the simulator that will be responsive to the training requirements associated with the aircraft. It involves the specification of training goals to be assigned to the simulator, the definition of the simulator's configuration, its interface with other training and maintenance equipment, and the selection of engineering approaches to be taken in the design of the device's features that will assure that the intended training can be accomplished with it. This activity permits implementation into each device's design of the latest state-of-the-art in relevant training and engineering technologies. Attention must also be directed to the allocation of the identified training goals among the various types of training devices considered appropriate for use in conjunction with the planned simulator (i.e., part-task trainers) and to the design of these devices. Thus, Step 1 involves the definition of a training system consisting of a simulator and necessary supporting part-task trainers for the aircraft concerned. The products of Step 1 are (1) comprehensive performance specifications for the simulator and other related devices; and (2) a training plan defining how this equipment will be employed, in conjunction with the aircraft, in future aircrew training. The performance specifications will be the principal instruments used to communicate the Army's requirements to a manufacturer, whereas the training plan governs the scheduling of other resources and events and is designed to insure cost-effective implementation of simulator training in the overall training effort.

This first step is critical in the simulator developmental process.¹

The simulator design activity can be very time-consuming. For example, a rather protracted interaction was required between user and engineering personnel in the case of the 2B31 and 2B33. Based upon recent Army experience, it would be appropriate to allocate nine to fifteen months to Step 1. However, it is reasonable for this first step to be accomplished in fully satisfactory fashion in somewhat less time if appropriate project management procedures are initiated. For planning purposes, a period of approximately six to seven months should be allocated to assure thorough study of relevant engineering and training technologies, review of the training mission of the proposed device, and investigation of the vehicle being simulated.

It should be noted that Step 1 does not involve the systems engineering of a training course, nor does it involve the development of justification for the procurement of a simulator. Step 1 can be initiated only after the Army has already approved the development of a particular simulator (i.e., only after an approved Training Device Requirement (TDR) exists). It can, however, lead to a conclusion that the technology required to develop the desired simulator is unavailable, and, consequently, to a recommendation that the planned procurement be reconsidered.

¹ It has been characteristic of this first step in most previous Army simulator procurements that little attention has been paid to the development of part-task trainers for use in conjunction with those simulators or to the training plan defining the future role of simulation in the training program.

2. Contract Award

This step involves preparation of a solicitation package, obtaining proposals from potential simulator developers, evaluating these proposals, and negotiating and awarding an engineering development contract. Based upon recent Army experience, a period of approximately six to nine months should be allowed for this activity. The bulk of the activities associated with Step 2 cannot be initiated until the performance specification developed during Step 1 is completed.

3. Development of an Engineering Development Model

This step consists of development and delivery of an engineering development model simulator meeting the design requirements identified in Step 1. The time required for Step 3 depends upon a number of factors, chief of which is the amount of advanced development required to produce the simulator. If the device is essentially a variation of an existing device, it might be delivered to the Army in as little as 18 to 24 months. Since the state-of-the-art is not fully adequate with respect to simulation of aspects of the Army's unique mission environment, it is considered likely that simulators procured by the Army during the period under consideration here will necessitate a modest advancement in simulation technology for each succeeding device. Thus, it is not likely that simulation for the new helicopters will be produced in minimum time. A more likely estimate of the delivery time requirement for each engineering development model will be 24 to 36 months.

Step 3 concludes when the new simulator has complete final acceptance testing by the Army. Normally, this testing will be conducted at a

selected Army site such as the U S. Army Aviation School.

4. Suitability Testing

The purpose of the fourth step is to perform all design and operational tests necessary to assess the simulator's suitability for its intended role in Army training as defined during Step 1 and to identify any deficiencies in its design which should be corrected prior to further procurement. A necessary part of this activity involves the development of techniques for using the device and a training program that will exploit its design-for-training features.

The amount of time required to accomplish Step 4, assuming most of the device's deficiencies have been corrected during acceptance testing at the conclusion of Step 3, is estimated to be six to twelve months. At the end of that period, the engineering development model of the device would be available for aircrew training activities on a limited basis while undergoing any design changes resulting from findings of the suitability tests. In addition, a revised procurement package should have been prepared to enable the Army to obtain production models of the device which reflect the findings of these tests.

5 Production Procurement

The final activity is the procurement of production models of the simulator under consideration so that they will be available in sufficient numbers to meet expected training requirements. If the suitability test results confirm the basic device design, it is reasonable to expect initial deliveries within 15 to 24 months. Meeting this schedule, of course, requires expeditious Army approval of the procurement

plan and contract award. Should it be necessary to procure production models of the device on a competitive basis, Steps 2, 3, and 4 would largely have to be repeated, extending the time requirement by approximately 36 to 57 months. In view of the limited number of simulators of any one type that the Army is likely to procure, it would not appear feasible to consider competitive procurement of production models, however, so the longer time period is unlikely.

Table 1 summarizes the approximate time estimated to be required, following the above five-step procedure, for the development of a new Army simulator. It can be seen that a minimum of 42 months should be planned, following an Army decision to procure a particular helicopter simulator, before even an engineering development model will be available for training. At least an additional 15 months will be required before production models will be available. Meeting this minimum schedule would require careful management of the procurement.

Table 1

Simulator Developmental Steps and Time Requirements

<u>Step</u>	<u>Estimated Months Required</u>
1	6 - 7
2	6 - 9
3	24 - 36
4	6 - 12
5	15 - 24*

*Months to delivery of the first
production unit or production prototype

NEW SIMULATOR DEVELOPMENT PROJECTS

During the next decade the Army will likely introduce four new helicopters: the Utility Tactical Transport Aircraft System (UTTAS), the Advanced Attack Helicopter (AAH), the Heavy Lift Helicopter (HLH), and the Aerial Scout Helicopter (ASH). Based upon information available at the time of this study concerning the mission of these helicopters, their complexity and projected operating costs, and the probable numbers of aircrews to be trained to operate them, simulators and other training devices will be required for the conduct of cost-effective training for each helicopter.

Requirements for the development of simulators for the UTTAS, AAH, and HLH are included in the SFTS TDR. However, no formal requirement has been stated by the Army for development of an ASH simulator. For the purposes of this report, a requirement for an ASH simulator is assumed, since the ASH Project Office has indicated that such a requirement is foreseen. Likewise, it has been assumed in this report that requirements will be identified and ultimately approved by the Army for part-task trainers for these four aircraft. This latter assumption is considered necessary since such devices as cockpit procedures trainers can provide more cost-effective aircrew training than can the simulators themselves in some instances and since the Army has procured such devices for use in other aircrew training programs. Therefore, the UTTAS, AAH, HLH, and ASH simulator projects described below each includes the development of part-task trainers as well as simulators.

General Design and Procurement Considerations

The details of the design of each of these four simulators will, of course, be determined during the course of Step 1 of each project. The need for part-task trainers to be used with each simulator and the configuration of each will be determined at the same time. It would be inappropriate to attempt to specify the design of these devices in detail prior to the completion of Step 1. Nevertheless, it is necessary to determine the general scope of the design of each in order to develop estimates of their probable development and procurement cost.

For convenience of discussion here, each simulator may be conceived as consisting of an operational flight trainer (OFT) and a visual display attachment (VDA). None of the OFT portions of these simulators will require research or advanced development effort. Each will be based upon state-of-the-art technology and will involve essentially no development risk. The same is not true for the VDA portions, however. Advanced development efforts, involving a moderate degree of risk that the design goals will have to be compromised, will be required for each, although the risk will be less in the case of the HLH than for the other three. It is expected that the utility of the UTTAS, AAH, and ASH simulators will be limited with respect to tactical visual training because of deficiencies in the state of the visual simulation art.¹

¹See the discussion of the proposed ATVIDS Project in Section III of this report for a discussion of efforts needed to extend the state-of-the-art in visual simulation and thus provide better tactical training.

Each of these simulators also will involve limited advanced development efforts related to their advanced training and performance measurement features. It is expected that the development of the technology of computer-assisted simulator training which has been taking place in Devices 2B24, 2B31, and 2B33 will continue in these four simulators. The general goal of these efforts will be to enhance the training capabilities of Army simulators through computer-assisted performance monitoring, measurement and recording, performance playback; automatically administered flight demonstration; and visual and instrument checkrides.

Estimates of the number of simulators that will be required to provide the desired amounts of aircrew training must be based upon basis of issue data, but those data were not available at the time of this study. Nevertheless, it was essential to preparation of this report that some number of simulators be used for budget planning purposes--to serve at least as "straw man" figures until more definitive ones could be derived. Consequently, after conferring with the Contracting Officer's Technical Representative, a quantity was identified for each simulator, and that number is indicated in the appropriate discussion below. To the extent that these numbers are in error, it is believed they tend to represent overestimates of the numbers of simulators ultimately to be required.

The principal features of each simulator are described separately below.

UTTAS Simulator Project

The objective of the UTTAS Simulator Project is to develop a UTTAS training simulator, as well as other training devices, for use in UTTAS training at the Aviation School and at selected aviation field units. Training to be conducted in these devices will include transition, combat readiness proficiency, and visual and instrument refresher training. The simulator will play a major role in the Army-wide standardization of UTTAS aviator performance. While the design of this simulator will be based upon state-of-the-art technology, advanced developments in the areas of visual environment simulation and computer-controlled training and performance assessment will be required. The UTTAS simulator will consist of a pilot and copilot trainee compartment, a flight instructor station, a visual display system, a six-axis motion system, and a computer complex. Each of these major components is described in more detail in the UTTAS Project Summary to be found in Appendix A.

The OFT portion of the UTTAS will be similar in configuration to the corresponding portion of Device 2B31, which is currently under development for the CH-47. It will have a cockpit area modeled after the aircraft, and adjacent to the cockpit area will be an instructor position with controls to allow the instructor to manipulate training activities. These components will be mounted on the motion system. The OFT will be driven by a digital computer program which will perform, in addition to the computations necessary for aircraft and environmental simulation, all operations associated with the various advanced training and maintenance troubleshooting features of the simulator.

The VDA portion of the UTTAS simulator will be based upon camera-model visual display technology, but it will require advanced development efforts with a moderate degree of risk that the design goals will have to be compromised. These goals include a wide angle, 120° x 50°, high resolution display with a simulated eye position such that ground operation of the aircraft can be simulated. The display will be full color. Scene content will be modeled generally for stagefield-type training, although some tactical training will be possible, i.e., confined area and pinnacle operation, and low level, limited nap-of-the-earth flight. It is expected that tactical visual training in the UTTAS simulator will be limited because of deficiencies in the state of the visual display art.

Since the basis of issue of UTTAS simulators has not yet been determined, for the purposes of this report it is assumed that requirements will be identified for an engineering development model plus one production unit at the Aviation School and an additional nine production units at aviation field units. A single cockpit procedures trainer is assumed to be required to support UTTAS simulator training at the Aviation School. These assumptions are based upon the concept of decentralized UTTAS simulator training. Should the ultimate basis of issue for the simulator provide for bringing aviators to a central facility (e.g., the Aviation School) for UTTAS refresher training and standardization, it is likely that a lesser number of simulators and a greater number of part-task trainers would be more appropriate.

Requirements related to the scheduling of UTTAS simulator development steps are discussed in Appendix C. The time relationship among

these five steps and the various funding requirements are also contained in that Appendix. Table 2 summarizes these UTTAS simulator funding requirements by fiscal year and by funding category.

Table 2
UTTAS Simulator Funding Requirements
(Thousands of Dollars)

Fund Category	Fiscal Year				
	1976	1977	1978	1979	1980
6.4	4,950	5,082	-0-	508	-0-
OPA	-0-	-0-	419	-0-	25,122
MCA	-0-	-0-	-0-	1,575	1,731

AAH Simulator Project

The objective of the AAH Simulator Project is to develop an AAH simulator and other training devices for use in AAH aircrew training at the Aviation School and at selected aviation field units. These devices will be used in transition, weapons qualification, combat readiness proficiency, and visual and instrument refresher training programs. The simulator will play a major role in the Army-wide standardization of AAH aircrew performance. While the design of this simulator will be based largely on state-of-the-art technology, advanced developments will be needed in the areas of visual simulation and computer-controlled training and performance assessment.

The design of the OFT portion of the AAH simulator is similar to that of Device 2B33, the AH-1Q simulator which is currently under development. The AAH simulator will be capable of providing training for AAH pilots and gunners separately or as a crew. It will have two separate trainee compartments, one each for the pilot and for the copilot-gunner. Each compartment will be modeled after the corresponding portion of the aircraft. Adjacent to each of the trainee compartments will be an instructor station with the controls and displays necessary to administer and monitor training. Each trainee compartment/instructor station will have its own visual display and will be mounted on a six-axis motion system. The OFT will be driven by a digital computer programmed to perform, in addition to computations necessary for aircraft and weapons systems and environmental simulation, all operations associated with advanced training and maintenance troubleshooting features of the simulator. Each of the major components of the AAH simulator is discussed in more detail in the AAH Project Summary in Appendix A.

The VDA portion of the AAH simulator will be based on camera-model visual display technology, but will require advanced development efforts with a moderate degree of risk that the design goals will have to be compromised. These goals include a horizontal 150° by a vertical 50° color field of view generated from a single model board which can be used simultaneously by the pilot and gunner trainee for coordinated crew training or can be time-shared for separate training missions; a simulated eye height of not more than approximately seven feet to allow visual ground-level maneuvering; day and night visual simulation of

weapons trajectories and impact signature; and infra-red imagery displays for both crew members. Scene content will be modeled generally for stagefield-type training, although some tactical training will be possible, i.e., confined area and pinnacle operation, low-level, limited nap-of-the-earth flight, and target engagement and weapons delivery. As with other simulators having state-of-the-art visual display attachments, it is expected that tactical visual training will be limited.

The basis of issue of AAH simulators has not yet been determined. For the purposes of this report, it is assumed that requirements will be identified for one engineering development model and for three production models to be used at AAH-equipped field units. A single cockpit procedures trainer is assumed to be required to support AAH simulator training at the Aviation School.

Requirements related to the scheduling of AAH simulator development steps are discussed in Appendix C. The time relationship among these five steps and the various funding requirements are also contained in that Appendix. Table 3 summarizes the AAH simulator funding requirements by fiscal year and by fund category.

Table 3

AAH Simulator Funding Requirements
(Thousands of Dollars)

Fund Category	Fiscal Year				
	1976	1977	1978	1979	1980
6 4	82	-0-	15,173	-0-	842
OPA	-0-	-0-	-0-	498	-0-
MCA	-0-	-0-	-0-	-0-	1,340

HLH Simulator Project

The objective of the HLH Simulator Project is to develop HLH simulators and other training devices for use in HLH aircrew training at the Aviation School and at a selected aviation field unit. These devices will be used to conduct transition, cargo transport, combat readiness proficiency, and visual and instrument refresher training. The simulator will play a major role in the Army-wide standardization of HLH aircrew performance. While the design of the HLH simulator will be based on state-of-the-art technology, advanced developments will be required in the area of visual simulation and computer-controlled training and performance measurement. The HLH simulator will consist of a pilot-copilot trainee compartment, a hoist operator trainee compartment, visual displays, instructor stations, motion systems, and a computer complex. Each of these major components is described in more detail in the HLH Project Summary to be found in Appendix A.

The HLH simulator will have two separate trainee compartments, one for the pilot and copilot, and the other for the hoist operator, and each compartment will be modeled after the corresponding portion of the aircraft. These compartments can be used independently for pilot and copilot training and for hoist operator training, or jointly for integrated crew training. Adjacent to each trainee compartment will be an instructor station with the controls and displays necessary to administer and control training. The pilot-copilot compartment will be mounted on a six-axis motion system, while the hoist operator compartment will be mounted on a two-axis motion system. The simulator will be driven by a

digital computer programmed to perform, in addition to computations necessary for aircraft, aircraft system and environmental simulation, all operations associated with the advanced training and maintenance troubleshooting features of the simulator

The simulator will have a visual display system consisting of VDA's for each trainee compartment. The system will be used for non-tactical mission training in conjunction with both the pilot and copilot and the hoist operator compartments, either separately or for integrated crew training. The system will be based upon computer-generated visual point-light and surface technology and will employ state-of-the-art optics and electronics. A design goal will be to provide a 120° horizontal by 35° vertical color field of view for the pilot and copilot, and a 120° horizontal by 90° vertical color field of view for the hoist operator.

The basis of issue of HLH simulators has not yet been determined. For the purposes of this report, it is assumed that requirements will be identified for an engineering development model to be used at the Aviation School and one production unit to be used at an aviation field unit. A single cockpit procedures trainer is assumed to be required to support HLH transition training at the Aviation School.

Requirements related to the scheduling of HLH simulator development steps are discussed in Appendix C. The time relationship among these five steps and the various funding requirements are also contained in that Appendix. Table 4 summarizes these HLH simulator funding requirements by fiscal year and by funding category.

Table 4

HLH Simulator Funding Requirements
(Thousands of Dollars)

Fund Category	Fiscal Year				
	1976	1977	1978	1979	1980
6 4	82	10,527	-0-	714	-0-
OPA	-0-	-0-	586	-0-	-0-
MCA	-0-	-0-	-0-	-0-	-0-

ASH Simulator Project

The objective of the ASH Simulator Project is to develop an ASH simulator and other training devices for use at the Aviation School and at selected aviation field units. Training to be conducted in these devices will include transition, target acquisition and engagement, combat readiness proficiency, and visual and instrument refresher training. The simulator will also play a major role in the Army-wide standardization of ASH aviator performance. While the design of this simulator will be based upon state-of-the-art technology, advanced developments in the area of visual simulation and computer-controlled training and performance assessment will be required. The ASH simulator will consist of a pilot and copilot trainee compartment, a flight instructor station, a visual display system, a six-axis motion system, and a computer complex. Each of these major components is described in more detail in the ASH Project Summary to be found in Appendix A.

The OFT portion of the ASH will be similar in configuration to the corresponding portion of Device 2B31 which is currently under development for the CH-47. It will have a cockpit area modeled after the aircraft, and adjacent to the cockpit area will be an instructor position with controls to allow the instructor to manipulate training activities. These components will be mounted on the motion system. The OFT will be driven by a digital computer program which will perform, in addition to the computations necessary for aircraft and environmental simulation, all operations associated with the various advanced training and maintenance troubleshooting features of the simulator.

The VDA portion of the ASH simulator will be based upon camera-model visual display technology, but it will require advance development efforts with a moderate degree of risk that the design goals will have to be compromised. These goals include a wide angle, 180° horizontal by 60° vertical, high resolution display with a simulated eye position such that ground operation of the aircraft can be simulated; and simulation of the in-cockpit electronic sensor displays which must be correlated with features of the model board. The display will be full color. Scene content will be modeled generally for stagefield-type training, although some tactical training will be possible, i.e., confined area and pinnacle operations, target engagement, and low-level, limited nap-of-the-earth flight. It is expected that tactical visual training will be limited in the ASH simulator because of deficiencies in the state of the visual display art.

Since the basis of issue of ASH simulators has not yet been determined, for the purposes of this report it is assumed that an eventual requirement will be identified for an engineering development model plus one production unit at the Aviation School and an additional nine production units at aviation field units. A single cockpit procedures trainer is assumed to be required to support ASH simulator training at the Aviation School. These assumptions are based upon the concept of decentralized ASH simulator training. Should the ultimate basis of issue for the simulator provide for bringing aviators to a central facility (e.g., the Aviation School) for ASH refresher training and standardization, it is likely that a lesser number of simulators and a greater number of part-task trainers would be more appropriate.

Requirements related to the scheduling of ASH simulator development steps are discussed in Appendix C. The time relationship among these five steps and the various funding requirements are also contained in that Appendix. Table 5 summarizes these ASH simulator funding requirements for the period of interest here.

Table 5
ASH Simulator Funding Requirements
(Thousands of Dollars)

Fund Category	Fiscal Year				
	1976	1977	1978	1979	1980
6.4	82	5,808	5,990	-0-	599
OPA	-0-	-0-	-0-	410	-0-

CONTINUING SIMULATOR DEVELOPMENT PROJECTS

At the present time, the Army has under development simulators for the CH-47 (Device 2B31) and the AH-1Q (Device 2B33). In addition, procurement of production quantities of UH-1 simulators (Device 2B24) is in progress. These are active projects, covered under the SFTS Development Plan and for which previous years' funding has been provided. Funding of them must be continued during the time period under consideration here. Descriptions of these simulators are contained in separate Project Summaries to be found in Appendix A.

Devices 2B31 and 2B33

In terms of the five-step simulator development process described earlier in this report, the 2B31 and 2B33 projects are scheduled to complete Step 3 during the third and fourth quarters of FY 1976, respectively. Step 4 will occupy the following two or three quarters, putting the initiation of Step 5 into late FY 1977.

Funding for one production unit of the 2B31 (estimated to require approximately \$5,324,000 for the OFT and VDA combined) and for nine production units of Device 2B33 (at an estimated OFT and VDA combined unit cost of \$7,720,000) can begin in early FY 1978. These are the quantities of each device determined to be required from the SFTS Development Plan. Procurement of Device 2B33 can be extended over a three-year period with deliveries occurring approximately quarterly, beginning with the third quarter of FY 1979. MCA funding will be required for each device destined for field unit installation, as are

eight of the 2B33 production units. Individual buildings for these eight Device 2B33's should be funded two years before each is scheduled for delivery. The escalated unit cost of these buildings will be \$641,000 in FY 1977, \$705,000 in FY 1978, and \$776,000 in FY 1979. The first 2B33 production unit and the 2B31 production unit are scheduled for installation at the Aviation School.

There have been several changes in the CH-47 aircraft which are not reflected in Device 2B31, and there are likely to be changes in the AH-1Q aircraft which are not reflected in Device 2B33. These devices should be modified in the future to reflect such changes. In addition, it is likely that the devices will require some modifications as a result of their suitability testing during Step 4. Funds should be available during FY 1977 to effect such modifications following completion of Step 4 for each device. It is estimated that approximately \$350,000 will be required for this purpose for Device 2B31, and approximately \$450,000 for Device 2B33.

Device 2B24

Device 2B24 is currently at Step 5. One engineering development model has been procured and tested, and seven production units were procured for delivery to the Aviation School in FY 1974 and 1975. FY 1975 funds have been appropriated for procurement of four additional production units. The SFTS Development Plan indicates that a total of 31 production units will be procured altogether.

Funding estimates for procurement of the remaining twenty Device 2B24 production units are indicated below. Funding should provide for

procurement of six units per year, beginning in FY 1976, until this requirement is fulfilled. If a contract is awarded for these 20 units during FY 1976, the average unit cost is likely to be approximately \$3,146,000 (based upon an FY 1977 unit price estimate).

Additional funding for buildings to house these Device 2B24's, each of which will be located at an aviation field unit, will be required. Funds for these buildings should be available approximately two years before their scheduled delivery, i.e., during FY 1976 (\$1,881,000), FY 1977 (\$2,069,000), FY 1978 (\$2,270,000), and FY 1979 (\$1,667,000) for the delivery of six each during FY's 1978, 1979, and 1980, and the last two during FY 1981.

During the course of this study, it was brought to the attention of the Study Team that funds have not yet been appropriated for the construction of buildings at aviation field units to house the four Device 2B24's for which FY 1975 procurement funds have been appropriated. This oversight should be corrected as soon as possible, and the deliveries of the device concerned should be delayed until suitable buildings can be constructed. For this purpose, funds for these four buildings (\$1,254,000) should be added to the amount indicated above for FY 1976 MCA funding.

The total estimated funding requirements for continuation of the 2B31, 2B33, and 2B24 procurement projects are summarized in Table 6 by fiscal year and by fund category.

Table 6

Device 2B31, 2B33, and 2B24 Funding Requirements
(Thousands of Dollars)

Device	Fund Category	Fiscal Year				
		1976	1977	1978	1979	1980
2B31	6.4	-0-	350	-0-	-0-	-0-
	OPA	-0-	-0-	5,324	-0-	-0-
	MCA	-0-	-0-	-0-	-0-	-0-
2B33	6.4	-0-	450	-0-	-0-	-0-
	OPA	-0-	-0-	30,879	33,967	9,341
	MCA	-0-	641	2,820	2,328	-0-
2B24	OPA	18,876	18,876	18,876	6,292	-0-
	MCA	3,135	2,069	2,272	830	-0-

PART-TASK TRAINER PROCUREMENT PROJECTS

There is a need in the Army for part-task training devices, such as cockpit procedures trainers, for aircraft transition training courses. At the present time, such devices are available or under development for many of the transition training courses taught at the Aviation School, and it is expected that they will be procured for all such present and future courses. In the case of the UTTAS, the AAH, the HLH, and the ASH, design and procurement of part-task trainers should be undertaken as a part of the respective simulator project. In the case of the simulator projects currently underway, however, this was not done. Consequently, funding will be needed for part-task trainers for the CH-47 and the AH-1Q. Devices have already been procured for the UH-1.

Project Summaries describing these two part-task trainer needs are at Appendix A. An estimate of the level of funding these projects will require is indicated below. It is assumed that, in the case of these devices, the development process will be abbreviated by reducing the scope of Step 1 (much of the work normally required here was completed previously) and eliminating Steps 3 and 4. Procurement of these devices can be initiated during FY 1976, although earlier initiation would be desirable should additional funds become available. The estimated cost of each is indicated in Table 7. No MCA requirement will exist specifically for these devices, since they will be housed in facilities constructed for the simulators they support.

Table 7

CH-47 and AH-1Q Part-Task Trainer Funding Requirements
(Thousands of Dollars)

Device	Fund Category	Fiscal Year				
		1976	1977	1978	1979	1980
CH-47	OPA	462	-0-	-0-	-0-	-0-
AH-1Q	OPA	341	-0-	-0-	-0-	-0-

AVIATION SCHOOL SIMULATOR FACILITY REQUIREMENTS

The estimates of simulator project funding requirements discussed in this section of the report include estimates of MCA funding that will be required for each simulator located at aviation field units. These estimates are based upon the data presented in Appendix B, and they assume

that a separate building will be required to house each device. This assumption was necessary for the purposes of this report because no guidance could be obtained as to the specific disposition of each simulator. Should more than one device be located at a given field unit, it would be appropriate to consider constructing a single facility which would house all of them. Such a joint-use building would result in some savings in MCA costs, since it would be possible to reduce the requirement for administrative offices, maintenance/supply areas, and latrines. It is estimated that, on the average, a joint-use building would result in a savings of approximately 10% of the costs of constructing individual buildings to house each simulator.

In the case of simulators destined for installation at the Aviation School, a joint-use building should be planned. At the present time, a single building has been constructed to house all Device 2B24's that are being procured for the Aviation School. In addition, FY 1975 funds have been appropriated for construction of a building to house the engineering development models of Devices 2B31 and 2B33 which are scheduled for delivery in March and June, 1976, respectively. An addition to that building to provide classroom and administrative areas and to house existing and planned part-task training devices for use in conjunction with the Aviation School's simulators is planned, and it is understood that FY 1976 funds in the amount of \$1,726,000 have been requested by the Aviation School for that purpose.

Another addition--or another building--will be required to house other simulators described in this report which are to be located at the

Aviation School. Six of these devices, and the date of their expected delivery to the Aviation School, are indicated in Table 8 below.¹

Production units of the UTTAS and ASH are also planned for the Aviation School, but are not included in Table 8 because MCA funding for a building to house them can occur beyond the period of this report.

Table 8
Projected Schedule of Simulator Deliveries
To the Aviation School
(Quarter and Fiscal Year)

Simulator	Date
HLH Engineering Development Model	1, 1979
2B31 Production Model #1	1, 1979
2B33 Production Model #1	1, 1979
UTTAS Engineering Development Model	2, 1979
AAH Engineering Development Model	4, 1979
ASH Engineering Development Model	1, 1980

A single building to house these six simulators will be required not later than the time the earliest one is expected to be delivered, i.e., for the HLH engineering development model, during the first quarter of

¹ The time estimates in Table 1 for Steps 3 and 5 include delivery of devices to their intended destinations. At least three months must be allowed for setting up a new simulator on site. Therefore, a building must be available for delivery of a simulator at least one quarter prior to the scheduled completion of Steps 3 or 5.

FY 1979. To assure the building's availability by that time would require funding during FY 1977. The amount of such funding can be estimated by adding the cost of six buildings designed to house these simulators individually and reducing the sum by 10%. This figure, escalated to expected FY 1977 costs, is \$2,620,000, the amount of MCA funding required during the period addressed in this study to house simulators expected to be delivered to the Aviation School.

The funds required for the construction of facilities at the Aviation School to house simulators and part-task training devices is summarized in Table 9.

Table 9

Aviation School Simulator Building Funding Requirements
(Thousands of Dollars)

Fund Category	Fiscal Year				
	1976	1977	1978	1979	1980
MCA	1,726	2,620	-0-	-0-	-0-

SECTION III

SIMULATOR RESEARCH AND ADVANCED DEVELOPMENT PROJECTS

Four research projects have been identified that will lead to advancement in technologies associated with simulator training. These research projects are described in this section of the report. One of these concentrated upon an area in which the greatest need exists, so far as simulator hardware is concerned, the visual simulation area. Its objective is to develop and test a visual display system that will permit cost-effective nap-of-the-earth (NOE), night, and air-to-air engagement training in the Army's helicopter simulators.

A second project would lead to the acquisition of a simulator for conduct of Army aircrew training research. This would be accomplished either by acquiring a dedicated and specially-designed research simulator and/or by establishing access to existing Army training simulators on a basis that would assure their availability for needed research.

The third project involves the conduct of research designed to improve the manner in which simulators are used in training. This work is largely a continuation of present simulator training-related research which the Army has conducted for a number of years and which has led to the present highly effective use of Device 2B24 in Army undergraduate training.

The fourth project covers a series of training device management and application studies, the most important of which would involve the expansion of the present study into a comprehensive Army aviation simulator development and utilization plan. Also covered are studies of aircraft systems

maintenance trainers, simulator procurement practices, and the use of training devices for performance prediction.

ADVANCED TACTICAL VISUAL DISPLAY SYSTEM DEVELOPMENT (ATVIDS) PROJECTS

In the future, the Army must rely heavily upon the use of simulators for aircrew training. Present technology permits generally adequate simulation of present and planned Army aircraft in an instrument flight environment, but the bulk of Army flying takes place in a visual flight environment. The existing visual display system technology was developed primarily for use with high performance fixed wing aircraft simulators and is limited in the extent that the visual environment of Army rotary wing aircraft can be simulated.

The most fruitful approach to meeting the Army's future visual display requirements appears to be the camera-model approach, but this approach has some deficiencies. For example, present techniques of model construction do not permit the simulation of scene content at the level of detail required for low airspeed flight near natural or man-made objects at economical scale sizes. Over time, there is a tendency for models to warp and discolor, and large amounts of energy are required to provide adequate lighting of the models. Bulky gantries used to move TV cameras over the model board surfaces have inertia characteristics that may preclude simulation of some helicopter maneuvers.

Problems with the model are not the only deficiencies in this approach. Existing optical probes designed for use in conjunction with camera-model board visual display systems are bulky, fragile, and limited in both field of view and depth of field. Their size typically is such that they cannot

simulate pilot eye position close to environmental surfaces and obstructions without distortion. Because they are easily damaged or disaligned if contact is made with the model, training at tasks such as nap-of-the-earth navigation involves considerable equipment risk. The field of view coverage of existing probes is far less than that which the Army aviator is believed to need to perform many training tasks. Simultaneous focus of the probe on objects at near and far distances is precluded in many training situations.

Unlike high performance fixed wing training, most Army training tasks involve responding to visual information obtained from a relatively wide field of view. Techniques for displaying camera-model system information over a relatively narrow area are well advanced, but a satisfactory working model of a display that would permit viewing of a wide scene area comparable to that viewed in a helicopter does not exist.

Because of such limitations, the planned UTTAS, AAH, HLH, and ASH simulators, as well as Devices 2B31 and 2B33 currently under development, will have a limited capability with respect to visual simulation of the tactical environment. However, the need for tactical training through simulation is generally recognized, and each of these simulators must push the state of the art as far as practicable toward achieving a broad tactical training capability goal. Particularly in the case of the field of view needed for NOE training, each successive development will seek a more flexible and realistic environmental simulation.

Based upon present technology, it would be possible to develop an NOE visual display, but it would be expensive and would have limited training value. It would have to consist of a large-scale model board that would

be expensive to fabricate and house and, in order to provide adequate protection to the optical probe, would require extensive programming to locate surface obstructions in computer memory. Field of view would be much more limited than is considered needed in NOE flight. The high cost of such a development, together with the limited scene content it would contain, make procurement of a fully satisfactory tactical NOE visual display for the simulators currently under development an impractical goal at this time.

NOE training, of course, is but one of the tactical training requirements for which better visual simulation is desired. Others of particular concern involve night training in a tactical environment, both with and without electronic aids such as infra-red imagery displays and low light level television, visual target acquisition, and helicopter-to-helicopter gunnery. Also of concern will be the capability of providing tactical instrument training involving varying combinations of instrument flying and degraded VFR conditions. Providing simulator training relevant to these tactical requirements at reasonable cost is even farther into the future than is NOE training. In fact, the Army is not now working toward solution of these latter tactical simulation problems as it is toward solution of the NOE problem.

It would appear that the potential training benefits are sufficient to justify undertaking, as a long-term goal, the development of visual display systems that would provide effective tactical training through simulation. Therefore, Appendix A contains a Project Summary for the development of an Advanced Tactical Visual Display System (ATVIDS). The ATVIDS, when used in

conjunction with an existing simulator, would permit the conduct of the desired tactical training for the aircrew qualified in or transitioning to a particular aircraft. In effect, the ATVIDS would temporarily replace the visual display system procured with a particular simulator, e g , AAH, and would permit NOE tactics, night tactics, or air-to-air (i.e , helicopter-to-helicopter) gunnery training to be conducted in it. Ideally, the replacement of one visual display system with another would be a matter of switching video and computer circuits only, thus allowing the interchange to take place during the time normally allocated between instructional periods in existing simulators. Before such a goal can be realized, however, a number of technical problems must be resolved. The principal problems related to camera-model technology per se have been described above. Others relate specifically to generation of the required tactical display.

At the present time, the Army Research Institute for the Behavioral and Social Sciences (ARI) has an on-going program of research in the NOE training area. During FY 1976 and 1977, ARI plans to procure an NOE visual display "test bed." That device, in conjunction with other elements of the Army's NOE research program, should provide valuable data needed to develop a tactical visual display system with an NOE training capability. Input from the ARI project, together with other developments from industrial research and development groups, should enable the Army to move forward toward the goal of tactical training through visual simulation.

Comparable effort should be expended during the coming years to advance the simulation of night tactics and air-to-air gunnery. It is likely, of course, that developments in the NOE area will have implications for other

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areas of tactical training, since both night tactics and air-to-air gunnery for Army helicopter pilots will take place largely in the NOE environment. There are, however, some additional problems that can be investigated separately. Simulation of infra-red and television viewing devices are examples of problems associated with night tactical simulation. In the case of air-to-air simulation, there are obvious problems related to display field of view and resolution. Others relate to techniques for representing the "other" helicopter as it seeks cover among the features of the simulated terrain. Air-to-air simulation techniques recently developed by the Air Force and NASA would appear to be of limited value in the Army's tactical environment, since high altitude "dog fights" do not require accurate environmental simulation as would similar engagements involving Army helicopters.

Solutions to the requirement for an ATVIDS are not likely to be available within the next few years. Instead, the ATVIDS project should be viewed as a long-range development project that will require funding over a number of years. Included in that funding should be provision for research to expand the data base in NOE, night, and air-to-air tactics (e.g., the scene content, field of view, etc., required to conduct a specific aircraft maneuver), concept definition studies, development of laboratory and bread-board devices to test engineering concepts, fabrication of an advanced development model of an ATVIDS, modification of one or more then-existing simulators for use with it (e.g., AAH, ASH), and tests to determine the value of the system in an operational training situation.

A reasonable time schedule for this project would be to conduct the necessary investigatory and engineering research during the period FY 1976 to FY 1980 with a view toward initiating the five-step simulator development procedure during the early 1980's. With an adequate level of funding of such efforts, it should be possible to achieve the goal of valid tactics training through visual simulation during the time frame FY 1985-1990.

The Air Force and Navy are actively engaged in research and development programs in the camera-model visual display area. This work is concentrating upon improved field of view, resolution, and color, and the results of most of their work will have immediate application to ATVIDS. Problems related to model construction and probe protection are not of interest to the other services, however. Simulation requirements involving the NOE environment are almost unique to the Army.

The funding estimates indicated below are believed to represent the minimum level of funding that will yeild reasonable assurance of developing an ATVIDS by the middle to latter part of the next decade. There are many technical problems to be overcome, and any single activity leading to the overall project goal must be considered to involve a moderate risk of failure. In addition, this project will involve relatively empensive hardware investment by the industries with the capabilities needed to mount the extensive research and development programs to be required. They must be assured that there will be sustained investment by the Army over a period of time if they are to invest their own resources and talents in such a difficult and risky project. For that reason, and after conferring with industries and agencies likely to participate in development of an ATVIDS, the estimates contained in Table 10, below, are judged appropriate.

Table 10
ATVIDS Research Funding Requirements

Funding Category	Fiscal Year				
	1976	1977	1978	1979	1980
6.2	200K	250K	250K	250K	250K
6.3	750K	1,000K	1,000K	1,000K	1,000K

AIRCREW TRAINING RESEARCH SIMULATOR (ATRES)

During the past decade, the U. S. Army has made tremendous strides in the application of the technology of training in its aircrew training programs. During this period, the Army has more than kept up with other military training agencies. In the case of aircrew training through simulation, the Army's programs have set the pace, and in the past few years, they have become models for other U. S. and foreign aviator training programs. The Army is at the forefront in the use of aircraft simulators in aircrew training.

There probably are many factors which help account for this state of affairs. Some are economic, and others relate to service tradition; but, the most important factors relate to the manner in which the Army has approached the problem of increasing the efficiency and effectiveness of its aircrew training activities. The emphasis in the Army's approach has been upon implementing modern *training* technology and the use of simulators to achieve training goals.

The Army's approach has stressed that the physical characteristics of training devices and simulators are much less important in training aviators

than are the manner in which the simulators are used and the qualifications of the instructional staff. This approach has emphasized implementing in Army aircrew training programs the advances made through applied training research in a wide range of training settings. Army simulator design and utilization have been determined primarily by the nature of the training mission, as opposed to a more common approach of designing simulators on the basis of aircraft physical characteristics and without regard to training per se, and then adapting training programs to fit simulator characteristics.

During the past several years, however, the research effort which led to the Army's advanced aviator training capability has become less effective. There are two principal reasons for this: Army applications have just about caught up with the state-of-the-training-art with respect to simulation; and operational training devices and simulators have not been generally available to serve as vehicles for the research currently required. But at the same time, the Army's investment in aircrew training simulators is growing at an accelerated pace. If the Army is to maintain its pre-eminence in military aircrew training and continue to meet its increasingly complex and costly aircrew training requirements, an increased emphasis must be placed upon its unique pilot training research requirements.

The conduct of the required research is dependent upon access to research devices, i.e., access to simulators. This research involves development of training programs for specific devices, development of techniques for the use of the various advanced features the newer devices incorporate (e.g., techniques do not exist for training use of some of the advanced features of soon-to-be-delivered Devices 2B31 and 2B33--features never before available in Army aviator training programs), evaluation of the effects upon training

of both hardware and software modifications to the simulators, and, as in the case of Device 2B24, the further development of some of the advanced training features themselves. The Army generally has failed to make adequate provision for such research.

Both the Air Force and the Navy have faced the same problems, but they have responded differently. The Air Force has acquired a simulator wholly devoted to training-related research. This device, the Advanced Simulator for Undergraduate Pilot Training (ASUPT), will be used to develop simulator training equipment and techniques suitable specifically for implementation in that services's undergraduate-level jet pilot training program. The Navy has a research simulator called TRADEC which is used for a broad range of training research applications. These two research programs should be watched with interest by the Army, because it is likely that much can be learned from them concerning the general nature of training through simulation as well as the manner in which simulators can be designed. They cannot be looked to, however, for solutions to Army helicopter pilot training problems or for the development of equipment or techniques of training appropriate to the Army's mission.

It has been suggested that the Army would be in a better position to conduct needed simulator training research if it had a simulator similar to ASUPT or TRADEC. Acquisition of such a device, dedicated to and available for research, would, in many respects, enable more efficient conduct of needed research to support the Army's increasing investment in aircraft simulation.

Clearly, the Army must devise effective ways of using simulation, but acquiring a dedicated research simulator is an expensive route to follow.¹ Further, any simulator, even one designed for research purposes, reflects a single design philosophy and, as such, is not optimally suited for research not envisioned originally. This is a severe limitation which cannot be overcome except by extensive hardware and/or software modification.

An alternative to acquisition of a research simulator would be to make use of operational simulators, i.e., simulators procured for training use, for research purposes. This could be done by acquiring an "extra" device for use exclusively for simulation research, or by making a training simulator available, on some equitable time-sharing basis, for use in the necessary training program development, training technology advancement, and related research activities. Other research could involve use of existing simulators designed for applications other than training. For example, the Advanced Simulation Facility of the Army Missile Command, NASA simulators at Ames and Langley, and research simulators operated by aircraft manufacturers could be used in conjunction with research involving certain equipment-related problems and possibly some training problems.²

¹It is understood through informal sources that the acquisition costs of ASUPT and its associated support equipment and facilities have been in excess of \$24,000,000 (pre-FY 1974 dollars).

²There have been suggestions that the Army might acquire an aircraft development research simulator to be used in research projects related to requirements for data for aircraft under development. The present study did not address simulation other than for training and training-related research. A separate study could address other requirements such as the need for an Army aircraft development simulator. The Army already has available some resources of this type, e.g., the research simulators at Ames Research Center.

Acquisition of a simulator research *capability* is considered necessary if the Army is to continue to develop effective simulator training programs. The route to be taken, however, is not clear. While a case can be made for acquisition of a research-dedicated simulator, it is the writers' judgment that this route should not be pursued without a detailed study of such action. Such a study should involve definition of research programs to be undertaken and tradeoff studies comparing the relative merits and costs of such a simulator versus fulfilling the same research requirements through alternative approaches. Definition of the research *program* to be undertaken is a necessary first step, because the program should dictate the simulator's characteristics, not vice versa.

During FY 1975, it would appear desirable to form a study team to investigate this area and to present detailed program plans and recommendations to the Army concerning the best route to follow in fulfilling the research capability requirement described here. Should a recommendation to acquire such a research simulator result from the study team's investigation, a simulator acquisition project would then be initiated.

In order to provide for the development by the Army of a capability to conduct needed research with a simulator--whether a dedicated research simulator or a time-shared operational simulator--funding estimates have been developed and are included in Table 11, below. These estimates are based upon the assumption that the Army will elect to acquire a dedicated simulator specially designed for research purposes, an action which is not being recommended at this time, however. The estimates provide for contracting for such an acquisition over a three-year period beginning in FY 1976,

with funding beyond that time being at the level judged necessary for operation and maintenance of the resource in order to conduct a full utilization research program. These funds would provide for procurement of a simulator for a two-pilot aircraft (\$8,800,000), a versatile camera-model visual system (\$7,260,000), and components of a computer-based visual system to be added to it (\$3,630,000). Estimated funding requirements for a building to house the simulator (approximately 12,500 square feet) are also included in Table 11.

Table 11
Research Simulator Funding Requirements
(Thousands of Dollars)

Fund Category	Fiscal Year				
	1976	1977	1978	1979	1980
6.3a	8,800	7,260	3,630	-0-	-0-
6.3b	-0-	-0-	250	900	990
MCA	-0-	862	-0-	-0-	-0-

RESEARCH CONDUCTED WITH SIMULATORS

A previously described project, ATRES, involves the acquisition of simulators for use in other research projects. The present project deals with the research that needs to be conducted with ATRES, should a dedicated research simulator be acquired, and/or with other simulators such as Devices 2B24, 2B31, and 2B33, if adequate access to them can be acquired. A well-rounded Army simulation research program must include research in which simulators and other training devices are used to develop specific training

programs, as well as to define better the content of simulator training, the manner in which it is conducted, and the measurement of its effectiveness.

Training Program Development

It has been demonstrated repeatedly at the Army Aviation School and elsewhere that a flight simulator or other training device is only the vehicle for a particular training program, and is often less important than are the organization and content of the training program and the training of the instructional staff. Several instances have been documented in which research aimed at devising better ways of employing a training device in a particular application has resulted in a significant improvement in its transfer-of-training value. Such research aimed at the development of specific training programs is extremely important if the Army's growing investment in simulators is to prove beneficial.

Research should be planned to develop optimum training programs for each of the simulators the Army is acquiring. This has been done in one instance, with Device 2B24. In that case, a program was developed which enables the Army to accomplish essentially all of its initial instrument training in the device, whereas a savings of no more than 25% had been expected prior to the research. Additional savings are possible with that particular simulator as well as with others the Army is procuring, but these savings probably will not be fully realized unless research programs designed to develop optimum ways of using the devices are conducted.

Training Program Content Research

In most instances, simulator training programs are oriented toward meeting a portion of the training objectives of the overall aircraft training programs. When a simulator is introduced into a training program, a sub-set of the training objectives of the program are relegated to the simulator for full or partial accomplishment. However, in the area of malfunction or emergency procedures training, simulator training programs may be the sole means of accomplishing some of those objectives because they cannot be attained at all in the aircraft due to safety of flight considerations.

A fruitful area for Army research, now that high fidelity simulators are becoming available, would be investigation of new simulator training requirements, i.e., the identification of other areas where training via simulation could result in a more effective aviation capability. Such investigations could be conducted in available or soon-to-be-available simulators. For example, a systematic investigation of human performance variables such as fatigue, stress, performance during extended operations, and flight during reduced visibility conditions could lead to the identification and understanding of presently unknown or known inadequacies in existing aircrew training programs and to the definitions of training objectives that would alleviate those inadequacies.

Some inadequacies of present Army aircrew training are reflected in U. S. Army Agency for Aviation Safety (USAAVS) data on aviation accidents. During the years from 1958 to 1972, 7,505 of the 9,331 Army aviation accidents, i.e., 80%, were attributed to pilot error. Such accidents resulted in a yearly average loss of \$58 million in terms of aircrew injuries, deaths,

and aircraft damage.¹ Since accidents caused by pilot error suggest possible deficiencies in training, further study of these errors in relation to existing training programs is justified. For example, the USAAVS records show that a number of these pilot-error accidents are attributable to pilot disorientation, some presumably involving illusions which occur during conditions of reduced visibility. These visual illusion phenomena are poorly understood, and present training programs are known to be inadequate with respect to providing the training pilots need to recognize and cope with them. The allocation of simulator training research resources to investigation of such accidents, for the purpose of identifying additional areas where training could be conducted safely in simulators, would be desirable.

Development of Training Techniques

Training is a technology which can be engaged in, after appropriate training, by reasonably bright and adaptable people, not an art which is an inherent characteristic of a "good instructor." Like other technologies, it is not static, but rather it is continually subject to refinement as new data become available. The Army has contributed significantly to recent advances in the technology of simulator training through its support of various research programs, and, as a consequence, has some of the most cost-effective aircrew training programs to be found anywhere. In view of the increasing role of simulator training in Army aviation, it is appropriate

¹Ricketson, D. S. *Pilot Error as a Cause of Army Helicopter Accidents*, U. S. Army Agency for Aviation Safety, Fort Rucker, AL., March, 1974.

that even more effort be devoted in the future to the development of techniques for more effective training through simulation.

This research could be two-pronged. In one instance, attention should be directed to the techniques of machine-controlled training. The Army has pioneered the area of automatic demonstration of flight maneuvers, automatic training exercise administration, and automatic performance assessment. The work has just begun, and payoffs are largely in the future. The potential benefits in training quality control and world-wide performance standardization make further research in this area desirable. Devices 2B24, 2B31, and 2B33 all have automatic training capabilities to be exploited.

Training technology research should also be directed toward non-machine controlled training techniques. As budget and fuel considerations force the Army to effect extensive reductions in aircraft training, particularly at the undergraduate level, it becomes increasingly important that the training given in simulators and in other training devices be effective training. Even if flight time reductions are not required, the need for increased tactical training, such as NOE, requires that as much of the training objectives as possible be accomplished through cost-effective simulators. To assure this, research involving simulators is needed in sequencing of instructional tasks, peer and crew training, functional context training, new roles for instructors, and a host of other areas. The cost reductions that could be gained through effective techniques of individualizing Army flight instruction, and thereby reducing costly and time-consuming overtraining, probably could more than pay for all the research the Army, Navy, and Air Force are likely to conduct in pilot training over the next decade.

Performance Measurement Research

It is axiomatic that if training is worth conducting, it is worth the effort to verify that the training has been effective. In pilot training, however, it has been accepted that the effectiveness of training would be determined subjectively, largely because economical techniques for objective pilot performance assessment have not been developed. With the advent of flight simulators driven by digital computers, however, it would appear unnecessary to continue to rely so heavily upon the subjective judgment of flight instructors and examiners to determine when an aviator is qualified in a particular aircraft or for a particular mission.

The capability for objective performance measurement is a part of each simulator the Army is buying, but the knowledge required to exploit that capability has yet to be developed. Research is needed to define aviator performance requirements and to devise simulator computer programs that will monitor the relevant parameters during a training exercise or checkride administered in a simulator. If on-line, automatically administered, objective performance assessment techniques can be devised, advanced and highly effective training concepts such as machine adaptive training can be employed routinely to produce qualified Army aviators at minimum cost of time as well as dollars.

Training technology research with simulators has been recognized as a fruitful area of investigation for some time. In fact, most of the Army's investment in simulation research during the past decade, apart from the costs of procuring simulators themselves, has been devoted to this area. Techniques for training devised during work at the Aviation School with

procedures trainers, instrument trainers, and flight simulators has made possible both increases in aviator proficiency and significant reduction in the cost of their training. Similar work by the Air Force and Navy is also under way, and it is expected that techniques developed by these research agencies will be adaptable to Army training programs in many instances

Project Funding

The funding estimates indicated in Table 12 are based upon the estimated level of effort (approximately 10 man-years per year) the Army should invest in the kinds of research described. That research would make use of existing simulators, such as Device 2B24, and devices soon to be available, such as Devices 2B31 and 2B33. Should a dedicated research simulator be acquired, it could also be used in these various research tasks. The expense of operating the particular simulators involved in this research is not included in the estimates in Table 12. It is assumed that the required access to operational simulators would not be extensive and would not place a significant burden upon the resources of the training agency engaged in its operation.

Table 12
Funding Requirements for Training Research
With Existing Simulators
(Thousands of Dollars)

Fund Category	Fiscal Year				
	1976	1977	1978	1979	1980
6.2	275	303	333	366	403
6.3	275	303	333	366	403

AVIATION TRAINING DEVICE MANAGEMENT AND APPLICATION STUDIES

Several references have been made in earlier portions of this report to the need to study particular problems as a part of research or development projects. For example, Step 1 of the training simulator development process involves studies leading to the design of a specific simulator, the specification of training goals to be assigned, and the selection of engineering approaches to be taken to assure its suitability for training. In another instance, a need was stated for a study to investigate alternative ways of obtaining access to simulators so that necessary training-related research might be undertaken. In each of these earlier study references, such effort was conceived largely as part of, or supportive of, a particular research project.

There are other, more general, problems to which study effort should be directed during the coming years. The objectives of these studies would be to yield information, plans and hypotheses related to the design, procurement, management and use of aircrew training equipment. While it is not practical in the present report to attempt to define all topics for such study, several of the more obvious ones are briefly described below in order to illustrate the kinds of studies required. They are all subsumed under a single project summary in Appendix A.

Simulator Research, Development and Utilization Plan

The present study report resulted from a need to forecast funding requirements to support Army simulation research and development activities. In order to forecast such requirements, the activities themselves must be

identified. This task was difficult because of an absence of a coordinated and comprehensive program underlying present and planned future procurements of Army flight simulators and other aircrew training devices. Except for planning which has been specific to SFTS procurements and to the limited simulation research programs of HUMRRO and the Naval Training Equipment Center, Army investments in simulation have been responsive to ad hoc requirements for particular simulators rather than to a coordinated, long-range and broad-scope plan of action.

There is an obvious need for an Army simulator development and utilization plan. The plan should cover the life cycle of simulators and other aircrew training devices, beginning with identification of needs for their development and including their design, development, testing, maintenance, use, and retirement when no longer responsive to changing training needs. The plan should encompass the conduct of research necessary to assure more cost-effective simulator training in the future. It should establish a framework for continuing communications among simulator users, developers, evaluators, and researchers.

The plan should also cover the need to expand the technology of simulator design and utilization, as well as the need to expand the R&D base of both government and industry. Provision should be made in the plan to maintain and expand existing competencies with respect to simulator researchers, designers and manufacturers, as well as to develop a broader competitive base for the future. The plan, since it would of necessity be temporal, must contain provisions for its own continuity, review and updating.

Aircraft Systems Maintenance Trainers Studies

Aircraft systems maintenance training devices are widely used in pilot and aviation mechanic training by all aviation training establishments. It has been the writers' observation that many of these devices, although often quite expensive to procure and operate, have not been subjected to the same careful design study that has been devoted to Army aircraft simulators. Maintenance devices typically are designed to have elements of engineering identity to some aircraft system rather than to training problem requirements. In the case of Army procurement of such devices, they are usually bought from a device "shopping list" along with a new aircraft, with little attention given to design-for-training considerations or, indeed, to what the training requirements are.

It is conceivable that present maintenance training devices are all optimally designed for their training purposes. A few devices that the writers have inspected do reflect application of training design technology. Others, however, lead to some doubt. In any event, it would appear to be of significant potential cost benefit to conduct a systematic study of aviation maintenance training device needs and device employment practices. Of primary concern should be the extent to which the Army's aviation maintenance training devices reflect the state of the art in relevant engineering and training technologies.

Simulator Procurement Practices Studies

The writers' experience in recent Army, Navy and Coast Guard simulator design and procurement projects has led to a conviction that many of the

Army's procurement practices and requirements are adding unnecessary costs to these projects. It is believed that a study, or series of studies, of various aspects of simulator procurement could identify areas where modified requirements could save significant amounts of money. Several possible areas of study are summarized below. There are undoubtedly many others.

At the present time, the data purchased in conjunction with development of a simulator accounts for 10% to 20% of the cost of the engineering development model.¹ Historically, such data packages were required to support subsequent competitive procurement of production quantities of the device and to enable Army maintenance of those devices at remote locations. In view of the limited quantity of any given flight simulator likely to be procured, the complexity of those devices, and the trend toward use of contract maintenance for flight simulators, it is questionable that such extensive and expensive data requirements can be justified for modern simulators. In any event, some of the requirements regarding such factors as data formatting lead to extensive and costly duplications of effort on the part of simulator manufacturers, effort that might best be expended elsewhere.

Some of the Army's requirements concerning details or methods of construction of simulators appear unnecessary, since they are not required in the construction of simulators for non-Army simulator users. It is understood, for example, that the electrical cable bundling requirements for Army simulators, while serving little apparent need, require a much more expensive manufacturing process than do the less demanding requirements of non-Army

¹For specific examples of the estimated cost of documentation in a training device procurement, see the part-task trainer cost estimates in Table B-2, Appendix B.

commercial simulator buyers. While undoubtedly there are construction requirements associated with Army equipment that justifiably exceed those of "best commercial practice," the manner in which Army flight simulators must be used and maintained is much like that of the commercial airlines, and it would seem that their procurement standards, by and large, would be sufficient for Army flight simulators. It is believed that review of some restrictive simulator design requirements, in the light of the Army's simulator use, maintenance and management practices, could identify areas of substantial potential cost savings over the coming decade with no compromise in the quality or performance of the equipment.

Aircraft procurement agencies are adopting design-to-cost requirements that are resulting in significant reductions in the unit price of production aircraft. This is possible because advanced and engineering development model production costs are allowed to increase in order to develop less expensive manufacturing techniques and processes. Simulator procurement agencies, on the other hand, cannot benefit in the same way from cost savings in manufacturing processes, since large-quantity production of simulators is seldom planned. Thus, the design-to-cost procurement management tool is not being applied in the case of simulator procurement by the Army. It would appear that a study designed to adapt the design-to-cost model to Army simulator procurement practices could be of significant value over the coming decade.

Studies of Training Devices for Performance Prediction

The prediction of success in flight training has been one of the primary areas of psychological research almost since the beginning of aviation. Yet,

while progress has been made, the average rate of attrition continues to remain high--about one-third of the candidates selected for flight training do not graduate. There has been some research indicating that training devices can be used as screening devices, i.e., as secondary selection tools, to improve trainee selection. Of particular concern in coming years will be identification of trainees who can successfully cope with the demands of nap-of-the-earth flight. Studies in this area could result in significant cost savings in Army undergraduate pilot training.

Centralization of Simulator Training

Present Army planning for the deployment of simulators calls for their decentralization. Simulators located at the Aviation School will be used principally for school training programs and for proficiency training by non-flight instructor personnel stationed at Fort Rucker. Additional simulators will be located at field units for the proficiency training of aviators located at and near those units.

An alternative approach that should be studied would centralize all simulators at one location--or possibly at several key locations--for the proficiency training of all aviators. Centralization of simulator training would have a number of advantages, e.g., better standardization of training and reduced training costs. The cost of bringing aviators periodically to a centralized simulator training facility would probably be more than offset by the savings resulting from the lesser number of simulators that would be required to provide adequate amounts of training.

Other services are adopting the centralized simulator training approach for their helicopter proficiency training requirements. Both the Air Force

and the Coast Guard conduct annual proficiency training programs for their helicopter pilots, around the world, at Hill Air Force Base, Utah, and at Mobile, Alabama, the locations of their respective helicopter simulators.¹ The Army should undertake a study to determine whether a similar approach to its proficiency training requirements might not be more cost effective, all things considered, than the presently planned decentralized approach. If such should be the case, the location(s) of such a training center(s) should also be addressed in this study.

Studies of Visual Field-of-View Simulation Requirements

Simulator visual display attachments for Army helicopters require wide fields of view (estimates of desired fields of view have exceeded 270° for the AH-1 and AAH). Present visual display technology cannot provide wide viewing angles without sacrificing level of detail or exceeding likely funding restraints. Therefore, it is important that visual displays developed for future Army helicopters provide the viewing angles required for aircrew training, but that such angles not be exceeded unnecessarily.

One of the difficulties involved in developing visual display attachments with optimum viewing angles is simply that these angles are not known for existing or planned helicopters. There is analytic evidence that missions such as target engagement and nap-of-the-earth navigation require side horizontal viewing angles of 90° or more, and possible future missions such as helicopter-to-helicopter gunnery will probably require much wider angles. While requirements for forward vertical viewing angles for some other Army

¹The Navy has no helicopter simulators at the present time.

missions may be relatively small, there is again analytic evidence that side vertical viewing requirements are much wider.

Rather than continuing to design visual display attachments for Army simulators on the basis of judgment and analytic data, it is desirable that studies be initiated to define empirically the viewing angles required to perform necessary training missions in Army helicopters. While study emphasis should be upon requirements for future simulators, with input to the Step 1 design studies to be undertaken for each, existing helicopters can be used to generate the required data.

Simulator Program Language Study

With the increased use of simulators to support Army aircrew training, the efficiency with which those devices are used becomes important. A study is needed of the types of computer assembly and programming languages being employed in Army simulators with a view toward increasing the efficiency and effectiveness of existing programming techniques.

With the existing simulators, significant amounts of time must be spent training personnel to maintain and modify programs using the devices' machine-oriented language. Consideration should be given to development of a higher order or simulator programming language for use with flight simulators. A simulator programming language could produce several major advantages. It would be easier to learn than a machine-oriented language, and a problem written in a simulator programming language would be shorter and easier to debug.

As the Army continues to acquire computer-driven simulators, it is probable that changes in computer complexes will occur. A characteristic of higher order languages is the potential for program conversion to other computers.

This could be a significant advantage since programming costs often exceed hardware costs. Programming languages tend to be relatively machine independent, and ease of conversion becomes an important advantage.

Probably the greatest single advantage to a programming language is that it reduces the total time from inception of the problem to its solution. Higher order languages have been known to cut programming time from months to hours. Development of a higher order language for simulators could improve Army programmer productivity and increase the overall efficiency of future simulators.

Studies Funding Requirements

The studies described in this section of the report represent examples of studies that should be conducted by the Army to assure wider application of the techniques of simulator training with their concomitant savings in training costs, to a wide variety of aircrew training problems. While individual studies such as these require relatively minimum effort--one to three man years, typically--there is a requirement for many such studies. It is appropriate for the Army to plan that there will be a continuing requirement for work such as is described here and to make provision for its funding at some relatively stable level responsive to variances in cost.

For the purposes of this report, it is believed that an annual effort of approximately 20 man years could be profitably devoted to aviation simulator training management and application studies by the Army. This represents a level of effort which is much lower than that presently supported by the Air Force and the Navy (25-30 man years each).

A twenty man year level of effort would require the funding indicated in Table 13 below during the period under review in the present study.

Table 13
Funding Requirements for Training Device
Management and Application Studies
(Thousands of Dollars)

Fund Category	Fiscal Year				
	1976	1977	1978	1979	1980
6.3	1,100K	1,210K	1,331K	1,464K	1,610K

SECTION IV

SIMULATOR COST EFFECTIVENESS AND COST SUMMARIES

SIMULATOR COST-EFFECTIVENESS CONSIDERATIONS

The estimates of the likely costs of developing and procuring training simulators contained in Section II of this report will enable budget planners to request an adequate level of funding of those simulators. Those estimates deal with simulator costs alone, however, not with questions related to whether the use of the devices, once they have been procured, would be economical. Undoubtedly, the question will arise concerning whether procurement of these simulators, particularly the simulators for the UTTAS, AAH, HLH, and ASH, would enable the Army to conduct the required aircrew training in more economical or cost-effective fashion.

The topic of flight simulator cost-effectiveness is a complex one. There exists no Army-approved model for such determinations, and there are few publications dealing with this subject. Nevertheless, there is need among Army budget planners for a valid, analytical model for predicting cost effectiveness for flight simulators that are being considered for future procurement. While there may be overriding considerations that dictate the procurement of a simulator regardless of cost (e.g., flight safety, or where simulators provide the only feasible means of administering essential training), in most instances a principal basis for their procurement is potential training cost savings through the substitution of simulator training time for more expensive aircraft training time.

The prediction of training cost savings made possible through future simulator procurement involves the following elements: (1) forecasting simulator training costs; (2) forecasting aircraft training costs; (3) forecasting the training flight hour reductions that will result from substitution of simulator training for flight training; and (4) forecasting the number of aircrews to be trained.

The first two cost elements mentioned above are obvious in their relevance. There are difficulties in deriving valid forecasts of their cost, however. For example, in forecasting simulator and aircraft training costs, equipment depreciation must be considered, so an average unit cost for each simulator and aircraft cockpit to be used in training is required. Forecasting this unit cost is complicated by the problems of varying yearly inflation rates and uncertainty concerning the number of production units to be procured. Additional complications arise due to the difficulty of allocating certain training costs between aircraft and simulator. In some cases, a substitution of simulator for aircraft training could result in substantial savings that are difficult to quantify or forecast, such as reduced requirements for firing ranges, lower personnel losses from training accidents, and increased aircrew performance.

The third cost element, that involving simulator-flight substitution, is critical to cost-effectiveness forecasts. In some areas of flight training, a good deal is known about transfer of training from simulator to aircraft, whereas in others, very little is known. For example, there is considerable evidence that the combination of a well-designed simulator

and a well-designed training program can allow the replacement of virtually all undergraduate aircraft instrument training with simulator training on the basis of an hour-for-hour substitution. In contrast, much less is known about simulator substitution ratios for various aspects of flying involving extra-cockpit visual cues such as visual navigation, visual target acquisition, and weapons employment.

The fourth cost element, the number of aircrews to be trained, is particularly important because it bears directly upon the number of simulators which must be procured. In the case of the four helicopters under development, reliable estimates of these numbers could not be derived from presently available information. Previous basis of issue data were not judged suitable for several reasons, for forecasting the numbers of personnel who will be trained to operate the aircraft in question. For example, it is likely that these aircraft will exhibit much higher availability rates than current aircraft due to superior maintainability design. Also, it is possible that continuous operations combat concepts may require additional crews for each aircraft.

No firm data exist at this time concerning any of these four cost elements when applied to the probable cost effectiveness of UTTAS, AAH, HLH, and ASH simulator training. There are some data that will facilitate derivation of estimates of these values, however. Some of these data are the estimated development and procurement costs for the simulators involved. Additional data concerning target aircraft operating costs were obtained from the four aircraft Project Management Offices during the present study. Other data can be extrapolated from other applications. Data from studies

of the cost of training in the UH-1 and the 2B24 at the Aviation School, reported costs of training in somewhat larger and more complicated helicopters and their simulators by the U. S. Coast Guard, and selective comparisons between simulator and aircraft training costs made by commercial airlines can serve as guidelines for the estimation of both simulator and aircraft training costs and of the amount of transfer of training that can be expected in a given course.

Rather than attempting to estimate the absolute cost of training in simulators and aircraft, it was decided that a ratio of costs between these two types of training vehicles would be of more benefit. Firm data were developed during the suitability testing of Device 2B24 that an hour of training in that simulator cost approximately one sixth ($1/6$) of the cost of an hour of training in the UH-1 aircraft. Data are also available from the U. S. Coast Guard which operates two helicopter simulators: devices for the HH-52 and the HH-3. The cost of an hour of training in these simulators is approximately one-tenth ($1/10$) of the cost of an hour in the aircraft. American Airlines reports simulator-to-training cost ratios of approximately 1 to 20 for their larger aircraft simulators. Thus, there exists a reasonable basis of Army and non-Army experience for estimating a ratio of cost between simulator and aircraft training for the simulators identified in this report.

On the basis of indirect evidence such as that described above, it is estimated that an hour of training in the UTTAS and ASH simulators will cost approximately one-fifth ($1/5$) to one-tenth ($1/10$) as much as an

hour of training in these aircraft. For the AAH, the comparable estimate is one-tenth (1/10) to one-fifteenth (1/15) when ordnance costs are included. Because of the very high operating cost of the HLH, it is estimated that the training cost in the HLH simulator will be approximately one-fifteenth (1/15) to one-twentieth (1/20) of the aircraft training costs.

Although these estimates clearly show a cost advantage for simulator training, they do not necessarily indicate that the cost savings resulting from their use will offset the cost of simulator procurement within a reasonable time frame. Rather, they indicate that the more use simulators receive, the greater will be their cost benefits.

A single simulator cockpit can be scheduled for training, based upon Aviation School experience with Device 2B24, for approximately 16 training hours per day, 250 days per year, and still have the reserve training capability likely to be required during periodic peak training loads. This schedule allows for necessary maintenance. Thus, during the ten- to fifteen-year life cycle of a simulator, 40,000 to 60,000 hours of training are available. In the case of Device 2B24, where simulator training costs approximately \$40/hour and aircraft training costs over \$240/hour,¹ the savings during the life of the device will amount to from 8 to 12 million dollars per cockpit if this utilization schedule is followed.

¹Based upon FY 1972 cost data with both aircraft and simulator fully depreciated.

With respect to the amount of simulator time that can be substituted for aircraft time, it also is possible to look to other simulator applications for guidance. In the case of Device 2B24, for example, it has been demonstrated that virtually all UH-1 instrument training requirements can be met in the device. The previously mentioned Coast Guard simulators, neither of which has visual displays, are providing approximately one-fourth (1/4) to one-half (1/2) of the training required to transition aviators to the aircraft simulated. The airlines, using simulators with visual display attachments designed for their particular training requirements, are able to accomplish in excess of 90% of their transition and proficiency maintenance training requirements without recourse to the aircraft. Although the Army will be using these simulators in the meeting of much more stringent tactical training requirements, it would appear safe to plan upon at least half of its aircrew training requirements to be met using the simulators planned for the UTTAS, AAH, HLH, and ASH.

The data discussed here strongly suggest that procuring simulators for the UTTAS, AAH, HLH, and ASH will result in reduced overall training costs. The total of such savings, however, cannot be estimated on the basis of the data available. Until such time as reliable data exist on the four factors previously cited as underlying the prediction of training cost savings, budget planners will be forced to rely partially upon their best judgment concerning the overall justification for a procurement program. However, the budget program data given in this report provide a basis for the development of firm budget programs for the period FY 1976-1980.

COST SUMMARIES

The tables which follow summarize the cost estimates contained in Sections II and III of this report. The cost data contained in these tables reflect the best estimates of the level of funding necessary to provide reasonable assurance that each project can be completed as described herein.

Table 14

Summary of FY 1976-1980 Funding Requirements:
 Simulator Engineering Development and Procurement Projects
 (Thousands of Dollars by Fund Category)

Project.	Fiscal Year					Total
	1976	1977	1978	1979	1980	
UTTAS						
6.4	4,950	5,082	-0-	508	-0-	10,540
OPA	-0-	-0-	419	-0-	25,122	25,541
MCA	-0-	-0-	-0-	1,575	1,731	3,306
AAH						
6.4	82	-0-	15,173	-0-	842	16,097
OPA	-0-	-0-	-0-	498	-0-	498
MCA	-0-	-0-	-0-	-0-	1,340	1,340
ASH						
6.4	82	5,808	5,990	-0-	599	12,479
OPA	-0-	-0-	-0-	410	-0-	410
HLH						
6.4	82	10,527	-0-	714	-0-	11,323
OPA	-0-	-0-	586	-0-	-0-	586
2B24						
OPA	18,876	18,876	18,876	6,292	-0-	62,920
MCA	3,135	2,069	2,272	830	-0-	8,306
2B31						
6.4	-0-	350	-0-	-0-	-0-	350
OPA	-0-	-0-	5,324	-0-	-0-	5,324
2B33						
6.4	-0-	450	-0-	-0-	-0-	450
OPA	-0-	-0-	30,879	33,967	9,341	74,187
MCA	-0-	641	2,820	2,328	-0-	5,789
CH-47 CPT						
OPA	462	-0-	-0-	-0-	-0-	462
AH-1Q CPT						
OPA	341	-0-	-0-	-0-	-0-	341
Aviation School Simulator Bldg.						
MCA	1,726	2,620	-0-	-0-	-0-	4,346
Total						
6.4	5,196	22,217	21,163	1,222	1,441	51,239
OPA	19,679	18,876	56,084	41,167	34,463	170,269
MCA	4,861	5,330	5,092	4,733	3,071	23,087

Table 15

Summary of FY 1976-1980 Funding Requirements:
 Simulator Research and Advanced Development Projects
 (Thousands of Dollars by Fund Category)

Project	Fiscal Year					Total
	1976	1977	1978	1979	1980	
ATVIDS						
6.2	200	250	250	250	250	1,200
6.3	750	1,000	1,000	1,000	1,000	4,750
ATRES						
6.3	8,800	7,260	3,880	900	990	21,830
MCA	-0-	862	-0-	-0-	-0-	862
Training Research						
6.2	275	303	333	366	403	1,680
6.3	275	303	333	366	403	1,680
Training Device Management and Application Studies						
6.3	1,100	1,210	1,331	1,464	1,610	6,715
Total						
6.2	475	553	583	616	653	2,880
6.3	10,925	9,773	6,544	3,730	4,003	34,975
MCA	-0-	862	-0-	-0-	-0-	862

Table 16

Summary of FY 1976-1980 Funding Requirements:
 Simulator Research, Development, and Procurement Projects
 (Thousands of Dollars)

Project	Fiscal Year					Total
	1976	1977	1978	1979	1980	
UTTAS	4,950	5,082	419	2,083	26,853	39,387
AAH	82	-0-	15,173	498	2,182	17,935
HLR	82	10,527	586	714	-0-	11,909
ASH	82	5,808	5,990	410	599	12,869
2B24	22,011	20,945	21,148	7,122	-0-	71,226
2B31	-0-	350	5,324	-0-	-0-	5,674
2B33	-0-	1,091	33,699	36,295	9,341	80,426
CH-47 CPT	462	-0-	-0-	-0-	-0-	462
AH-1Q CPT	341	-0-	-0-	-0-	-0-	341
Aviation School Simulator Bldg.	1,726	2,620	-0-	-0-	-0-	4,346
ATVIDS	950	1,250	1,250	1,250	1,250	5,950
ATRES	8,800	8,122	3,880	900	990	22,692
Training Research	550	606	666	732	806	3,360
Training Device Management and Application Studies	1,100	1,210	1,331	1,464	1,610	6,715
Total	41,136	57,611	89,466	51,468	43,631	283,312

Table 17
Summary of FY 1976-1980 Funding Requirements
(Thousands of Dollars)

Fund Category	Fiscal Year					Total
	1976	1977	1978	1979	1980	
6.2	475	553	583	616	653	2,880
6.3	10,925	9,773	6,544	3,730	4,003	34,975
6.4	5,196	22,217	21,163	1,222	1,441	51,239
OPA	19,679	18,876	56,084	41,167	34,463	170,269
MCA	4,861	6,192	5,092	4,733	3,071	23,949
Total	41,136	57,611	89,466	51,468	43,631	283,312

APPENDIX A
TRAINING SIMULATOR RESEARCH, DEVELOPMENT AND PROCUREMENT
PROJECT SUMMARIES

Project Summary

Project Title: UTTAS Simulator

Objective: To develop simulators and other aircrew training equipment for the Utility Tactical Transport Aircraft System (UTTAS).

Description of the Problem Area: A requirement exists for a UTTAS simulator subsystem of the Synthetic Flight Training System (SFTS). The simulator will be used in conjunction with the UTTAS and with other training devices to provide training for UTTAS aircrews at the Army Aviation School and at aviation field units. The simulator will be used in transition, combat readiness proficiency, and instrument refresher training programs and will play a major role in the Army-wide standardization of UTTAS aviator performance. While the design of the UTTAS will be based upon state-of-the-art technology, advanced developments in the area of visual environment simulation and computer-controlled training and performance assessment will be required. The UTTAS simulator will have the following major components:

(1) Pilot and Copilot Trainee Compartment. The interior of the simulator will be identical to the pilot-copilot compartment in the UTTAS with respect to size, arrangement, and appearance of panels, instruments, controls, seats, and other components. All equipment in this compartment required for ground operation, as well as those required for visual and instrument flight operations, will be functional and will simulate the operation and function of the corresponding equipment in the aircraft.

(2) Flight Instructor Station. A flight instructor station will be located adjacent to the trainee compartment. It will contain all the controls and displays necessary for a flight instructor to administer the training for which the simulator is designed. The flight instructor will be positioned so as to have an unobstructed view of the trainees and their visual displays while having easy access to the instructor control panel.

(3) Visual Display System. The visual display system will simulate a visual environment which will enable the pilot and copilot to perform visual and instrument maneuvers required for UTTAS training without degradation, modification, or compromise of actual aircraft handling characteristics. The system will be based on camera-model technology and will employ state-of-the-art optics and electronics. A design goal will be to provide a horizontal 120° by vertical 50° color field of view generated from one model board with a minimum apparent eye height of seven feet, although compromise of this goal may be necessary.

(4) Motion System. A six-axis motion system will provide acceleration, deceleration, displacement and vibration cues associated with normal and emergency flight conditions for the aircraft. The trainee compartment,

instructor station, and display portions of the visual display system will be contained in an environmentally controlled enclosure mounted on the motion system.

(5) Computer System. The computer system will enable the real time simulation of the UTTAS and management of all related advanced training, navigation/communication, aircraft subsystems, and visual display system programs, and operation of the simulator's built-in test and maintenance diagnostic programs. The computer system will have sufficient capacity to absorb changes in simulation requirements resulting from design changes in the aircraft and aircraft subsystems, new equipment additions to the UTTAS, and expansion of advanced training programs. Computer peripheral equipment will include that necessary to change computer programs and to obtain hard copy records of student performance and maintenance checks.

(6) Advanced Training and Performance Measurement. Advanced training features of the UTTAS simulator will include computer-assisted performance monitoring, measurement, recording and evaluation; performance playback; automatically administered flight demonstrations and exercises; and visual and instrument checkrides.

Related Projects: The Army currently has under development simulators for the CH-47 (Device 2B31) and the AH-1Q (Device 2B33), both of which will constitute major subsystems of the SFTS. It is planned that additional projects will be established to develop SFTS subsystems for the AAH, the HLH, and the ASH. An earlier SFTS subsystem, Device 2B24, is in operation at this time. Other U. S. and foreign military and civilian agencies have similar projects under way.

Approach: The requirement for a UTTAS simulator has been stated in the SFTS Training Device Requirement. The project will be initiated in FY 1975 with the conduct of engineering and training design concept studies. Final design must await selection of a UTTAS aircraft design, but simulator procurement will be expedited by contracting for an engineering development model visual display attachment in FY 1976 and aircraft simulators in FY 1977. This initial device will be delivered to the Aviation School for suitability testing in FY 1979 and ultimately for use in UTTAS aircrew training.

Quantities Required: Present estimates of the extent of projected use of UTTAS simulators indicate an ultimate requirement for one (1) advance development model and ten (10) production models of this simulator, plus at least one cockpit procedures trainer.

Funding Requirement Summary:

FY 1976: 4,950K (6.4)
FY 1977-1980: 6,009K (6.4); 25,122K (OPA); 3,306K (MCA)

Project Summary

Project Title: AAH Simulator

Objective: To develop simulators and other aircrew training equipment for the Advanced Attack Helicopter (AAH).

Description of the Problem Area: A requirement exists for an AAH simulator subsystem of the Synthetic Flight Training System (SFTS). The simulator will be used in conjunction with the AAH and other training devices to provide training for AAH aircrews at the Army Aviation School and at selected aviation field units. The simulator will be used in transition, weapons qualification, combat readiness proficiency, and instrument refresher training programs, and in the Army-wide standardization program for AAH qualified aviators. It will provide training for AAH pilots and gunners separately or as a crew. While the design of the simulator will be similar to that of Device 2B33, additional advanced developments will be required in the area of visual environment simulation, computer-controlled training, performance assessment, and weapons systems simulation. The AAH simulator will have the following major components:

(1) Pilot and Copilot-Gunner Trainee Compartments. Separate trainee compartments, one for the pilot, the other for the copilot-gunner, will be provided. Each compartment will have an independent display system. The interior of each compartment will be identical to the respective portion of the AAH aircraft with respect to size, arrangement, and appearance of panels, instruments, controls, seats, and other components. All equipment in these compartments required for ground and flight operations, including systems checks, day and night visual and instrument flight operations, and ordnance delivery, will be functional and will simulate the operation and function of the corresponding equipment in the aircraft.

(2) Flight Instructor Stations. A flight instructor station will be required for each of the trainee compartments, one associated with the pilot's compartment and another with the copilot-gunner's compartment. Each station will contain all of the controls and displays necessary for the respective flight instructors to administer the training for which the simulator is designed. Each flight instructor will be positioned so as to have an unobstructed view of the trainee and his visual displays while having easy access to the instructor control panel.

(3) Visual Display Systems. The visual display system will provide a visual scene which will enable the pilot or copilot-gunner to perform visual and instrument maneuvers and ordnance deliveries required for AAH training without degradation, modification or compromise of actual aircraft handling characteristics. When the device is operating in an integrated crew training mode, the same visual display will be viewed from each cockpit.

When independent pilot and copilot-gunner training activities are taking place, the visual display will be time-shared between the two trainee compartments. The system will be based on camera-model technology. A design goal will be to provide a horizontal 150° and a vertical 50° color field of view generated from one model board with an apparent eye height of approximately seven feet. Additional design goals will include day and night visual simulation of weapons trajectories and impact signatures and infra-red goggle imagery displays for both crew members. Some compromise of these visual requirements may be necessary.

(4) Motion System. Each trainee compartment, flight instructor station and the associated visual display components will be contained in an environmentally controlled enclosure mounted on a six-axis motion system. These systems will provide acceleration, deceleration, displacement and vibration cues associated with normal and emergency flight conditions for the aircraft.

(5) Computer System. The computer system will enable the real time simulation of the AAH and management of all related advanced training, navigation/communication, weapons, visual display systems, and aircraft subsystems programs; and operation of the simulator's built-in test and maintenance diagnostic programs. The computer system will have sufficient capacity to absorb changes in simulation requirements resulting from aircraft modifications, new equipment additions to the AAH, and expansion of advanced training programs. Computer peripheral equipment will include that necessary to make computer program modifications and to produce hard copy records of student performance and maintenance checks.

(6) Advanced Training and Performance Measurement. Advanced training features of the AAH simulator will include computer-assisted performance monitoring, measurement, recording and evaluation; performance playback; automatically administered flight and weapons systems demonstrations and exercises; and visual flight and weapons systems checkrides.

Related Projects: The Army currently has under development simulators for the CH-47 (Device 2B31) and the AH-1Q (Device 2B33), both of which will constitute major subsystems of the SFTS. It is planned that additional projects will be established to develop SFTS subsystems for the UTTAS, the HLH, and the ASH. An earlier SFTS subsystem, Device 2B24, is in operation at this time. Other U. S. and foreign military and civilian agencies have similar projects under way.

Approach: The requirement for an AAH simulator has been stated in the SFTS Training Device Requirement. The basic configuration of the AAH simulator is expected to be similar to that of Device 2B33. Therefore, initiation of this project will be delayed to take advantage of data generated during suitability testing of Device 2B33. AAH simulator engineering and training design concept studies will be initiated in FY 1978 and will overlap Device 2B33 testing. A contract for an engineering development model will be awarded in late FY 1977. This device will be delivered to the Aviation School in FY 1979 or FY 1980 for suitability testing and ultimately for use in AAH aircrew training.

Quantities Required: Present estimates of the extent of projected use of AAH simulators indicate an ultimate requirement for one (1) engineering development model and three (3) production models of this simulator, plus at least one pilot compartment cockpit procedures trainer.

Funding Requirement Summary:

FY 1976: 82K (6.4)
FY 1977-1980: 16,015K (6.4); 498K (OPA); 1,340K (MCA)

Project Summary

Project Title: HLH Simulator

Objective: To develop simulators and other aircrew training equipment for the Heavy Lift Helicopter (HLH).

Description of the Problem Area: A requirement exists for an HLH simulator subsystem of the Synthetic Flight Training System (SFTS). The simulator will be used in conjunction with the HLH and other training devices to provide training for HLH aircrews at the Army Aviation School and at selected aviation field units. The simulator will be used in transition, cargo transport, combat readiness proficiency, and instrument refresher training, and in the Army-wide standardization program for HLH qualified aviators. While the design of the HLH simulator will be based on state-of-the-art technology, advanced developments will be required in the area of visual environment simulation and computer-controlled training and performance assessment. The HLH simulator will have the following major components:

(1) Pilot-Copilot Trainee Compartment. The interior of the simulator will be identical to the pilot-copilot compartment in the HLH with respect to size, arrangement, and appearance of panels, instruments, controls, seats, and other components. All equipment in this compartment required for ground operations and systems checks, as well as those required for night visual and instrument flight operations, will be functional and will simulate the operation and function of the corresponding equipment in the aircraft.

(2) Hoist Operator Trainee Compartment. A trainee compartment for the HLH hoist operator will be provided. This compartment will be separate from the pilot-copilot compartment, and will provide training for hoist operator crewmen independently of pilot-copilot training activities or in coordination with them, as desired. The compartment will be identical to the interior of the HLH hoist operator station with respect to size, arrangement, and appearance of panels, instruments, controls, seats, and other components. All equipment in this compartment required for normal mission operations will be functional and will simulate the operation and function of the corresponding equipment in the aircraft.

(3) Instructor Stations. An instructor station will be required for each of the two trainee compartments. Each station will be adjacent to the respective trainee compartment. These stations will contain all the controls and displays necessary for instructors to administer the training for which the simulator is designed. The instructors will be positioned so as to have an unobstructed view of the trainees and their respective visual displays while having easy access to the instructor station controls.

(4) Visual Display Systems. A visual display system, capable of independent as well as coordinated display to each trainee compartment, will be required. The system will provide visual scenes which will enable the pilot and the copilot to perform visual and instrument non-tactical maneuvers required for HLH training and for the hoist operator to perform his operational mission. The visual system presentation will be such that the training can be accomplished without degradation, modification, or compromise of actual aircraft handling characteristics. The systems will be based on computer generated visual point-light and surface technology and will employ state-of-the-art optics and electronics. A design goal will be to provide a 150° horizontal, 50° vertical color field of view for pilot and copilot and a 90° horizontal, 75° vertical color field of view for the hoist operator.

(5) Motion Systems. The pilot-copilot compartment and the associated instructor station and visual display components will be contained in an environmentally controlled enclosure mounted on a six-axis motion system which will provide acceleration, deceleration, displacement and vibration cues associated with normal and emergency flight conditions for the aircraft. Corresponding components associated with the hoist operator compartment will be mounted on a two-axis motion system which will provide corresponding cues for that position.

(6) Computer System. The computer system will enable the real time simulation of the HLH and management of all related advanced training, navigation/communication, aircraft subsystems, and visual display system programs; and operation of the simulator's built-in test and maintenance diagnostic programs. The computer system will have sufficient capacity to absorb changes in simulation requirements resulting from design changes in the aircraft and aircraft subsystems and expansion of advanced training programs. Computer peripheral equipment will include that necessary to make computer program modifications and to obtain hard copy records of student performance and maintenance checks.

(7) Advanced Training and Performance Measurement. Advanced training features of the HLH will include computer-assisted performance monitoring, measurement, recording, and evaluation; performance playback; automatically administered flight and hoist operation demonstrations and exercises; and visual flight and instrument checkrides.

Related Projects: The Army currently has under development simulators for the CH-47 (Device 2B31) and for the AH-1Q (Device 2B33), both of which will constitute major subsystems of the SFTS. It is planned that projects will be established to develop additional SFTS subsystems for the AAH, the UTTAS, and the ASH. An earlier SFTS subsystem, Device 2B24, is in operation at this time. Other U. S. and foreign military and civilian agencies have similar projects under way.

Approach: A requirement for an HLH simulator has been stated in the SFTS Training Device Requirement. Early development of this device will permit its use during the training of HLH Operational Test aircrews during FY 1979 and beyond, and thereby will enable a major savings because of the high hourly operating cost of that aircraft. Simulator engineering and training design concept studies will be initiated not later than early FY 1976, and a contract for an engineering development model will be awarded in early FY 1977. The device will be delivered and tested in FY 1979. Upon completion of HLH testing, aircraft design changes will be incorporated into the simulator engineering development model, as well as into a subsequent production model.

Quantities Required: Present estimates of the extent of projected use of HLH simulators indicate an ultimate requirement of one (1) engineering development model and one (1) production model of this simulator. A pilot-copilot cockpit procedures trainer also will be required.

Funding Requirement Summary:

FY 1976:	82K (6.4)
FY 1977-1980:	11,241K (6.4); 586K (OPA)

Project Summary

Project Title: ASH Simulator

Objective: To procure simulators and other aircrew training equipment for the Aerial Scout Helicopter (ASH).

Description of the Problem Area: A requirement is foreseen for an ASH simulator subsystem for the Synthetic Flight Training System (SFTS). The simulator will be used in conjunction with the ASH and other training devices to provide training for ASH aircrews at the Army Aviation School and at selected aviation field units. The simulator will be used in transition, combat readiness proficiency, and instrument refresher training, and in the Army-wide standardization program for ASH qualified aviators. While the basic design of the ASH will be state-of-the-art technology, advanced developments will be required to provide acceptable visual simulation of nap-of-the-earth (NOE) and night operations and computer-controlled training and performance assessment. The ASH simulator will have the following major components:

(1) Pilot and Copilot Trainee Compartment. The interior of the simulator will be identical to that of the forward crew section of the ASH with respect to size, arrangement, and appearance of panels, instruments, displays, controls, seats, and other components. All equipment in this compartment required for ground operations and systems checks, as well as those required for day and night visual and instrument flight operations, will be functional and will simulate the operation and function of the corresponding equipment in the aircraft.

(2) Flight Instructor Station. A flight instructor station will be located next to the trainee compartment. It will contain all of the controls and displays necessary for a flight instructor to administer the training for which the simulator is designed. The flight instructor will be positioned so as to have an unobstructed view of the trainees and their visual displays while having easy access to the instructor control panel.

(3) Visual Display System. The visual display system will simulate a visual environment which will enable the pilot and copilot to perform visual and instrument day or night maneuvers associated with the ASH aircrew training. The visual simulation will not require degradation, modification, or compromise of actual aircraft handling characteristics. The system will be based on camera-model technology. A design goal will be to provide a horizontal 180° , vertical 60° color field of view with a minimum apparent eye height of five feet. An additional goal is to provide infra-red imagery to the pilot and copilot for night operations. Some compromise in these goals may be necessary.

(4) Motion System. A six-axis motion system will provide acceleration, deceleration, displacement and vibration cues associated with normal and

emergency flight conditions for the aircraft. The trainee compartment, instructor station, and display portions of the visual display system will be contained in an environmentally controlled enclosure mounted on the motion system.

(5) Computer System. The computer system will enable the real time simulation of the ASH and management of all related advanced training, navigation/communication, aircraft subsystems, and visual display system programs; and operation of the simulator's built-in test and maintenance diagnostic programs. The computer system will have sufficient capacity to absorb changes in simulation requirements resulting from design changes in the aircraft and its subsystems, new equipment additions to the ASH, and expansion of advanced training programs. Computer peripheral equipment will include that necessary to change computer programs and to obtain hard copy records of student performance and maintenance checks.

(6) Advanced Training and Performance Measurement. Advanced training features of the ASH simulator will include computer-assisted performance monitoring, measurement, recording and evaluation; performance playback; automatically administered flight demonstrations and exercises; and visual and instrument checkrides.

Related Projects: The Army currently has under development simulators for the CH-47 (Device 2B31) and the AH-1Q (Device 2B33), both of which will constitute major subsystems of the SFTS. It is planned that projects will be established to develop additional SFTS subsystems for the AAH, the HLH, and the UTTAS. An earlier SFTS subsystem, Device 2B24, is in operation at this time. Other U. S. and foreign military and civilian agencies have similar projects under way.

Approach: Development of an ASH simulator will be recommended to DA as part of its Study by the ASH Project Office in August 1974. If approved, development of the simulator will be initiated with an engineering and training design concept study beginning in FY 1976. Procurement of this device will be time-dependent upon the selection of an ASH design. Present projections indicate delivery of an engineering development model for suitability testing in FY 1979 and ultimately for use in UTTAS aircrew training.

Quantities Required: Present estimates of the extent of projected use of ASH simulators indicate an ultimate requirement for one (1) engineering development model and ten (10) production models of this device. A requirement for a cockpit procedures trainer for use in initial ASH aircrew qualification training is also foreseen.

Funding Requirement Summary:

FY 1976: 82K (6.4)
FY 1977-1980: 12,397K (6.4); 410K (OPA)

Project Summary

Project Title: Device 2B24

Objective: To continue procurement of production models of Device 2B24 simulators

Description of the Problem Area: A requirement exists for 32 units of the UH-1 subsystem (Device 2B24) of the Synthetic Flight Training System (SFTS) at the U. S. Army Aviation School and at field installations throughout the world. The engineering development model of Device 2B24 was type classified in June 1972. Device 2B24 is being used at the Aviation School in the Initial Entry Rotary Wing Course, the Rotary Wing Instructor Course, the Rotary Wing Qualification Course, and the Instrument Method of Instruction Course. Future use is planned for the Rotary Wing Instrument Flight Examiner Course and for Combat Readiness Proficiency Training, as well as for annual instrument checkrides and for flight instructor standardization at the Aviation School and at aviation field units. Research with the engineering development model demonstrated its capability to yield a savings of approximately \$5,000 per initial entry pilot trainee. Production units of Device 2B24 can be expected to enable comparable savings in other training programs.

Seven production units of Device 2B24 are being procured with FY 1973 and FY 1974 funds, and an additional four units will be procured with FY 1975 funds. The major components of Device 2B24 are:

(1) Four Pilot-Copilot Trainee Compartments. Each Device 2B24 has four pilot-copilot trainee compartments. The interior of each trainee compartment is modeled after the pilot-copilot compartment of the UH-1 with respect to size, arrangement, and appearance of panels, instruments, controls, seats, and other components. All equipment in this compartment required for instrument flight is functional and simulates the operation and function of the corresponding equipment in the actual aircraft. Advanced training controls and displays are also located in the cockpit area to facilitate automatic training features of the SFTS.

(2) In-Cockpit Instructor Position. Each of the four trainee compartments contains an instructor position located directly behind the pilot and copilot seats. It consists of displays and controls providing limited control of training problems and communication links with instructional personnel outside the compartment. This position is designed for use by flight instructors when training from the remote operator console is not appropriate.

(3) Instructor/Operator Console. A single instructor/operator console enables the centralized monitoring of training in all four cockpits. It contains all the controls and displays necessary to the conduct of the training for which the simulator is designed.

(4) Motion Systems Each of the four trainee compartments with its associated in-cockpit instructor position is mounted on a five degree of freedom cascaded motion system which provides acceleration, deceleration, displacement and vibration cues associated with normal and emergency flight.

(5) Computer System The computer system allows the real time simulation and management of all related advanced training, navigation/communication, and aircraft subsystems. Peripheral computer equipment is used to provide hard copy records of student performance and to modify computer programs.

(6) Automated Training and Performance Measurement. Advanced training design features of Device 2B24 include adaptive training, automated demonstrations, briefings, and guided practice; performance recording and playback; and performance measurement. Device 2B24 has an automated mode of operation in which automated training programs may be administered and a checkride mode in which an automated checkride may be given. The automated programs and checkride are not yet operational. Further development of the automated training capability of the device is needed to make its automated training programs operational.

Related Projects: The Army currently has under development simulators for the CH-47 (Device 2B31) and the AH-1Q (Device 2B33), both of which are major subsystems of the SFTS. It is planned that projects will be established to develop additional SFTS subsystems for the UTTAS, the AAH, the HLH, and the ASH. Other U. S. and foreign military and civilian agencies have similar projects under way.

Approach: Procurement of production models of Device 2B24 will continue. FY 1975 funding is adequate for the procurement of approximately four units in addition to one engineering development and seven production units already procured. Procurement of 20 additional units will be phased over a three-year period. For units destined for non-School units, suitable buildings will be required.

Quantities Required: Present estimates of the extent of project use of Device 2B24 indicate a requirement for eight units for the Aviation School and 24 additional units for field installations. Of these, 12 will have been procured with FY 1975 and prior year funds.

Funding Requirement Summary:

FY 1976:	18,876K (OPA); 1,881K (MCA)
FY 1977-1980:	44,044K (OPA); 5,169K (MCA)

Project Summary

Project Title: Device 2B31

Objective: To continue development of simulators for the CH-47 aircraft.

Description of the Problem Area: A requirement exists for a CH-47 simulator subsystem of the Synthetic Flight Training System (SFTS). Development of this simulator began in FY 1972 and is continuing. A contract for an engineering development model was awarded in June 1973, and the device is expected to begin suitability testing in March 1976. The simulator will be used in transition, combat readiness proficiency, load operations, and instrument refresher training programs at the Aviation School and will play a major role in the standardization of CH-47 aviator performance. While the design of Device 2B31 will be based upon state-of-the-art technology, advanced developments in the area of visual environment simulation and computer-controlled training and performance assessment are required. Device 2B31 will have the following major components:

(1) Pilot-Copilot Trainee Compartment. The interior of the trainer will be identical to the pilot-copilot compartment of the CH-47 with respect to size, arrangement, and appearance of panels, instruments, controls, seats, and other components. All equipment in this compartment required for ground operation as well as visual and instrument flight operations will be functional and will simulate the operation and function of the corresponding equipment in the aircraft.

(2) Flight Instructor Station. A flight instructor station will be located at the rear of the pilot and copilot seats. It will contain all of the controls and displays necessary for a flight instructor to administer the training for which the simulator is designed. The flight instructor will be positioned so as to have an unobstructed view of the trainees and the visual displays while having easy access to his control panels.

(3) Visual Display System. The visual display system will provide a visual scene viewed through the pilot and copilot forward window which will enable either trainee to perform many visual and instrument maneuvers required for CH-47 training. The system will be based on camera-model technology and will employ state-of-the-art optics and electronics. The system will provide a horizontal 48° by vertical 36° color field of view generated from one model board. Additional computer generated representation of the terrain will be presented to each pilot through the "chin bubbles" of the simulator.

(4) Motion System. A six-axis motion system will provide acceleration, deceleration, displacement and vibration cues associated with normal and emergency flight conditions for the aircraft. The trainee compartment, instructor station, and display portions of the visual display system will be contained in an environmentally controlled enclosure mounted on the motion system.

(5) Computer System. The computer system will enable the real time simulation of the CH-47 and management of all related advanced training, navigation/communication, aircraft subsystems, and visual display system programs, and operation of the simulator's built-in test and maintenance diagnostic programs. The computer system will have sufficient capacity to absorb changes in simulation requirements resulting from aircraft modifications, new equipment additions to the CH-47, and expansion of advanced training programs. Computer peripheral equipment will include that necessary to make computer program changes and to produce hard copy records of student performance and maintenance checks.

(6) Advanced Training and Performance Measurement. Advanced training features of the CH-47 simulator will include computer-assisted performance monitoring, measurement, and recording; performance playback; automatically administered flight demonstrations; and visual and instrument checkrides.

Related Projects: The Army currently has under development a simulator for the AH-1Q (Device 2B33), another major subsystem of the SFTS. It is planned that projects will be established to develop additional SFTS subsystems for the UTTAS, the AAH, the HLH, and the ASH. An earlier SFTS subsystem, Device 2B24, is in operation at this time.

Approach: The engineering development model of Device 2B31 will be delivered to the Army in the third quarter of FY 1976. A building is to be constructed to house it and Device 2B33 at the Aviation School, but it will not be completed prior to the fourth quarter of FY 1976. Suitability testing of Device 2B31 may therefore be delayed. Contracting for a production model of the device is scheduled for FY 1977.

Quantities Required: Present estimates of the extent of projected use of CH-47 simulators indicate an ultimate requirement for one (1) engineering development model and one (1) production model of Device 2B31.

Funding Requirement Summary:

FY 1976:	None
FY 1977-1980:	350K (6.4); 5,324K (OPA)

Project Summary

Project Title. Device 2B33

Objective: To continue development of simulators for the AH-1Q aircraft.

Description of the Problem Area: A requirement exists for an AH-1Q simulator subsystem of the Synthetic Flight Training System (SFTS). Development of this simulator began in FY 1973 and is continuing. A contract for an engineering development model was awarded in January 1974, and the device is scheduled to begin suitability tests in June 1976. The simulator will be used in transition, weapons systems familiarization, combat readiness proficiency, and instrument refresher training programs at the Army Aviation School and at aviation field units, and will play a major role in the Army-wide standardization of AH-1Q aviator performance. It will be used to train AH-1Q pilots and copilot-gunners independently or as crews. While the design of Device 2B33 will be based upon state-of-the-art technology, advanced developments in the area of visual environment simulation and computer controlled training will be required. Device 2B33 will have the following major components:

(1) Pilot Trainee Compartment. The interior of the pilot trainee compartment will be identical to the pilot compartment of the AH-1Q aircraft with respect to size, arrangement, and appearance of panels, instruments, controls, seats and other components. All equipment in this compartment required for ground operation as well as visual and instrument flight operations and weapons employment will be functional and will simulate the operation and function of the corresponding equipment in the aircraft. The helmet sight unit will be simulated.

(2) Copilot-Gunner Trainee Compartment. The interior of the copilot-gunner trainee compartment will be identical to the copilot-gunner compartment of the AH-1Q aircraft with respect to size, arrangement and appearance of panels, instruments, controls, seats, and other components. All equipment in the compartment required for ground operation as well as visual and instrument flight operation and weapons employment will be functional and will simulate the operation and function of the corresponding equipment in the aircraft. The telescopic sight and helmet sight units will be simulated.

(3) Flight Instructor Station. A flight instructor station will be located adjacent to each trainee station. It will contain all the controls and displays necessary for a flight instructor to administer the training for which the simulator is designed. The flight instructor will be positioned so as to have an unobstructed view of the trainee and the visual displays while having easy access to the control panels.

(4) Visual Display System. The visual display system for Device 2B33 consists of two parallel high resolution camera-model systems with

identical model boards. They may both be viewed by the pilot (forward and left side views) and one may be viewed by the copilot-gunner (forward only). During crew training, both trainees will view the same forward scene; during independent training, one system can be assigned to each trainee. Simulation of weapons trajectories and impact signatures is provided. Each display provides a 48° horizontal by 36° vertical color field of view. Simulation of the environment and targets through the telescopic sight unit employs computer generated symbology.

(5) Motion System. Each trainee compartment and its associated instructor station and display portions of the visual display system will be contained in an environmentally controlled enclosure mounted on separate six-axis motion systems. Each system will provide acceleration, deceleration, displacement and vibration cues associated with normal and emergency flight conditions for the aircraft.

(6) Computer System. The computer system will enable the real time simulation of the AH-1Q and management of all related advanced training, navigation/communication, aircraft and weapons subsystems, and visual display system programs; and operation of the simulator's built-in test and maintenance diagnostic programs. The computer system will have sufficient capacity to absorb changes in simulation requirements resulting from aircraft modifications, new equipment addition to the AH-1Q and expansion of advanced training programs. Computer peripheral equipment will include that necessary to make computer program changes and to produce hard copy records of student performance and maintenance checks.

(7) Advanced Training and Performance Measurement. Advanced training features of the AH-1Q simulator will include computer-assisted performance monitoring, measurement, and recording; performance playback; automatically administered flight demonstrations; and visual and instrument checkrides.

Related Projects. The Army currently has under development a simulator for the CH-47 (Device 2B31), another major subsystem of the SFTS. It is planned that projects will be established to develop additional SFTS subsystems for the UTTAS, the AAH, the HLH, and the ASH. An earlier subsystem, Device 2B24, is in operation at this time. Other U. S. and foreign military and civilian agencies have similar projects under way.

Approach: Device 2B33 will undergo acceptance testing in January 1976. A building is to be constructed to house it and Device 2B31 at the Aviation School, but it will not be completed prior to the fourth quarter of FY 1976. Suitability testing of the device may therefore be delayed. Contracting for production models of the device is scheduled for FY 1977.

Quantities Required: Present estimates of the extent of projected use

of AH-1Q simulators indicate an ultimate requirement for one (1) engineering development model and nine (9) production models of this device.

Funding Requirement Summary:

FY 1976: None

FY 1977-1980: 450K (6.4); 74,187K (OPA); 5,789K (MCA)

Project Summary

Project Title: CH-47 Part-Task Trainer

Objective: To procure a cockpit procedures trainer for use in CH-47 transition training.

Description of the Problem Area: A requirement is foreseen for a cockpit procedures trainer for use in conjunction with Device 2B31 and the CH-47 aircraft for CH-47 aircrew training at the U. S. Army Aviation School. The device will permit a reduction in the cost of aircrew training by permitting procedure-associated training to be conducted in it rather than in the more expensive 2B31 or the aircraft.

Related Projects: Cockpit procedures trainers are in use at the Aviation School in UH-1, OV-1, and U-21 training programs and are planned for use in conjunction with all Aviation School transition training courses. Comparable devices are to be procured for the AH-1Q, the UTTAS, the AAH, the HLH, and the ASH.

Approach: The device will be based upon state-of-the-art technology. No developments are required.

Quantities Required: One (1).

Funding Requirement Summary: FY 1976: 462K (OPA)

Project Summary

Project Title: AH-1Q Part-Task Trainer

Objective: To procure a cockpit procedures trainer for use in AH-1Q pilot transition training.

Description of the Problem Area: A requirement is foreseen for a cockpit procedures trainer for use in conjunction with Device 2B33 and the aircraft for AH-1Q aircrew training at the U. S. Army Aviation School. The device will permit a reduction in the cost of aircrew training by permitting procedure-associated training to be conducted in it rather than in the more expensive 2B33 or the aircraft. (Cockpit procedures training for the AH-1Q copilot-gunner will be provided in the 2B33 copilot-gunner compartment at minimum cost since it is expected that sufficient time will be available in that device in excess of the time required for pilot training.)

Related Projects: Cockpit procedures trainers are in use at the Aviation School in UH-1, OV-1, and U-21 training programs and are planned for use in conjunction with all Aviation School transition training courses. Comparable devices are to be procured for the CH-47, the UTTAS, the AAH, the HLH, and the ASH.

Approach: The device will be based upon state-of-the-art technology. No developments are required.

Quantities Required: One (1).

Funding Requirement Summary: FY 1976: 341K (OPA)

Project Summary

Project Title: Advanced Tactical Visual Display System (ATVIDS)

Objective: To develop a visual display system capable of providing tactical nap-of-the-earth, night, and helicopter-to-helicopter gunnery training through simulation.

Description of the Problem Area: In the future, the Army must rely heavily upon the use of simulators for pilot training. Present technology permits generally adequate simulation of present and planned Army aircraft in an instrument flight environment, but the bulk of Army flying takes place in a visual flight environment. Existing visual display system technology was developed primarily for high performance fixed wing aircraft simulators and is limited in the extent that the visual environment of Army rotary wing aircraft can be simulated. Particular deficiencies exist with respect to the environment needed for nap-of-the-earth, night, and helicopter-to-helicopter engagement training. Based upon present technology, an NOE visual display would have to consist of a large-scale model board that would be expensive to fabricate and house, and, in order to provide adequate protection to the optical probe, would require extensive programming to locate surface obstructions in computer memory. Field of view would be much more limited than is considered needed in NOE flight. Areas where technology advances are needed include the following:

(1) Present techniques of terrain model construction do not permit the simulation of scene content at the level of detail required for low airspeed flight near natural or man-made objects at economical scale sizes. Over time, there is a tendency for models to warp and discolor. Large amounts of energy are required to provide adequate lighting of the models. Bulky gantries used to move TV cameras over the board surfaces have inertia characteristics that may preclude simulation of some helicopter maneuvers.

(2) Existing optical probes are bulky, fragile, and limited in field of view and depth of field. Because they are easily damaged or disaligned if contact is made with the model, training at tasks such as nap-of-the-earth navigation involves considerable equipment risk. The angular field of view coverage of existing probes (and display optics) is far less than that which the Army aviator is believed to need.

(3) Techniques do not exist at present to simulate the environment as viewed through night and limited visibility viewing devices such as infra-red goggles and forward looking infra-red.

(4) Techniques for simulating the "other" helicopter in an NOE day or night environment as it seeks cover among the features of the simulated terrain, do not now exist.

Related Research: The Air Force and Navy are actively engaged in research and development programs in the camera-model visual display area. This work is concentrating upon improved field of view, resolution, and color, and the results of most of that work will have immediate application to ATVIDS. Problems related to model construction and probe protection are not of interest to the other services, however. Simulation involving the NOE environment, both day and night, are almost uniquely Army, so Army effort must concentrate upon seeking solution to NOE-related tactical requirements and to adapting Air Force and Navy research findings related to other display considerations (e.g., resolution and field of view) to Army requirements.

Approach: The ATVIDS project is a long-range research and advanced development project which will culminate in a visual display system designed for use in conjunction with training simulators in use during the period 1985-90 (e.g., AAH, ASH and beyond). Toward that goal, there will be research to expand the data base in NOE, night, and air-to-air tactics (e.g., the scene content, field of view, etc., required to conduct a specific aircraft maneuver), concept definition studies, development of laboratory and bread-board devices to test engineering concepts, fabrication of an advanced development model of an ATVIDS, modification of one or more then-existing simulators for use with it, and tests to determine the value of the system in an operational training system.

Funding Summary:

FY 1976: 200K (6.2); 750K (6.3)

FY 1977-1980: 1,000K (6.2); 4,000K (6.3)

Project Summary

Project Title: Aircrew Training Research Simulator (ATRES)

Objective: To acquire a simulator dedicated to the conduct of Army aircrew training research.

Description of the Problem Area: The Army in recent years has stressed the application of training technology in both the design and use of flight simulators. Meeting specific training goals has been emphasized, rather than designing simulators to resemble aircraft and then adapting training goals to fit simulator characteristics. The advances made through applied training research in a wide range of settings have been incorporated into its devices and training programs. As a consequence, the Army's programs have become models for other U. S. and foreign aviator training programs.

During the past decade, however, the research effort which led to the Army's advanced training capability has diminished. Applications have about caught up with the state-of-the-training art with respect to simulator design and training program development, and simulators have not been available to serve as vehicles for the research currently needed to advance that art further. If the Army is to meet its increasingly complex and costly pilot training requirements, simulators must be made available to support the research needed to develop training programs for specific devices, to develop techniques for the use of advanced simulator training capabilities, and to evaluate the effects upon training of various hardware and software changes in the simulators themselves.

There are several possible solutions to this dilemma. One is to acquire a simulator specially designed for the Army's training research needs. Other solutions involve arranging access, for training research purposes, to existing and soon-to-be-available simulators; and procuring an "extra copy" of one of these devices and dedicating it to training research applications.

Faced with similar problems, the Air Force and Navy have acquired specially designed simulators for aviator training research. Similar actions by the Army would enable the Army to pursue its training research requirements without conflict with operational training commitments. In any event, the Army must move in the direction of acquiring a badly needed *capability* to conduct simulator-dependent training research.

Related Research: The Air Force's ASUPT and the Navy's TRADEC, both of which are specially designed simulators dedicated to training research, represent major investments by these services in this problem area. There are other government and industrial aircraft simulators that are suitable in some respects for training research, and occasionally they are used for such purposes. While the Army can benefit from research done with these simulators, particularly with respect to problems related to aircraft simulation per se, the research programs of these other agencies will not address Army-specific training problems.

Approach: During FY 1975, a thorough study should investigate the precise simulator training research needs of the Army, propose a simulator research program based upon training needs and upon gaps in training technology, and identify the best route to follow in fulfilling the research capability requirement described above. Should a recommendation to acquire a research simulator result from this investigation, a simulator acquisition project would be initiated, with initial procurement occurring in FY 1976. This Project Summary was prepared in anticipation of such a study finding and assumes a requirement to procure a specially designed simulator with a visual display system based upon a combination of camera-model and computer-generated image technology.

Funding Requirement Summary:

FY 1976: 8,800K (6.3)
FY 1977-1980: 13,233K (6.3); 784K (MCA)

Project Summary

Project Title. Training Technology Research with Simulators

Objective: To increase the effectiveness of aircrew training conducted in present and future Army aircraft simulators.

Description of the Problem Area: The effectiveness of simulator training is dependent principally upon the manner in which the device is used. Continuing research, consisting of both comprehensive programmed efforts and individual experiments addressed to specific problems, is required to assure that present and future simulators are used in optimum fashion. Conduct of this research will require use of simulators as research tools. Principal areas of research needs include:

(1) Training Program Development. Research to develop optimum training programs for existing simulators and other devices has benefited the Army, and similar efforts should be planned in order to make optimum use of existing, as well as future, simulators. The likely results will be greater transfer of training benefits as well as more rapid amortization of simulator costs.

(2) Training Program Content Definition. Simulators themselves can be used as effective tools in research programs designed to identify training that should be conducted in simulators. One likely fruitful area for new training to be conducted in simulators will be that resulting from aircraft accident investigation and research. Other training objectives can be identified in simulator research related to performance under conditions of stress, extended operations, and reduced visibility.

(3) Training Techniques Development. The Army has benefited greatly from recent research into the technology of simulator training, but much work remains to be done in this area. Simulators are being procured that are potentially capable of largely automatic aircrew training, but the techniques for using that capability are lacking. In addition, research is needed in more conventional instructor-administered simulator training technology areas, such as task sequencing, crew training, and functional context training.

(4) Performance Measurement. The capability for objective performance measurement is a part of each simulator the Army is buying, but the knowledge required to exploit that capability is yet to be developed. The long-range goal of such research is to develop techniques for on-line, automatically administered, objective performance assessment of each aviator throughout his training.

Related Research: The Air Force and Navy are engaged in research related to this problem area. It is anticipated that much of that

research will be of benefit to the Army. In view of the relatively primitive state of the technology involved, however, there is little danger of undue duplication of effort. Nevertheless, an awareness of the work of other research groups should be maintained by agencies conducting training simulator utilization research for the Army.

Approach. The research needed in this area requires access to simulators. Existing and planned Army simulators (Devices 2B24, 2B31, and 2B33) are well-suited for much of the required research. These devices should be made available to in-house and contract research agencies qualified to conduct the required studies. It is expected that research in this area will be a continuing requirement, and maintenance of a long-range research capability should be planned. Continued research should be planned at an initial level of effort of at least 10 man-years per year.

Funding Requirement Summary:

FY 1976: 250K (6.2); 250K (6.3)
FY 1977-1980: 1,405K (6.2); 1,405K (6.3)

Project Summary

Project Title: Aviation Training Device Management and Application Studies

Objective. To enhance Army aviation training through research and development in the utilization and management of aviation training devices.

Description of the Problem Area: The effectiveness of simulation in Army aircrew training can be enhanced through research yielding information related to the design, procurement, management, and use of training devices. This research should take the form of multiple, low level of effort studies which address a variety of Army simulator training problems. Illustrative examples of areas requiring study include:

- (1) Simulator Research, Development, and Utilization Plan. In order to maximize the training benefits it receives through simulation, the Army should develop a coordinated, comprehensive long-range planning program on which to base: (a) simulator development and utilization research; and (b) the procurement and utilization of future simulators and other aircrew training devices.
- (2) Aircraft Systems Maintenance Trainers Studies. Systematic study of Army aviation maintenance training device needs, designs, and employment practices should be undertaken. Of primary concern is whether these devices reflect the state-of-the-art in relevant engineering and training technologies.
- (3) Simulator Procurement Practices Studies. Some Army procurement practices and requirements seem to be adding unnecessary costs to training device design and procurement projects. Systematic study of these practices could yield significant dollar savings to the Army.
- (4) Studies of Training Devices in Performance Prediction. There has been some research indicating that training devices can be used as screening or secondary selection tools to improve pilot trainee selection. Studies in this area could result in significant cost savings in Army undergraduate pilot training.
- (5) Centralization of Simulator Training. The location of Army simulator training--whether centralized at a few key locations or decentralized at aviation field units--should be based upon both cost and training management considerations. Other services, after study, have adopted centralized training to serve world-wide pilot populations. The possible benefits of centralized training to the Army should be determined.
- (6) Simulator Visual Field of View Studies. Army helicopter simulators require wide visual viewing angles to accomplish training goals,

but satisfactory and economical wide angle visual simulation systems are not available. To determine optimum visual viewing angle design requirements for future simulators, studies should gather data defining the viewing angles involved in performance of various training and operational missions for future helicopters.

(7) Simulator Programming Language. At present, manipulation of the computer program used in flight simulators requires considerable time of expert programmers who are familiar with the specific machine languages involved. Development of a higher order simulation computer programming language would be highly desirable and, in view of the Army's growing investment in simulation, would result in increased operating efficiency and cost savings.

Related Research: Studies of aviation training device utilization and management are being carried out by all of the major users of aircraft simulators. Much of this effort will have application in Army simulation, and close liaison will be maintained with other military and civilian aviator training organizations to avoid duplication of effort as well as to assure timely access to their study findings.

Approach A continuing effort will be devoted to the identification of requirements for, and the conduct of, studies that can lead to wider application of the techniques of simulator training and to the more effective management of the Army's simulation resources. While individual studies will be relatively small, the amount of effort required will approximate 20 man years annually. Studies will be conducted by combinations of in-house and contractor personnel with expertise in areas of Army needs.

Funding Requirement Summary:

FY 1976: 1,100K (6.3)
FY 1977-1980: 5,615K (6.3)

APPENDIX B
MATERIALS AND SERVICES COST ESTIMATES

APPENDIX B
MATERIALS AND SERVICES COST ESTIMATES

The estimates of the cost of materials and services included in this report are based upon data provided by principal suppliers of equipment and services related to simulation. The manner in which these estimates were derived is described in the study Introduction, Section I. In summary, suppliers provided budgetary estimates of the probable cost of specified materials and services as of the date of this report, i.e., mid-1974. These various budgetary figures were integrated and adjusted by the Study Team, and the adjusted estimates were treated as the data upon which all funding forecasts were based. This Appendix contains the adjusted data, i.e., the estimated costs of procuring the materials and services specified if they were to be procured approximately 1 July 1974. None of the costs given in this Appendix has been escalated for the out-years as has been done in the body of the report. The reader is referred to the discussion on page 12 for treatment of cost escalation.

Services of Research Personnel

The services of research personnel are estimated to average approximately \$50,000 per professional man year in mid-1974. This figure includes all direct and indirect costs, travel, report preparation, and secretarial support, likely to be required in studies such as those described herein.

Simulator Development and Procurement Costs

The estimated unit costs of procuring the engineering development and production models of the simulators described in this report are identified

in Table B-1. Estimates are provided separately for the Operational Flight Trainer (OFT) and Visual Display Attachment (VDA) portions of each simulator.

Table B-1
1974 Unit Costs of Simulator Development and Procurement
(Thousands of Dollars)

Simulator	Engineering Development Model			Production Model		
	OFT	VDA	Total	OFT	VDA	Total
UTTAS	4,200	4,500	8,700	2,500	2,700	5,200
AAH	6,200	5,200	11,400	3,800	3,800	7,600
HLH	5,900	2,800	8,700	4,000	2,200	6,200
ASH	4,500	4,800	9,300	2,900	3,100	6,000
2B31	NA	NA	NA	2,800	1,200	4,000
2B33	NA	NA	NA	3,000	2,800	5,800
2B24	NA	NA	NA	2,600	NA	2,600

Simulator Modification Costs

The schedules identified in this report for the development of simulators for the four new Army helicopters require procurement of engineering development models prior to completion of development of the helicopters themselves. Funds will be needed to modify these simulators to reflect changes made in the aircraft as a result of its testing. It is estimated that funds equal to approximately 10% of the cost of procuring the OFT portion of the respective simulator engineering development models will be adequate for that purpose. This 10% will be applied to the escalated simulator procurement price.

Part-Task Trainer Procurement

The estimated unit costs of developing a cockpit procedures trainer (CPT) for each of the aircraft under consideration in this report are indicated in Table B-2. Estimates are provided separately for the trainer and for the documentation typically procured with such equipment to illustrate the relative cost of such documentation. The costs indicated for the trainer include a complete, full-scale representation of the simulated aircraft's cockpit to include all panels, instruments, controls, seats and other components; a computer programmed to provide full aircraft and engine simulation of non-flight dependent procedural tasks (including approximately 30 abnormal or emergency conditions); and a simplified control loading system.

Table B-2

1974 Cost of CPT Procurement
(Thousands of Dollars)

Aircraft	Trainer	Documents	Total
UTTAS	240	75	315
AAH	260	80	340
HLH	350	90	440
ASH	220	60	280
CH-47	340	80	420
AH-1Q	240	70	310

Trainer Building Costs

Buildings must be constructed to house the simulators that are to be procured. Estimates of the cost of a trainer building to house each of the simulators described in this report are contained in Table B-3. These estimates are based upon 1974 construction costs of \$57.00 per square foot, and assume that a separate building will be required for each simulator. Estimates of the sizes of the buildings to house the various simulators are based upon allowances for both OFT and VDA portions of the simulators, plus space for associated classrooms, maintenance activities, rest rooms, and briefing and administrative offices. The basis for these allowances for a building to house a simulator for Device 2B33 is presented in Table B-4 for illustrative purposes.

Table B-3

1974 Costs of Trainer Buildings

Simulator	Building Size (sq. ft.)	Cost
UTTAS	6,300	\$359,000
AAH	7,900	\$450,000
HLH	6,100	\$348,000
ASH	6,300	\$359,000
2B31	6,300	\$359,000
2B33	9,300	\$530,000
2B24	5,000	\$285,000

Table B-4
Space Requirements for a 2B33 Simulator Building

Space Use	Area in Sq. Ft.
Pilot OFT	1600
Gunner OFT	1600
Computer Room	600
Two Pump Rooms	400
Four Briefing Rooms	400
Model Board Room	3400
Administrative Space	400
Men's Latrine	200
Women's Latrine	100
Maintenance/Supply	<u>600</u>
TOTAL	9300