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HUMAN FACTORS RESEARCH IN AIRCREW PERFORMANCE AND TRAINING: FINAL SUMMARY REPORT

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for

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   - Flight Surgeons

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This report presents a summary of the work performed by Anacapa Sciences, Inc. (ASI) for ARIARDA at Fort Rucker, Alabama, under Contract No. MDA903-81-C-0504, "Human Factors Research in Aircrew Performance and Training." The report contains summary descriptions for each of 29 projects on which ASI personnel worked during the period 1 September 1981 to 31 December 1985. Each summary description contains (a) a background section that describes the rationale for the research and the research objectives, (b) a research

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rationale for the research and the research objectives, (b) a research approach section that describes the tasks and activities required to fulfill the project objectives, (c) a results section that describes the research findings, and (d) a project status section that describes the work completed and projections for future research, if any.

HUMAN FACTORS RESEARCH IN AIRCREW PERFORMANCE AND TRAINING: FINAL SUMMARY REPORT

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GLOSSARY OF ACRONYMS

AAA - Army Audit Agency
AAFD - Army Aeroflightdynamics Directorate
AAMA - Army Aeromedical Activity
AAPART - Annual Aviator Proficiency and Readiness Test
AATL - Army Applied Technology Laboratory
AC - Active Component
ACE - Aviation Contractor Employees
ADOCS - Advanced Digital Optical Control System
AFTP - Additional Flight Training Period
AH - Attack Helicopter
AHC - Attack Helicopter Company
AHIP - Army Helicopter Improvement Program
ALSE - Aviation Life Support Equipment
ANCOVA - Analysis of Covariance
ANOVA - Analysis of Variance
ANVIS - Aviator Night Vision Image System
APS - Applied Psychological Services
AQC - Aviator Qualification Course
ARIARDA - U.S. Army Research Institute Aviation Research and Development Activity
ARMS - Aviation Resource Management Survey
ARNG - Army National Guard
ARPERCEN - Army Reserve Personnel Center
ARS - Ability Requirements Scale
ARTEP - Army Training and Evaluation Program
ARTI - Advanced Rotorcraft Technology Integration
ASF - Aviation Support Facility
ASI - Anacapa Sciences, Inc.
AT - Annual Training
ATC - Air Traffic Controller
ATM - Aircrew Training Manual
AVG - Academic Average
AVNOAC - Aviation Officer Advanced Course
AVRADA - Avionics Research and Development Activity
AVSCOM - Aviation Systems Command
AWO - Aviation Warrant Officer
BOIP - Basis of Issue Plan
CAS - Close Air Support
CAV - Constant Angular Velocity
CG - Commanding General
CH - Cargo Helicopter
CINC - Commander in Chief
CMS - Camera Modelboard System
CO - Commissioned Officer
COI - Course of Instruction
CONUSA - Continental U.S. Armies
CPG - Copilot/Gunner
CPT - Cockpit Procedural Trainer
CTEA - Cost and Training Effectiveness Analysis

CWEPT	- Cockpit, Weapons, and Emergency Procedures Trainer
DA	- Department of the Army
DARCOM	- Development and Readiness Command
DCD	- Directorate of Combat Developments
DCSOPS	- Deputy Chief of Staff for Operations
DCSPER	- Deputy Chief of Staff for Personnel
DCST	- Deputy Chief of Staff for Training
DES	- Directorate of Evaluation and Standardization
DGFS	- Department of Gunnery and Flight Simulation
DIVARTY	- Division Artillery
DMPM	- Director of Military Personnel Management
DOAS	- Department of Aviation Subjects
DOFT	- Directorate of Flight Training
DOTD	- Directorate of Training and Doctrine
EO	- Electro-Optical
ETM	- Emergency Touchdown Maneuver
FAAO	- Field Artillery Aerial Observer
FAC	- Flight Activity Category; Forward Air Controller
FAR	- Functional Arm Reach
FARP	- Forward Area Arming and Refueling Point
FAST	- Flight Aptitude Selection Test
FC	- Field Circular
FLIR	- Forward-Looking Infrared
FMC	- Fully Modernized Cobra
FORSCOM	- Forces Command
FPT	- Flight Planning Test
FS	- Flight Simulator
FTTD	- Full Time Training Duty
FWS	- Flight and Weapons Simulator
FY	- Fiscal Year
HEL	- Human Engineering Laboratory
HELLFIRE	- Helicopter Launched Fire and Forget Missile System
IERW	- Initial Entry Rotary Wing
IHADSS	- Integrated Helmet and Display Sight System
IMC	- Instrument Meteorological Conditions
IP	- Instructor Pilot
IPR	- In-Progress Review
IRR	- Individual Ready Reserve
LAF	- Light Attenuation Filter
LHX	- Light Helicopter Family
LIG	- Laser Image Generator
LL	- Leg Length
LLA	- Low-Level Autorotation
LLHSA	- Low-Level High-Speed Autoration
MASSTER	- Modern Army System Test and Evaluation Review
MILPERCEN	- Army Military Personnel Center
MITAC	- Map Interpretation and Terrain Analysis Course
MLFA	- Maximum-Likelihood Factor Analysis
MOI	- Method of Instruction
MOPP	- Mission Oriented Protective Posture
MOS	- Military Occupational Specialty

MSI - Method of Successive Intervals
MTFE - Maintenance Test Flight Evaluator
MTO - Manual Throttle Operation
MTP - Maintenance Test Pilot
MUTA - Multiple Unit Training Assembly
NASA - National Aeronautical and Space Administration
NGB - National Guard Bureau
NBC - Nuclear, Biological, Chemical
NOE - Nap of the Earth
NVG - Night Vision Goggles
OAP - Office of Accident Prevention
OH - Observation Helicopter
PC - Peer Comparison
PIC - Pilot in Command
PIP - Product Improvement Program
POI - Program of Instruction
POL - Petroleum, Oil, Lubricants
PNVS - Pilot Night Vision System
PPDR - Pilot Performance Description Record
RC - Reserve Component
RCPAC - Reserve Component Personnel and Administrative Center
RFAST - Revised Flight Aptitude Selection Test
ROC - Required Operational Capability
ROTC - Reserve Officer Training Corps
SA - Standard Autorotation
SARL - Shallow Approach to a Running Landing
SCAS - Stability and Control Augmentation System
SCAT - Scout-Attack Team
SET - Simulation Evaluation Team
SFTS - Synthetic Flight Training System
SH - Sitting Height
SHF - Simulated Dual Hydraulics Failure
SIP - Standardization Instructor Pilot
SME - Subject Matter Expert
SRAF - Simulated Right Antitorque Failure
SWAT - Subjective Workload Analysis Technique
TADS - Target Acquisition and Detection System
TAG - Technical Advisory Group
TD - Training Day
TEC - Training Extension Course
TH - Training Helicopter
THIESIS - Training Helicopter Initial Entry Students in Simulators
TNOD - Training Night Operations During Daylight
TPS - Task Proficiency Survey
TRADOC - Training and Doctrine Command
UH - Utility Helicopter
USAALS - U.S. Army Aviation Logistics School
USAARL - U.S. Army Aeromedical Research Laboratory
USAAVNC - U.S. Army Aviation Center
USAR - U.S. Army Reserve
USAREUR - U.S. Army Europe

USASSB	- U.S. Army Europe Aviation Safety and Standardization Board
USMA	- U.S. Military Academy
UT	- Unit Trainer
UTA	- Unit Training Assembly
VHIRP	- Vertical Helicopter IFR Recovery Procedures
VHSIC	- Very High Speed Integrated Circuit
WOC	- Warrant Officer Candidate

HUMAN FACTORS RESEARCH IN AIRCREW PERFORMANCE AND TRAINING: FINAL SUMMARY REPORT

INTRODUCTION

Since 1 September 1981, Anacapa Sciences, Inc. (ASI) has served as a co-located contractor for the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA), Fort Rucker, Alabama. The period of the original contract covering this effort (Contract No. MDA903-81-C-0504) was from 1 September 1981 to 31 August 1985; however, the contract termination date was subsequently extended to 31 December 1985. One requirement of the contract is to prepare an Annual Summary Report at the end of the first, second, and third year of the contract and a Final Summary Report at the end of the fourth and final year of the contract. The present report, submitted to fulfill the requirement for a Final Summary Report, presents a brief description of each of 29 projects on which ASI personnel have worked during the entire period of this contract (1 September 1981 to 31 December 1985).

Most of the project summaries follow the same format. Each summary begins with a background section that presents the information an uninitiated reader needs to understand the requirement for the project. Also, when relevant, the background section describes the key events that led to the project's initiation. The background section is followed by a concise statement of the project objectives. When the need for the research cannot be inferred clearly from either the background or the objectives, a statement of the need is presented.

The next section of the project summary, entitled "Research Approach, contains a moderately detailed description of what was done to accomplish the project objectives. For some projects, the research approach is an experiment in the strict sense of the word. For other projects, the research approach is a set of analytical or product development tasks. The research approach section is followed by a summary of the research findings or, in the case of product development efforts, a summary description of the product that was produced. The final section of each project summary, entitled "Project Status," describes the work accomplished and work projected, if any.

Summaries of the projects on which effort has been expended during the last 16-month reporting period are presented first. Summaries of the most recent projects are followed by summaries of projects that were completed during the third, second, or first year of the contract.

The final part of the report is an appendix that contains a chronological listing of all the reports and other products (questionnaires, programs of instruction, training modules, grading forms, etc.) developed by ASI personnel during the period of the contract.

It is important to point out that the projects summarized in this report represent only a portion of the work conducted at ARIARDA during the period of the contract; ARIARDA's program also includes numerous projects that are the sole responsibility of ARIARDA personnel. Readers who need additional information about projects summarized in this report or information about other ARIARDA projects are invited to contact Mr. Charles A. Gainer, Chief, ARIARDA. His address and phone number are shown below.

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A COMPUTER ANALYSIS OF LHX AUTOMATION OPTIONS AND THEIR EFFECT ON PREDICTED CREW WORKLOAD

Mr. Theodore B. Aldrich, Project Director

Background

As part of its aviation force modernization effort, the Army is in the conceptual phase of developing a new multi-purpose, lightweight experimental helicopter designated the LHX. One of the major LHX design goals is that it permit a single crewmember to perform scout and attack (SCAT) missions in an Air/Land Battle 2000 scenario. The advantages of a single-crewmember design include:

- a lighter, smaller vehicle,
- increased survivability of a smaller target profile,
- fewer pilot resources for manning the fleet,
- lower training costs, and
- more flight hours for a given pilot-to-aircraft ratio.

The Air/Land Battle 2000 scenario represents a high threat environment that will place heavy workload demands on the LHX operator(s); however, technology currently is being developed to reduce operator workload by automating many of the functions traditionally performed by crewmembers. The technological developments being considered for the LHX include the following:

- an increased number of sensors and target acquisition aids,
- improved navigation and communication systems,
- advanced crew station design features,
- improved flight controls,
- extraordinary avionics reliability,
- self-healing components,
- functional redundancies, and
- reconfigurable features.

While the technology described above is designed to reduce workload, it is possible that the tasks required to use the technology may actually increase the demands on the LHX operator(s). Therefore, to evaluate the role of advanced technology in the development of the LHX, the Army is conducting a series of trade-off analyses. The analyses address both human factors and hardware design issues associated with the development of the LHX.

Need

To assist in the determination of the LHX man-machine design requirements, the Aviation Systems Command (AVSCOM) requested that the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) at Fort Rucker, Alabama, conduct human factors analyses of the LHX SCAT missions. The mission analyses that Anacapa Sciences, Inc.

(ASI) conducted for ARIARDA are designed to predict the workload imposed on the LHX operator(s) in the performance of critical LHX mission segments. Specific objectives of the research and the research approach that was developed to meet the objectives are described below.

Project Objectives

General. The original tasking from AVSCOM defined two general objectives of the LHX research:

- to evaluate the feasibility of single-pilot LHX mission performance, and
- to identify the mission functions and subsystem operations for which automation would be most beneficial.

Phase 1. To meet the objectives, ASI developed a three-phase research approach. The initial phase consisted of manual analyses of critical LHX missions; the analyses were designed to predict the workload of the LHX operator(s) in each of three configurations:

- a one-crewmember baseline configuration assuming subsystems equivalent to technology in the OH-58D and AH-64A;
- a two-crewmember baseline configuration assuming subsystems equivalent to technology in the OH-58D and AH-64A; and
- a one-crewmember configuration assuming a high degree of automation for flight control, target search and acquisition, navigation, and weapon delivery functions.

Results from the initial analyses were rudimentary; nevertheless, the analyses permitted the researchers to achieve three technical objectives:

- development of an objective method for evaluating the feasibility of single pilot operation of the LHX during SCAT missions,
- identification of LHX mission functions and subsystem operations for which automation can reduce pilot workload and enhance mission performance, and
- provision of first iteration estimates of LHX workload and performance times at the function level of analysis.

Phase 2. Phase 2 of the research focused on developing a computerized data base for conducting LHX mission/task/workload analyses; the data base was designed to meet two technical objectives:

- provide a computer analysis of LHX design alternatives, and
- produce computer generated estimates of crew workload during critical mission functions for one- and two-crewmember configurations of the LHX.

To meet the objectives, ARIARDA requested that ASI perform a number of specific tasks:

- program the ARI computer to support entry of mission analysis data and LHX system, subsystem, and mission equipment data;
- enter mission analysis and system, subsystem, and mission equipment data into the computerized data base;
- develop software, including a simulation model, for evaluating the impact of various systems, subsystems, and mission equipment design alternatives on crew workload and performance times; and
- perform evaluative analyses and provide recommendations regarding the impact of design alternatives on operator workload.

The performance of these tasks resulted in the following accomplishments:

- automation of the mission/task/workload analysis data base;
- entry of the LHX generic subsystem identifiers into the data base;
- development of two computer models (one for the one-crewmember configuration and another for the two-crewmember configuration);
- development of four workload indices producible by the models;
- use of the four workload indices to compare the one- and two-crewmember baseline configurations; and
- the conduct of a paper-and-pencil analysis to identify automation options required to reduce excessive workload in the one- and two-crewmember configurations.

Phase 3. During the final phase of the research, iterative analyses of the automation options were conducted by exercising the one- and two-crewmember computer models developed during Phase 2. Specifically, the models were exercised to estimate LHX crewmember workload using (a) 26 individual automation options and (b) 16 combinations of the automation options. The iterative analyses were designed to meet the technical objectives listed below:

- identify the automation options being considered for the LHX,
- determine the predicted impact of each automation option on crew workload,
- determine the predicted impact of selected combinations of automation options on crew workload,
- provide analytical comparisons of one- and two-crewmember configurations of the LHX for each iteration,
- identify the optimum combinations of automation options for reducing workload in both a one- and a two-crewmember LHX, and
- determine the optimum combination of automation options and crewmember composition for the LHX.

Methodology

Phase 1. Phase 1 of the research consisted of a task analysis that featured subjective estimates of workload imposed on the operator(s) during performance of the LHX missions. Twelve missions, set in a European scenario, were divided into phases, segments, functions, and performance elements. The functions were classified into one of three categories and were placed on a rough timeline. The three categories of functions are as follow:

- Flight Control--functions associated with flying the aircraft (e.g., hovering, maneuvering nap-of-the-earth [NOE], and unmasking);
- Mission--functions associated with achieving combat objectives (e.g., acquiring and engaging targets); and
- Support--functions performed in support of flight control and mission functions (e.g., checking systems and threat warning displays, navigating, and communicating).

The performance elements are the basic units of the mission analyses. For each performance element, (a) the generic subsystem was identified, and (b) estimates of performance times and sensory, cognitive, and psychomotor components of workload were derived. The performance element information provided the basis for a series of manual analyses designed to estimate crew workload at the function level of analysis. Workload estimates were computed for each of the three configurations.

Results from the Phase 1 analyses suggest that (a) even with high automation, performance of the LHX mission imposes excessive demands on a single crewmember, and (b) some degree of automation will be required to reduce the workload for two crewmembers.

Phase 2. Phase 2 of the research consisted of developing one- and two-crewmember models that enable various LHX design alternatives to be evaluated quickly. The data derived during Phase 1 were entered into a computer data base. The time estimates for the performance elements were rounded off to the nearest half-second and a computer program was written to produce half-second timelines. The computer models were developed through the use of decision rules written to build functions from the performance elements and, subsequently, to build mission segments from the functions. Computer programs were developed for combining the functions and performance elements in accordance with the decision rules.

The computer models were used to simulate mission segments so that estimates could be produced at half-second intervals for each workload component (i.e., visual, auditory, cognitive, and psychomotor) of the performance elements. The workload estimates generated by the models were used for rapid identification of (a) mission conditions that are likely to result in operator overloads and (b) subsystems that are candidates for automation.

Also during Phase 2, manual analyses were performed to estimate the degree of automation required to eliminate excessive workload in both the one- and two-crewmember configurations. The manual analyses identified 28 automation options required to reduce excessive workload in the one- and two-crewmember configurations.

Phase 3. Phase 3 of the research consisted of exercising the models to predict how much LHX crew workload would be reduced by individual automation options and combinations of options. The performance element estimates of workload are the key variables in the computer models. The models are designed so that the workload estimates can be revised to reflect the impact of any given automation option. An early step in Phase 3 was to review the performance elements and make judgments about how each of the automation options would change the baseline workload estimates. Once the revised estimates had been derived, new computer files were built to reflect the impact of each automation option. Programs were written so that the one- and two-crewmember models could be exercised to predict the level of operator workload associated with any single automation option or any combination of options. Twenty-six of the individual options and 16 different combinations of options were exercised by the one- and two-crewmember models.

Two step-by-step analyses also were performed during Phase 3: one for the one-crewmember configuration and another for the two-crewmember configuration. The step-by-step analyses were designed to identify the optimum combination of automation options for reducing workload in both the one- and two-crewmember configurations. In each analysis, a computer program compared the individual automation option that produces the greatest reduction in workload with each of the remaining options and selected the single option that, when combined with the first option, formed a pair of options that reduces workload more than any other possible pair. The computer program then matched the pair of options with each of the remaining options to identify the set of three options that reduces workload the most. The selection process continued in this manner until additional automation options failed to produce a combination that would reduce workload further. The step-by-step analyses produced an optimum combination of 21 automation options for reducing workload in the one-crewmember configuration and an optimum combination of nine automation options for reducing workload in the two-crewmember configuration.

Results

Results from the computer analyses indicate that for the one-crewmember configuration, a combination of 21 automation options produces the maximum reduction (96%) in excessive workload for the pilot. With this optimum combination, excessive workload remains in six of the 29 mission segments analyzed. In contrast, 83.7% of the excessive workload is reduced by adding a second crewmember. Furthermore, an optimum combination of only nine automation options completely eliminates the remaining excessive workload in the two-crewmember configuration.

The results indicate that a high degree of automation will be required if a single aviator is required to fly and operate the LHX in a scout/attack role on the modern battlefield. Even with a high degree of automation, some mission requirements will impose excessive workload on a single LHX pilot. From a human factors point of view, a one-crewmember LHX design cannot be recommended unless all excessive workload conditions are eliminated.

A dramatic reduction in workload is achievable by allocating mission functions between two crewmembers, but some automation will be required in a two-crewmember LHX. Considered as a whole, the results from the analyses indicate that a two-crewmember design is the preferred configuration for the LHX.

Discussion

The results reported above must be considered tentative until the parameters in the models have been validated. Parameters requiring validation include:

- estimated times assigned to each performance element,
- the temporal relationships among performance elements,
- the procedural relationships among performance elements,
- the total workload estimates (across concurrent performance elements yielded by the models), and
- the threshold for excessive workload.

High fidelity flight simulation of LHX mission segments is the best method available for conducting the required validation studies.

Project Status

Work Completed. At the end of the contract, all three phases of the research project had been completed. The results of the data analyses for each phase have been briefed to Army researchers and to developers who are working on the LHX system development program. Finally, a report describing the methodology and results of each phase has been written and submitted to ARIARDA.

In addition to the three phases of research in the original proposal, a flight simulation study, conducted by the Army Aeroflightdynamics Directorate (AAFD), to evaluate the Advanced Digital Optical Control System (ADOCS) handling qualities provided an opportunity to start the validation of parameters in the models. Five segments in the ASI mission analysis matched segments in the ADOCS simulation scenario. The five segments are:

- assess bomb damage,
- transmit digital report,
- engage air-to-air target,
- maneuver NOE and navigate to firing point, and
- engage ground target.

Four Army test pilots flew 75 simulation trials in a two-crewmember configuration and 74 trials in a one-crewmember configuration. During each trial, ASI and AAFD researchers collected the following data:

- the start and end times for the segments of interest,
- the ADOCS configuration,
- Subjective Workload Analysis Technique (SWAT) ratings,
- NASA bipolar ratings,
- Cooper-Harper handling quality ratings,
- heart-rate recordings,
- flagrant deficiencies in pilot performance, and
- comments about observed pilot workload and other events that will assist in data analysis.

AAFD personnel have agreed to provide results from the analysis of the NASA bipolar and SWAT ratings of workload. They also have agreed to send copies of the video recordings of the simulation trials to assist ASI in the collection of additional data about pilot performance and workload. At the end of the contract, the videotapes from the AAFD simulations had not been delivered and data analysis had not begun.

Work Projected. Since the results from the ADOCS simulation can validate only a few of the parameters in the workload model, a high fidelity flight simulation research program, directed specifically toward validating the parameters in the workload model, is required. The next step in the research is to develop a detailed research plan for conducting the validation.

References

Aldrich, T. B., Craddock, W., & McCracken, J. H. (1984). A computer analysis to predict crew workload during LHX scout-attack missions (Draft Technical Report ASI479-054-84(B), Vol. I, II, III). Fort Rucker, AL: Anacapa Sciences, Inc.

Aldrich, T. B., Szabo, S. M., & Craddock, W. (1985). A computer analysis of LHX automation options and their effect on predicted crew workload (Draft Technical Report ASI479-063-85(B). Fort Rucker, AL: Anacapa Sciences, Inc.

McCracken, J. H., & Aldrich, T. B. (1984). Analyses of selected LHX mission functions (Army Research Institute Technical Note). Fort Rucker, AL: Army Research Institute Field Unit.

SUPPORT TO THE ADVANCED ROTORCRAFT TECHNOLOGY INTEGRATION (ARTI) PROGRAM

Mr. Theodore B. Aldrich, Project Director

Background

The Army is in the conceptual phase of developing a new multipurpose lightweight experimental helicopter designated the LHX. A primary design goal for the LHX is that it permit a single crewmember to perform scout and attack (SCAT) missions in an Air/Land Battle 2000 scenario. The Air/Land Battle 2000 scenario represents a high threat environment that will place heavy workload demands on the LHX operator(s).

The Army is hopeful that advanced technology applied to the LHX can reduce operator workload by automating many of the functions traditionally performed by crewmembers. In furtherance of the single crewmember goal, and as a precursor to full-scale development of the LHX, the Army established the Advanced Rotorcraft Technology Integration (ARTI) program.

The ARTI program is being managed as an advanced development program by the Army Applied Technology Laboratory (AATL) at Fort Eustis, Virginia. Five contractors are independently working to fulfill requirements of the ARTI statement of work. The five contractors are:

- Bell Helicopter,
- Boeing,
- IBM Federal Systems,
- McDonnell Douglas Helicopter Company, and
- Sikorsky Aircraft.

There are six broad objectives of ARTI that, if achieved, should provide direction for the LHX weapon system development program. The seven broad objectives are:

- design an integrated fault-tolerant avionics architecture and automated crew station to enhance helicopter mission capabilities and survivability;
- determine the practicality of the single crewmember man-machine interface based on an assessment of current and emerging technologies;
- mechanize candidate automation concepts in a realistic combat mission simulator to validate single-pilot operability;
- determine improvements in reliability and maintainability (to support two-level maintenance concepts);
- determine reductions in life-cycle costs using shared resources, interchangeable common modules, and other advanced concepts;

- provide supporting data and documentation based on research analysis, simulation, and flight tests to substantiate the above goals; and
- update engineering specifications to begin full-scale LHX development.

To meet these objectives, each ARTI contractor must complete the following nine tasks:

- Task 1: perform mission and task analyses and develop a workload prediction methodology,
- Task 2: perform system architecture and cockpit preliminary design,
- Task 3: perform cockpit and system architecture detailed design,
- Task 4: fabricate and check out an experimental cockpit and system architecture for an operational full-mission simulator,
- Task 5: perform simulation of mission profiles,
- Task 6: perform flight experiments,
- Task 7: prepare final report,
- Task 8: perform LHX electro-optical (EO) system preliminary design, and
- Task 9: perform LHX very high speed integrated circuit (VHSIC) system processor design.

The ARTI program management at AATL established an ARTI Technical Advisory Group (TAG) to provide technical monitoring of the program. Army organizations represented on the TAG include:

- U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) with responsibility for evaluating the adequacy of the contractors' (a) mission/task analyses and (b) methodologies for predicting single crewmember workload;
- Army Aviation Center Directorate of Combat Developments (DCD) with responsibility for evaluating the adequacy of the contractors' (a) understanding of the Battlefield 2000 environment and (b) responsiveness to the multitude of system requirements that will be imposed on a single crewmember performing SCAT missions in that environment.
- Army Aeroflightdynamics Directorate (AAFD) with responsibility for evaluating the adequacy of the contractors' simulation efforts;
- Army Human Engineering Laboratory (HEL) with responsibility for evaluating the adequacy of the contractors' human engineering designs for the ARTI cockpits;

- Army Avionics Research and Development Activity (AVRADA) with responsibility for evaluating the adequacy of the contractors' avionics and system architecture designs;
- Army Night Vision Laboratory with responsibility for evaluating the adequacy of the contractors' sensor designs;
- Army Safety Center with responsibility for evaluating the adequacy of the contractors' designs from a flying safety point of view; and
- Army Aeromedical Research Laboratory (USAARL) with responsibility for evaluating the adequacy of the contractors' designs from an aeromedical point of view.

In a separate project, ARIARDA tasked Anacapa Sciences, Inc. (ASI) to perform a mission/task analysis and to predict crew workload for LHX SCAT mission segments. (A summary of research performed under this project is included in this report, pp. 3-9.) Analysis of the LHX mission tasks and development of the workload prediction methodology provide a background of knowledge that can be applied to the needs of the ARTI program.

Need/Problem

AATL is not staffed with human factors specialists. Therefore, the program managers are dependent upon supporting Army organizations, as represented on the TAG, for technical evaluation of the ARTI contractors' human factors efforts. ARIARDA was tasked to assist in the evaluation of the adequacy of the contractors' mission/task analyses and workload prediction methodologies. The required evaluations started with the contractors' Task 1 efforts and will continue through completion of Task 7. ARIARDA, in turn, tasked ASI to assist with the evaluations because of ASI's experience with the LHX mission analysis project. Specific objectives of the technical evaluations and the approach that was developed to meet the objectives are described below.

Project Objectives

The ARTI general objective is to provide a demonstration of the practicality of single-crewmember operation of the LHX. To meet this objective, the ARTI research was designed to meet the specific objectives listed below. The objectives closely parallel the ARTI Tasks 1 through 7.

- introduce the ARTI contractors to the methodologies used by ASI to develop the LHX mission/task analysis and crew workload predictions;
- evaluate the adequacy of the contractors' mission/task analyses and workload prediction methodologies as developed during ARTI Task 1;

- evaluate whether the results from the contractors' mission/task analyses and workload predictions were used to influence ARTI Task 2 and Task 3 designs,
- evaluate whether the contractors performed iterations of their mission/task workload analyses and workload predictions as they performed their respective ARTI Task 2 and Task 3 designs;
- evaluate whether the results from the contractors' Task 5 flight simulations and Task 6 flight experiments validate their respective workload predictions; and
- evaluate whether the results from ARTI demonstrate the feasibility of single-pilot operability from a workload point of view.

Approach

The program managers at AATL recognized that the development of a workload prediction methodology and the application of workload predictions to decisions about automation and cockpit design in emerging Army systems was without precedence. The managers also recognized that the LHX mission/task analyses and workload prediction methodology developed by ASI could be applied during the conceptual stage of an emerging system. Therefore, to accomplish the first objective outlined above, ASI developed a briefing designed to familiarize each ARTI contractor with the ASI methodology. To meet the remaining objectives for evaluating the contractors' performance, the ASI project director represented ARIARDA as a working member of the ARTI TAG.

The ARTI TAG approach for performing the contractor evaluations consists of (a) reading contractor reports submitted at the end of ARTI Tasks 1, 2, and 7; (b) participating in the ARTI briefings scheduled at the end of Tasks 1, 2, 3, and 7; and (c) conducting independent flight simulation studies in each contractor's simulation facility during Task 5. The Army established a Simulation Evaluation Team (SET) for conducting the independent flight simulation studies. The ASI project director participated in the Task 5 evaluations as a working member of the SET.

Project Status

Work Completed

Introduce the ARTI Contractors to the Methodologies Used by ASI to Develop the LHX Mission/Task Analysis and Crew Workload Predictions. Early in the ARTI contract period, the ASI project director presented a familiarization briefing to the contractors' representatives. The briefing was held at Fort Rucker, Alabama, and consisted of a comprehensive explanation of (a) the ASI mission/task analysis methodology and

(b) the ASI workload prediction methodology and results. Each contractor was provided with a copy of the draft report that was produced at the end of Phase 1 of the LHX mission analysis project. The intent of the briefing was to present to the contractors one workload prediction methodology that could be used; there was no intent to require the ARTI contractors to adopt the ASI methodology.

As a result of the briefing, one contractor adopted the ASI workload prediction methodology with minor refinements. A second contractor used the ASI workload prediction methodology with major modifications. A third contractor used the ASI workload prediction methodology only to screen for probable high workload tasks prior to using the Siegel Wolf computer-based model as the workload prediction methodology. The other two ARTI contractors chose not to use the ASI workload prediction methodology.

Evaluate the Adequacy of the Contractors' Mission/Task Analyses and Workload Prediction Methodologies as Developed During Task 1. Evaluation of the contractors' Task 1 efforts was performed during:

- visits to the contractors' plants prior to completion of Task 1,
- reviews of the contractors' Task 1 reports, and
- participation in the contractors' Task 1 briefings to the ARTI TAG.

Each of these activities is summarized below.

Eight months after the familiarization briefing, the ASI project director, accompanied by ARTI program managers and other members of the ARTI TAG, visited each contractor's plant to review preliminary results from the respective ARTI Task 1 efforts. During the first day of each visit, the contractor described (a) the mission/task analysis methodology and preliminary results and (b) the workload prediction methodology and preliminary results. On the second day, the contractor (a) briefed on the approaches to meeting LHX mission requirements with advanced cockpit technology and (b) conducted plant tours featuring the human factors laboratory and flight simulation capabilities. During these preliminary evaluations, the primary concern was the adequacy of the contractors' mission/task analyses.

Four months later, the contractors' Task 1 reports were delivered to the ASI project director and the ARTI TAG members. Portions of the reports that described (a) the mission/task analyses and (b) the workload prediction methodologies and results were reviewed in preparation for the Task 1 briefings conducted by the contractors one month later.

The month following the contractors' Task 1 briefings, the ASI project director attended the Task 1 briefings conducted by representatives of the ARTI contractors. The briefings summarized the material in the reports and provided the ARTI TAG members with an opportunity to ask the necessary questions for completing the Task 1 evaluations. After reviewing the reports and attending the briefings, the ASI project director prepared letters of evaluation of each contractor's (a) mission/task analysis methodology and results and (b) workload prediction methodology and results. The evaluations made by the ASI project director were consolidated with evaluations from the other TAG members to comprise the overall Task 1 evaluation.

As a result of the Task 1 efforts, all five ARTI contractors concluded that single-pilot operability of LHX appeared feasible. The ASI project director concluded that four of the five contractors had (a) performed a satisfactory mission/task analysis and (b) developed a satisfactory workload prediction methodology. The fifth contractor was directed to expend additional Task 1 effort during Task 2 in order to correct deficiencies in the task analysis and workload prediction methodology.

Evaluate Whether the Results From the Contractors' Mission/Task Analyses and Workload Predictions Were Used to Influence Task 2 and Task 3 Designs. Evaluation of the contractors' Task 2 efforts was performed during:

- reviews of the contractors' Task 2 reports, and
- participation in the contractors' Task 2 briefings to the ARTI TAG.

Two months after completion of the ARTI Task 1 briefings, the contractors' Task 2 reports were delivered to the ASI project director and the ARTI TAG members. The reports were reviewed and evaluated to determine:

- whether each contractor's technology risk assessment had confirmed that the specific automation options required to reduce workload were achievable,
- whether each contractor had revised their mission/task analysis to match the confirmed automation options proposed in the preliminary design,
- whether each contractor's workload prediction methodology appeared to have utility for validating single-pilot design during flight simulation and the flight experiments to follow, and
- whether each contractor's task analysis was consistent with the preliminary design decisions.

The Task 2 briefings were conducted one month after receiving the Task 2 reports. As before, the ASI project director participated in the briefings and prepared written comments that addressed the Task 2 concerns.

As in Task 1, each of the ARTI contractors concluded after Task 2 that single-pilot operability of LHX appeared feasible. The ASI project director concluded that (a) two of the five contractors had satisfactorily completed Task 2, (b) two had marginally completed Task 2, and

(c) the contractor who was deficient in Task 1 was still deficient at the end of Task 2. The ARTI program manager subsequently declared the deficient contractor's performance to be unsatisfactory and instructed the contractor to correct the deficiencies. Two months later, the ARTI program manager and designated TAG representatives travelled to the deficient contractor's site for a second review of the contractor's Task 2 efforts. Four months later, the ARTI program manager and designated TAG representatives travelled to the sites of the two marginally satisfactory contractors for follow-up evaluations. The ASI project director participated in one of the follow-up visits. After the follow-up visits, all contractors were cleared to proceed with Task 3.

Evaluation of the contractors' Task 3 efforts started six months after completion of the first set of Task 2 briefings. The evaluations were performed during two-day visits to the contractors' plants. There was no Task 3 written report; moreover, the ARTI contract did not provide for Army approval/disapproval authority based upon the Task 3 review. Following the Task 3 visit, each contractor submitted (a) a preliminary system specification for the ARTI avionics system and (b) an ARTI computer program development specification.

The ASI project director contributed to the Task 3 evaluation of only one contractor. (Higher priority work on the LHX mission analysis project precluded participation in the evaluation of the other four contractors' Task 3 efforts.) It was determined that the contractor evaluated by the project director had implemented several changes in the Task 2 design; however, the contractor had not updated either the mission/task analysis or the workload predictions to match the updated design. Moreover, the contractor reported problems using the chosen workload prediction methodology at the higher level of task specificity available with the detailed design.

Evaluate Whether the Contractors Validated the Workload Prediction Methodology and Satisfactorily Demonstrated the Practicality of Single-Crewmember Operability During Full-Mission Simulation in Task 5 and the Flight Experiments in Task 6. As stated above, evaluation of the contractors' flight simulator efforts required ASI to participate in extensive preparation as a working member of the Army's SET. The preparations for the SET started immediately after the ARTI TAG had visited the five contractors for the preliminary Task 1 reviews. ASI contributed to the SET preparations by assisting in:

- development of a standardized LHX SCAT composite mission scenario,
- development of a list of performance measures designed to measure operator workload and performance during flight simulation of the scenario,
- development of training plans for the seven Army pilots selected to serve as subjects for the SET studies at each contractor's site,

- development of a high fidelity, independent Army flight simulation facility at NASA Ames, and
- development of independent Army flight simulation studies designed to address the LHX one- vs two-crewmember design question using the NASA Ames simulation facility.

Each of the ASI contributions to the SET preparations is summarized in the paragraphs below.

Development of a Standardized LHX SCAT Composite Mission Scenario. The first step in preparing for the SET was to prepare a composite LHX mission scenario that could be standardized and provided to the five contractors for use during flight simulation trials with the seven SET pilots. ASI participated in the design of the scenario with selected members of the ARTI TAG, augmented by scientists from Monterey Technologies, Inc. Using mission profiles provided by DCD and the LHX mission analysis provided by ASI, the group selected a composite set of mission tasks and arranged them into a standardized LHX mission scenario.

Development of Performance Measures for the Composite Mission Scenario. Next, the group developed a list of performance measures designed to measure operator performance and workload during the flight simulations of the standardized composite mission scenario. To develop the necessary criteria for satisfactory aviator performance, the ASI project director presented the composite mission tasks and their respective performance measures to a group of three subject matter experts (SMEs) at the U.S. Army Aviation Center (USAAVNC) at Fort Rucker, Alabama. The SMEs reached consensus on the requirements for the satisfactory performance of each composite mission task.

The composite LHX mission, complete with mission tasks, performance measures, and criteria for satisfactory performance, was subsequently provided to each ARTI contractor. The intent was for each contractor to implement the standardized scenario and prepare to collect the performance measures during flight simulation trials with the SET.

Development of Plans for Training Subjects for the SET Studies. ASI assisted in developing a training program for the seven Army pilots selected to serve as subjects for the SET evaluations to be performed at each ARTI contractor's flight simulation facility. To develop the program, the ASI project director collaborated with scientists from the Aeroflightdynamics Directorate, Psycholinguistics Research Associates, and Monterey Technologies, Inc. In addition, as part of the training, the ASI project director briefed the seven pilots on (a) the mission/task analysis methodology used to develop the ASI workload prediction model and (b) the methodologies used by each of the contractors to conduct the ARTI Task 1 mission, task, and workload analyses.

Development of an Army Flight Simulation Facility. One of the limitations of ARTI Task 5 is that the contractors will perform the flight simulation studies with only a one-crewmember configuration. However, when the ARTI Task 2 milestone was reached, the Army decided that independent, high-fidelity flight simulation studies were required for both the one- and two-crewmember LHX configurations. It was judged that, without independent simulations, definitive answers to the one- vs two-crewmember design question would not be provided.

Upon request from the Aviation Systems Command (AVSCOM), through ARIARDA, ASI participated in the development of a plan for the Army's in-house flight simulation capability using NASA Ames facilities. One of the projected objectives of the Army in-house simulation studies is to validate the ASI workload prediction methodology. ASI participation in this activity included review and critique of the following:

- a study plan prepared by the Army's Aeroflightdynamics Directorate (NASA Ames) personnel, with the assistance of consultants from Monterey Technologies, Inc. and Psycholinguistics Research Associates;
- a draft facility specification prepared by CAE Electronics Ltd, the contractor selected to fabricate the flight simulation crew stations;
- a draft software proposal, prepared by Flight Systems, Inc., for conducting simulation of the LHX composite mission scenario; and
- a draft interface design specification also prepared by Flight Systems, Inc.

ASI also assisted in the definition of the design for the flight simulator's one-crewmember crew station. The ASI project director prepared a draft best technical approach that Aeroflightdynamics Directorate scientists used to help define the final crew station design features for the one-crewmember configuration.

Development of Army One- vs Two-Crewmember Flight Simulation Studies. ASI participated in the development of a performance measurement plan for the one- vs two-crewmember simulation studies to be conducted at NASA Ames. Specifically, the ASI project director assisted Aeroflightdynamics Directorate scientists in producing a list of variables and a set of building blocks for developing the computer-based performance measurement system. The performance measurement system, as developed, will fulfill requirements for (a) full-mission simulation performance measures, (b) part-task simulation performance measures, and (c) workload and performance measures for validating the ASI workload model.

Work Projected

At contract termination, ARTI Tasks 1, 2, and 3 had been completed. However, continued ARTI TAG support is projected as a program requirement through ARTI Task 7, scheduled for completion on 30 June 1986. The support is necessary to determine whether the contractors will (a) validate their workload prediction methodologies and (b) satisfactorily demonstrate the practicality of single-crewmember operability.

Plans for the Army's SET studies at each of the contractor's sites will require the following additional work:

- developing debriefing questionnaires;
- observing the conduct of the simulation trials;
- debriefing the Army subjects;
- collecting, reducing, and analyzing the performance and workload measurements; and
- briefing the results to the ARTI program managers and all members of the ARTI TAG.

In addition to the work required to complete the SET studies, the ARTI TAG will be required to review the results from the contractors' Task 5 flight simulation studies and Task 6 flight experiments as they are presented during the ARTI Task 7 final briefings and in the ARTI final reports. The ARTI TAG will then assess (a) the SET results and (b) the results presented by the contractors to determine whether the ARTI program has demonstrated the feasibility of single-pilot operability for the LHX.

DEVELOP A DETAILED DATA BASE FOR USE AS INPUT TO A WORKLOAD MODEL FOR THE AH-64 AIRCRAFT

Dr. Sandra M. Szabo, Project Director

Background

The Air/Land Battle 2000 scenario represents a high threat environment that will place heavy workload demands on combat helicopter operators. Advanced technology in the latest generation of Army helicopters is designed to reduce crew workload; however, in some instances the tasks required to use the technology have actually increased workload. The high workload, in turn, reduces mission effectiveness and increases the training necessary for acquiring and maintaining flight proficiency.

One of the primary reasons that technology has failed to reduce operator workload in current Army aircraft is that human factors concepts have not been given adequate consideration during the early stages of system design. In the past, no methodology existed for assessing the workload demands of emerging weapons systems prior to their development. Recently, however, the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) at Fort Rucker, Alabama, developed a methodology for evaluating the role of advanced technology in the development of the proposed Light Helicopter Family (LHX) aircraft. The methodology for predicting LHX workload in advance of system development can be extended to other weapons systems.

As part of its aviation Product Improvement Program (PIP), the Army currently is developing an AH-64B helicopter. The LHX workload prediction methodology can be applied to the PIP to assist in determining the impact that proposed modifications of the AH-64B aircraft will have on operator workload. The methodology thus provides a mechanism for avoiding human factors errors that previously have resulted in costly production changes and decreased operator performance.

The Aviation Systems Command (AVSCOM) has requested that ARIARDA adapt the LHX workload prediction methodology to the AH-64 PIP. In response to the request, ARIARDA currently is conducting a task analysis of the existing AH-64A aircraft. The task analysis data will be used to develop a computer model that can be exercised to yield predictions of the workload associated with various configurations proposed for the emerging AH-64B helicopter.

Project Objectives

The primary objective of the AH-64 workload prediction research is to determine the impact that advanced technology is likely to have on the workload of AH-64 crewmembers. Specifically the research is designed to:

- identify the AH-64 mission functions and subsystems for which design modifications will be most beneficial, and
- determine the predicted impact that various design modifications will have on AH-64 crew workload.

The systematic predictions of workload yielded by the methodology will provide valuable input into early human engineering design decisions for the AH-64B helicopter.

Methodology

The research approach for meeting the objectives consists of three phases. In Phase 1, the AH-64A helicopter will be used to conduct a baseline mission/task analysis of workload. In Phase 2, data provided by the mission/task analysis will be used to develop a computer model of AH-64 workload. In Phase 3, the computer model will be exercised to predict the impact that design modifications are likely to have on crew workload for various AH-64B configurations. Each of the phases is described below.

Phase 1

Phase 1 of the research consists of a mission/task analysis of all phases of the AH-64 attack mission. The tasks to be performed during the conduct of the task analysis are listed below:

- develop a composite mission scenario,
- divide the composite scenario into mission phases,
- divide the mission phases into segments,
- identify the functions in the mission segments,
- identify the tasks for each function,
- identify the subsystem(s) associated with each task,
- estimate the workload for each task,
- estimate the time required to perform each task, and
- allocate the tasks and functions.

Each of the tasks is briefly summarized in the sections that follow.

Develop a Composite Mission Scenario. Five AH-64 attack mission profiles, prepared by the Directorate of Combat Developments (DCD) at the U.S. Army Aviation Center (USAAVNC), were examined. The profiles were used to develop a composite scenario for the AH-64 attack mission. In the scenario, the mission begins with preflight and departure operations performed in the Assembly Area; the pilot flies from the Assembly Area to the Holding Area, where mission coordination is conducted. From the Holding Area the pilot flies to the Battle Area where target acquisition and engagement functions occur. When the weapons are expended, the pilot flies to the Forward Area Arming and Refueling Point (FARP) to refuel and rearm the aircraft. Following refueling and rearming, the crew returns to the Battle Area and again expends the weapons. The pilot then returns, via the Holding Area, to the Assembly Area, where terminal operations and postflight procedures are performed.

Other assumptions characterized by the scenario include the following:

- the pilot's primary function is to fly the aircraft and the gunner's primary function is to acquire and engage targets,
- optimal flight conditions (e.g., excellent weather conditions, no aircraft emergencies) exist throughout the mission, and
- all reconnaissance and team leader functions are performed by the scout pilot.

Divide the Scenario Into Mission Phases. The composite scenario was divided into seven mission phases. The phases are:

- Preflight,
- Departure,
- Enroute,
- Target Servicing,
- FARP Operations,
- Terminal Operations, and
- Postflight.

Divide the Mission Phases Into Segments. Each of the seven mission phases was subsequently divided into mission segments. A mission segment is defined as a major group of events that have a definite start and end point during a mission phase. The number of segments identified in each phase is listed below:

- Preflight - 6,
- Departure - 2,
- Enroute - 7,
- Target Servicing - 30,
- FARP Operations - 4,
- Terminal Operations - 2, and
- Postflight - 2.

Identify the Functions in Each Segment. Each of the 53 segments was further divided into functions. A function is defined as a set of activities that must be performed either by an operator or by equipment in order to complete a portion of the mission segment. A total of 151 unique functions was identified for the 53 segments.

Identify the Tasks for Each Function. Each of the 151 unique functions will be further divided into tasks considered critical to the successful performance of the function. Each task will consist of a verb and an object; the verb will describe the action, and the object will describe the recipient of the action. The tasks will be the basic units of the task analysis.

Identify the Subsystem(s) Associated With Each Task. The subsystems associated with each task will be identified. The subsystems will represent the following major categories of equipment:

- Armament,
- Flight Control,
- Utility,
- Engine,
- Navigation,
- Safety, and
- Visual.

Estimate the Workload Required for Each Task. Workload, as used in the present analysis, consists of three components: sensory, cognitive, and psychomotor. The sensory component refers to the complexity of the visual, auditory, and kinesthetic stimuli to which the operator must respond; the cognitive component refers to the level of thinking required; and the psychomotor component refers to the complexity of the behavioral response required. Short verbal descriptors of each of the workload components will be written for each task. The descriptors will then be compared to verbal anchors contained in seven-point rating scales designed to measure workload for each of the five workload components. In each instance, the analysts will reach consensus in the workload ratings; the consensual ratings will be reviewed by three subject matter experts (SMEs).

Estimate the Time to Perform Each Task. To develop a timeline for the AH-64 mission, it will be necessary to derive estimates of the time required to perform each task. Estimates for many of the tasks will be derived by timing the actual performance of the tasks in the Cockpit, Weapons, and Emergency Procedures Trainer (CWEPT). In assigning the times to the tasks, it will be necessary to define the tasks as discrete, continual, or random. The tasks are defined as follow:

- discrete tasks - tasks that have a definite start and end point in the function,
- continual tasks - tasks that run continually from the beginning to the end of a function, and
- random tasks - discrete tasks that occur intermittently throughout the function.

Allocate the Tasks and Functions. The next task in the analysis is to identify the crewmember who performs each task. Using the checklist, operator's manual, flight training guides, and SMEs, the researchers will assign each task to the pilot, gunner, or both crewmembers. In general, the pilot will be assigned flight tasks, and the gunner will be assigned target acquisition and engagement tasks.

Following the completion of the task analysis, the data will be summarized on function analysis worksheets. The function analysis worksheets will subsequently be reviewed by three AH-64A SMEs.

Phase 2

Phase 2 of the research consists of the following tasks:

- establishment of computer files for the mission/task analysis data,
- development of a computer model of the AH-64A baseline configuration, and
- production of computer estimates of workload for the baseline configuration.

Each of these tasks is described briefly below.

Establish Computer Files. The initial task in Phase 2 of the research is to enter the mission/task analysis data into a computer data base. Information on the Function Analysis Worksheets will be used to create the following data files:

- a list of phases,
- a list of segments,
- a list of functions,
- a list of tasks,
- estimates of workload for each task,
- estimates of time for each task,
- a list of subsystem identifiers, and
- a description of switches.

Develop a Computer Model. The Phase 1 mission/task analysis uses a top-down approach to identify AH-64 tasks (i.e., the analysis starts with a description of the mission and follows, top-down, through the phases, segments, and functions to the task level). The computer model of the AH-64 baseline configuration will use a bottom-up approach with the tasks serving as the basic units of analysis. The bottom-up analysis will be conducted through the use of decision rules that describe how the tasks should be combined to build functions and how the functions should be combined to build segments. Computer programs will then be written for combining the functions and tasks in accordance with the decision rules.

Estimate Workload. The computer models will be used to simulate the mission segments so that workload estimates can be produced at half-second intervals, for each workload component (i.e., visual, auditory, kinesthetic, cognitive, and psychomotor) of the tasks. The workload estimates generated by the computer will be used to identify (a) mission segments that are likely to produce overloads and (b) subsystems that are candidates for automation.

Phase 3

During Phase 3 of the research, the computer model developed and exercised in Phase 2 to provide a baseline analysis of AH-64 crew workload will be exercised to predict how much crew workload might be reduced by proposed configurations for the AH-64B aircraft. The methodology consists of the following steps:

- identify the automation options proposed for the AH-64B model,
- revise the estimates of workload for each task, and
- exercise the model to yield revised estimates of workload.

The results of the analysis can be used to (a) provide estimates of the reduction in workload for various AH-64B configurations and (b) identify the optimal configuration for the AH-64B aircraft.

Utilization/Need

The methodology provides a systematic means for predicting human operator workload in advance of system design. The systematic prediction of workload, in turn, provides an excellent foundation for human engineering decisions early in the development process when decisions are made about the functions that should be assigned to machines. Thus, the model provides an excellent tool for making decisions so that costly changes associated with PIPs will not be required.

In addition, the methodology provides information for identifying emerging training requirements. By assisting in the early identification of training requirements, the methodology provides a means for factoring training costs into trade-off studies conducted during the early stages of system development. Thus, training costs, which are a major contributor to the total life-cycle costs of a system, can be considered in the system design. Such a concept represents a dramatic change from the current system and training development process.

Project Status

Work Completed. Work on the project began 1 October 1985; consequently, by the end of the contract, only Phase 1 of the research had been initiated. Specifically, by 31 December 1985, a draft list of the phases, segments, and functions in the AH-64 mission/task analysis had been developed.

Work Projected. The conduct of the mission/task analysis will be completed. Following the completion of the mission/task analysis, decision rules will be written for combining the tasks into functions and the functions into segments. The workload prediction model will then be developed by writing computer programs for combining the tasks and functions in accordance with the decision rules.

Plans have been made by ARIARDA to (a) use the AH-64 combat mission simulator at Fort Rucker, Alabama, to validate the mission/task analysis and (b) develop and exercise the computer model for conducting the baseline analysis of workload. Assuming the required contractor support is available, it is anticipated that the model can be exercised to predict the impact of proposed configurations of the AH-64B aircraft by the end of FY87.

ANALYTIC ASSESSMENT OF NATIONAL GUARD AVIATOR TRAINING REQUIREMENTS

Dr. Sandra M. Szabo and Dr. John W. Ruffner, Project Directors

Background

An aviator in the Army National Guard (ARNG) must fulfill the same annual training requirements as an aviator in the active Army. The requirements are outlined in the Aircrew Training Manuals (ATMs) for individual training and in the Army Training and Evaluation Program (ARTEP) manuals for collective unit/combined-arms training. Both ATM and ARTEP requirements have changed significantly since the early 1970s, when most ARNG aviators presently in the force were originally trained. Moreover, the ARNG aviation fleet has been modernized significantly since that time and several additional aviator training requirements have been added. The major requirements that have been added include the following:

- instrument qualification,
- NOE qualification,
- unaided night tactical training,
- NVG qualification
- qualification in aircraft specific to the ARNG (e.g., CH-54, OH-6), and
- attack helicopter systems qualification (e.g., AH-1G, AH-1S [MC], AH-1S [Mod]).

In some instances, the courses necessary to meet the additional qualifications are no longer offered by the U. S. Army Aviation Center (USAAVNC) at Fort Rucker, Alabama; in other instances, it is impractical for the ARNG aviators to attend the courses. Therefore, the aviator must obtain the training necessary to meet the requirements by using National Guard support personnel and facilities during his/her available training time.

Despite the increase in the number and complexity of the training requirements that aviators must meet, the amount of time allocated for ARNG aviation training has remained relatively constant since the early 1970s. ARNG aviators currently must accomplish their annual training requirements during a combination of the three types of training periods described below.

Unit Training Assemblies (UTAs). A UTA consists of a four-hour training period. Forty-eight UTAs are allocated annually to each ARNG aviator. Four UTAs typically are scheduled in succession to constitute a weekend drill period. There are 12 weekend drill periods during the year. The drill periods are referred to as Multiple Unit Training Assemblies (MUTAs). MUTAs are authorized for unit training.

Additional Flight Training Periods (AFTPs). An AFTP consists of a four-hour period that is typically used to maintain individual crewmember skills and to accomplish the hands-on flight components of the Annual Aviator Proficiency and Readiness Test (AAPART). ARNG aviators are authorized 24 AFTPs per calendar year.

Annual Training (AT). Annual training periods typically are used for collective unit and combined-arms training employing a threat oriented scenario. Emphasis is placed upon unit operations tasks to ensure effective internal command, control, and communications, as well as external coordination with higher headquarters or supported units. ARNG aviators are authorized 15 days of AT. In addition, another type of training period, a Full Time Training Duty (FTTD) day, can be scheduled for training in the Synthetic Flight Training System (SFTS) and for special missions. FTTDs are scheduled and approved on a case-by-case basis.

Need

The training requirements that the ARNG aviator must meet have significantly increased over the last ten years, while the training time available to the ARNG aviator has remained constant. In addition to the problem of limited training time, ARNG aviators experience a number of other factors that may make it difficult to meet the training requirements. Important factors other than limited training time include the following:

- the ARNG aviators' commitments to their civilian job responsibilities,
- the geographical distances between the ARNG aviators' homes or places of work and the aviation facilities where training is conducted, and
- the ARNG aviators' family and civic responsibilities.

These factors may limit the ARNG aviators' capacity to utilize the currently allocated time in an efficient and effective manner.

Difficulty in meeting the training requirements may seriously reduce the aviators' ability to achieve and maintain a safe level of aviator proficiency. An unsafe level of proficiency, in turn, may cause some of the aviators to leave the National Guard. The potential attrition of large numbers of ARNG aviators is especially critical in view of the "aging of the force." National Guard Bureau (NGB) records indicate that approximately 55% of the aviators now in the ARNG inventory are between 34 and 39 years of age. In addition, within the next five years, approximately 20% of the current ARNG aviator force will be eligible for retirement with 20 years of military service. When these aviators leave the ARNG, a considerable amount of experience and expertise will be lost. Without the experience and expertise of the older aviators, unit commanders may find that it is more difficult for the younger, less experienced ARNG aviators to meet the training requirements.

The NGB recognizes that ARNG aviators may not be able to meet the training requirements in the amount of time that is currently allocated. In an effort to understand existing training time commitments, the NGB requested that the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA), Fort Rucker, Alabama, provide information about the ARNG aviators' ability to meet the training requirements in the amount of time that is presently allocated. The NGB requested that ARIARDA compile the information on seven types of ARNG aviation units:

- attack helicopter company/troop,
- air cavalry troop,
- combat support aviation company,
- aviation general support company,
- aerial surveillance aviation company,
- air ambulance detachment, and
- transportation company.

The information provided by the aviators in these units will be used to determine if additional time is needed to meet ARNG aviation training requirements.

Project Objectives

The ARNG aviation training requirements research has six specific objectives. The objectives are listed below:

- identify demographic characteristics of the current ARNG aviator force (e.g., age, years of service, number of flight hours);
- determine if the amount of time that is spent to meet the current ARNG aviation training requirements exceeds the amount of time that is allocated to meet the requirements;
- identify factors that may affect the ARNG aviators' ability to utilize the allocated time to meet the requirements (e.g., training obstacles, family influences, time commitments to civilian job);
- specify the ARNG aviators' willingness to spend additional time to meet the training requirements;
- identify factors that may influence the ARNG aviators' willingness to spend additional time to meet the training requirements (e.g., attitudes, civilian job requirements, family influences, training obstacles);
- specify the current career intentions of ARNG aviators; and
- identify factors that may influence the career intentions of ARNG aviators (e.g., civilian job requirements, satisfaction with ARNG job).

The objectives were met by compiling data for the total ARNG aviator force and for each of the seven types of ARNG aviation units specified by the NGB.

Research Approach

The research approach developed to meet the project objectives has three phases. Phase 1 consists of a questionnaire survey of all ARNG aviators. The questionnaire was designed to provide information about the aviators' perceptions of the training time and training requirements. In addition, the questionnaire provides information about the aviators' demographic characteristics, their ARNG career intentions, and their willingness to spend additional time to meet the training requirements. Phase 2 consists of an optically scannable training log that the aviators completed each month for 12 months. The training log was designed to provide information about the actual amount of time the aviators spend meeting the training requirements. Phase 3 consists of the consolidation of the data obtained in Phase 1 and Phase 2. A more detailed account of the methodology developed for each of the three phases is given in the following sections.

Phase 1. ARNG Aviator Questionnaire

The questionnaire developed during Phase 1 consists of the three parts described below.

Part 1. Current Training Requirements. In Part 1 of the questionnaire, aviators rated each of the following variables concerning training requirements:

- adequacy of the current training requirements for maintaining a safe level of aviation proficiency,
- adequacy of the time allocated for meeting the training requirements,
- willingness to spend additional paid time to meet the training requirements, and
- willingness to spend additional nonpaid time to meet the training requirements.

In addition, the aviators checked the factors that serve as obstacles to meeting the training requirements.

Part 2. Demographic Characteristics. In Part 2 of the questionnaire, the aviators provided information about the following demographic characteristics:

- personal characteristics (e.g., age, education),
- military characteristics (e.g., aircraft qualifications, total years of military service),
- civilian employment (e.g., income, supervisor's attitude toward ARNG), and
- family factors (e.g., employment of spouse, family attitudes toward ARNG).

Part 3. National Guard Career Intentions. Part 3 of the questionnaire required the aviators to provide information about the following aspects of their career intentions:

- intentions to stay in or leave the ARNG,
- factors influencing the intention to remain in or leave the ARNG,
- satisfaction with the ARNG, and
- general comments about the ARNG.

Phase 2. ARNG Aviator Training Log

Phase 2 was designed to provide objective information concerning the amount of time that is necessary to meet existing ARNG aviation training requirements. Specifically, an optically scannable, computer scored data collection form (Training Log) was developed to enable the ARNG aviators to report hours spent on flying and nonflying training activities during different types of training periods. The aviators reported the amount of time spent on each of the following flying activities:

- meeting ATM minimum iteration requirements and checkrides not as part of ARTEP training (Combined Arms/Collective),
- meeting ATM minimum iteration requirements during ARTEP training,
- meeting ARTEP training requirements exclusive of ATM minimum iteration requirements,
- inflight training and/or evaluation of other aviators exclusive of ATM minimum iteration requirements, and
- performing miscellaneous flight activities exclusive of ATM minimum iteration requirements.

The aviators also reported the amount of time spent on each of the following nonflying activities:

- performing required additional duties (e.g., supply officer, motor officer, administrative duties),
- completing and administering military education, common soldier skills, and career development training (e.g., correspondence courses, academic aspects of aviation qualifications),
- performing preflight and postflight tasks (e.g., pre- post-flight, weather/mission briefs, flight records),
- preparing for, undergoing, and administering oral and written nonflying aviation evaluations (e.g., annual writ, -10 test, flight physicals, checkrides), and
- performing miscellaneous nonflying activities (e.g., crew rest, dead time, inspections, meals, formations).

The aviators reported the amount of time spent on each of the activities described above during the following types of training periods:

- Unit Training Assembly,
- Additional Flight Training Period,
- Full Time Training Duty,
- Annual Training,
- Year Round Annual Training,
- Additional Training Assembly, and
- Split Unit Training Assembly,

In addition, aviators reported the amount of time spent on a nonpay status at the National Guard facility and on a nonpay status away from the National Guard facility (e.g., home, office).

Phase 3. Consolidation of Questionnaire and Training Log Data

Data obtained from the questionnaire and the training log will be consolidated during Phase 3. Analysis of the consolidated data will provide diagnostic information about the aviators' utilization of current training time and their need for additional training time.

Project Status

Work Completed: Phase 1

Pretesting of the questionnaire was completed in September 1984. Following revision of the questionnaire to incorporate feedback derived during the pretest, the questionnaires were sent to the ARNG facilities. A total of 3,640 questionnaires, representing 77% of the ARNG aviator population, was completed and returned by the 31 July 1984 cutoff date. Data from the questionnaires were entered into a data base and verified. Preliminary results of the data analyses were briefed to the National Guard Bureau and to Brigadier General Richard Dean, Deputy Commander of the Army National Guard, in May 1984; final results were briefed in September 1984.

In June 1985, a draft technical report describing the method and results of the questionnaire was submitted to the ARIARDA for formal review. A coordination copy of the draft report was sent to the NGB. The report is entitled "An Evaluation of the Training Requirements of Army National Guard Aviators, Phase 1: Analysis of Questionnaire Data." The major results described in the report are summarized in the paragraphs that follow.

Demographic Characteristics. Fifty-five percent of the aviators have at least a four-year college degree. The aviators typically have professional/technical civilian jobs and earn a median civilian income of $32,500. The aviators spend a median of 50 hours per week on their civilian jobs.

The ARNG aviators have attained a high level of military experience. Eighty percent of the aviators have some type of prior military experience upon entering the National Guard. The aviators have a median of 14 years of total military experience; 12 of these years have typically been spent on flight status. During their time in the military, the aviators have logged a median of 2,000 total flight hours.

Career Intentions. Approximately 25% of the aviators have completed between 15 and 20 years of service and, consequently, will be eligible for retirement within the next five years. However, only 38% of the total force of aviators indicate that they plan to leave the ARNG as soon as they reach 20-year retirement eligibility; 52% indicate that they plan to remain until 30-year retirement.

The three most important reasons for both joining and remaining in the National Guard are Opportunity to Fly, Pay, and Retirement Benefits. Pay and Retirement Benefits are somewhat more important reasons for remaining in the National Guard than they are for initially joining the National Guard. The factor that is most likely to influence the aviators to leave the National Guard is Loss of Flight Status. Unrealistic Training Goals and Administrative Details and Politics were also cited by the majority of the aviators as reasons for possibly leaving the ARNG.

Training Requirements. ARNG aviators judge the training time to be inadequate for meeting all the Continuation Training Requirements. The time is particularly inadequate for meeting Night Vision Goggle (NVG), Unaided Night Tactical, and Tactical/Special requirements; furthermore, the aviators judge that these requirements are inadequate for maintaining a safe level of aviator proficiency.

The aviators judge the training time to be marginally adequate for meeting all Additional Military Requirements except Inflight Evaluation/Training, for which the training time is judged to be inadequate. All of the Additional Military Requirements are judged to be only marginally adequate for maintaining a safe level of aviator proficiency.

The aviators are very willing to spend additional paid time to meet all the Continuation Training Requirements and the Additional Military Requirements that are related to career progression and aviation. The aviators are very unwilling to spend additional nonpaid time to meet any of the training requirements.

Obstacles to Training. The major obstacles that ARNG aviators encounter in meeting the Continuation Training Requirements are an Insufficient Number of Flight Hours and the Unavailability of Instructor Pilots (IPs). The major obstacle to meeting Additional Military Requirements is an Insufficient Amount of Personal Time. The requirement whose accomplishment is impeded most by training obstacles is NVG training; Unavailability of Equipment is the major obstacle to meeting the requirement. In addition, Unavailability of Aircraft and Unavailability of Training Support Areas are obstacles to meeting specific requirements in specific types of units.

Work Completed: Phase 2

Pretesting of the Phase 2 training log was conducted in conjunction with pretesting of the Phase 1 questionnaire. The training logs were mailed to the ARNG facilities in March 1984. The aviators completed the logs each month from June 1984 through May 1985. Analysis of the training log data had begun by the end of the fourth contract year.

Work Projected

Work yet to be completed includes analysis of training log data, coordination of the questionnaire data and training log data, and preparation of a final report. It is anticipated that the analysis of training log data will be completed by June 1986, and that the final project report will be completed by August 1986.

DETERMINATION OF ARMY RESERVE COMPONENT TRAINING REQUIREMENTS

Dr. John W. Ruffner, Project Director

Background

Anacapa Sciences, Inc. (ASI) and U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) personnel recently have conducted research to determine the adequacy of time allocated to meet Army National Guard (ARNG) training requirements and to identify key demographic characteristics of ARNG aviators. The results of this study are reported in detail by Szabo, Ruffner, Cross, and Sanders (1986) and are summarized in this report under the article entitled "Analytic Assessment of National Guard Aviator Training Requirements" (pp. 28-36).

Like their counterparts in the ARNG, aviators in the U.S. Army Reserve (USAR) Component must meet the same annual training requirements as aviators in the active Army. The types of information obtained during the ARNG study are equally valuable for addressing training and personnel management issues in the USAR. Therefore, the First Army Deputy Chief of Staff - Training (DCST) requested that ARIARDA/ASI conduct a similar study to obtain demographic data and information about the adequacy of training requirements and training time for USAR aviators in the First Army area.

Research Approach

The research approach adopted for this project is identical to that used for the ARNG project. The approach is described in Szabo et al. (1986) and in general elsewhere in this report. Briefly, during Phase 1, USAR aviators will complete a questionnaire developed to assess demographic variables, adequacy of current training requirements, adequacy of the time allocated to meet the requirements, and willingness to spend additional time to meet the requirements. During Phase 2, the aviators will provide information monthly about how they spend their time meeting current training requirements. Phase 3 will consist of a consolidation of Phase 1 and Phase 2 results.

Project Status

Work Completed. Work began on the project during June 1985. Separate versions of the data collection forms used in the ARNG study were developed. The Aviator Questionnaire, used to address the demographic and training requirements issues in the ARNG study, was modified slightly to reflect minor differences that exist between the ARNG and USAR (e.g., types of units and aircraft). In addition, a few items were added to the USAR version of the questionnaire to obtain information of interest to the First Army DCST (e.g., extent of simulator utilization).

The USAR version of the ARNG Training Log contains a subset of the training activity categories from the ARNG Training Log that are of particular interest to the First Army DCST. Both of the USAR data collection instruments were pretested in November 1985, and subsequently were revised based on feedback obtained during the pretest visits.

Work Projected. The Aviator Questionnaire will be completed by First Army USAR aviators during July - August 1986. It is anticipated that the report summarizing the results of Phase 1 will be available about 1 January 1987.

The Training Log will be completed by the aviators during September 1986 - February 1987. It is expected that the report summarizing the results of Phase 2 will be available about 1 June 1987, and that the report summarizing Phase 3 will be available about 1 September 1987.

Reference

Szabo, S. M., Ruffner, J. R., Cross, K. D., & Sanders, M. G. (1986). An evaluation of training requirements of Army National Guard aviators. Phase I: Analysis of questionnaire data (Technical Report ASI479-064-85). Fort Rucker, AL: Anacapa Sciences, Inc.

RESEARCH ON THE USE AND BENEFITS OF FLIGHT SIMULATORS FOR TRAINING FIELD UNIT AVIATORS

Dr. George L. Kaempf, Project Director

Background

The Army's Synthetic Flight Training System (SFTS) has been audited by the Army Audit Agency (AAA) on two occasions: first in 1981 and again in 1984. The primary issue in both audit reports is the number of flight simulators required to support the training of field unit aviators. Specifically, both reports concluded that the Army had not adequately quantified the return on its investment in flight simulators used for field unit training. The potential return includes benefits such as a reduction in the number of aircraft flight hours and an increase in the training effectiveness and combat readiness level of the Army's aviator force.

The AAA reports also admonished the Army for the manner in which operational tests had been conducted on the SFTSs. The reports stated that (a) the operational tests should have been conducted in a realistic operational environment with unit aviators, (b) the Army made unwarranted assumptions in its analyses of the operational test data, (c) appropriate methods and controls were not employed during operational testing, and (d) certain training capabilities required by the simulator specifications were not addressed in the operational tests (e.g., nap-of-the-earth [NOE] and night flight). In short, AAA concluded that adequate operational tests had not been performed to verify the putative benefits of using flight simulators as part of continuation training. The 1981 audit concluded that, although flight simulators had reduced the training costs and improved training at the U.S. Army Aviation Center (USAAVNC), the Army had not determined the effects that the employment of flight simulators would have on training in aviation field units. The following quotation summarizes this conclusion.

> Simulators generally meet the needs of the Aviation School. However, the needs of aviators in field units may not be met because training deficiencies have not been identified. The requirements document needs to be revised, giving consideration to current training doctrine and techniques used to satisfy training requirements during mission flying. (U.S. Army Audit Agency, 1982, p. 2)

The purpose of the follow-up audit in 1984 was to determine whether appropriate corrective actions had been taken on the recommendations made in the previous audit report (U.S. Army Audit Agency, 1985). In the second audit, AAA recognized that the Army has changed its bases for the justification of flight simulation. Previously, the Army had based its development of the SFTS program on the premise that simulators pay for themselves by reducing flight hour costs. Subsequently, the Army has taken the position that the number of hours flown in Army aircraft has already been reduced to the absolute minimum and that justification of flight simulators should be based on their ability to enhance training effectiveness and combat readiness. The report concludes, however, that the Army still has not taken the steps necessary to implement the previous audit's recommendation to quantify these benefits.

In response to the AAA audit reports, the Directorate of Training and Doctrine (DOTD) at USAAVNC formally tasked the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) to provide research support that would address the issues raised about the Army's SFTS training program. Specifically, DOTD requested that ARIARDA conduct research to answer such questions as:

- What tasks can best be trained in the simulators?
- What rate of practice in the simulator best enables aviators to maintain proficiency?
- How can the simulator be used to maintain proficiency in cognitive skills when these skills are no longer used on a routine basis?
- What impact does ammunition reduction have on training programs, aviator proficiency, and unit readiness?
- How can the simulator be used to provide Night Vision Goggle (NVG) training?

To answer the research questions, ARIARDA assembled a research team consisting of research psychologists, aviators, and simulation experts. The team subsequently developed a plan of research designed to provide a systematic approach for answering the issues raised by the AAA audits, as well as additional issues identified by other simulation experts (Cross et al, 1984; Cross & Gainer, 1985). The primary objective of the research plan is to generate data with which to (a) specify the type and amount of training that unit aviators should receive in flight simulators and (b) quantify the benefits of this training. Since the use of flight simulators for institutional training was not questioned by AAA, the research plan does not address the issue of employing flight simulation in primary flight training or in aircraft transition courses. Furthermore, for a number of reasons, the research plan was designed to assess the AH-1 Flight and Weapons Simulator (AH1FWS); however, the general approach is suitable for assessing the unit training benefits and limitations of any Army flight simulator (Cross & Gainer, 1985).

Overview of Research Plan

The research plan, which is described in detail in a report by Cross and Gainer (1985), consists of two complementary paths. A Short-Term Path outlines a program of research intended to evaluate and optimize the use of flight simulators that the Army has already acquired or contracted to purchase. The design of these flight simulators is fixed or will be fixed long before the research proposed under the Long-Term Path can be completed. The objectives of the Short-Term Path include (a) the determination of the optimal method of employing the flight simulators that have been or are soon to be fielded and (b) the identification of design modifications that will improve the training effectiveness of fielded simulators without incurring considerable costs.

The Short-Term Path describes a series of training effectiveness studies designed to determine the utility of flight simulators for fulfilling various training needs of aviation field units. However, these studies are resource intensive and their results can be biased by relatively minor problems. Therefore, Cross and Gainer (1985) proposed a backward transfer paradigm, to be conducted prior to the training effectiveness research, to (a) optimize simulator fidelity and performance through low-cost modifications and (b) reduce the scope of subsequent training effectiveness research by providing information about the tasks that can or cannot be trained in the flight simulator.

To begin concurrently with the Short-Term Path, the Long-Term Path describes basic and exploratory research concentrating on training fidelity requirements and the development of training techniques. The objectives of this approach include (a) collecting data to define the relationship between simulator fidelity and training transfer, (b) collecting data to define the relationship between flight simulator production costs and required fidelity in selected flight simulator design parameters, and (c) conducting research to determine the type, cost, and effectiveness of alternative training methods and media.

Need

The Army has purchased and installed five AH1FWSs at Forces Command (FORSCOM) and U.S. Army Europe (USAREUR) sites. In addition, a prototype model AH1FWS is currently in use at USAAVNC, and three additional production models are scheduled for installation at other FORSCOM sites. All AH1FWSs, except the prototype model, have been deployed for use by field unit aviators to conduct continuation/sustainment training. At the time the simulators were fielded, no empirical data existed to identify either the types of training suitable to conduct in the AH1FWS or the cost/training effectiveness of the AH1FWS. Furthermore, the Aircrew Training Manual Commander's Guide (FC 1-210; Department of the Army, 1984b) mandates that the development of unit training programs is the responsibility of the unit commanders. That is, the Army does not provide stringent guidelines for the incorporation or utilization of complex training devices into the training programs of individual units.

Project Objectives

The objectives of the present research effort are (a) to determine the optimal method of employing the AH1FWSs in training field unit aviators and (b) to identify design modifications that will improve the training effectiveness of the fielded AH1FWSs without incurring considerable costs.

Research Approach

The research approach that was developed to meet the project objectives consists of the implementation of the Short-Term Path described by Cross and Gainer (1985). The research prescribed by the Short-Term Path was conducted during two major data collection efforts that include (a) a study investigating the backward transfer of emergency touchdown maneuvers (ETMs) and (b) a series of studies of the AH1FWS fielded in the Federal Republic of Germany. The remainder of this report discusses the procedures and results of the study of ETMs and the procedures for the studies conducted in Germany. At the end of this contract period, the analyses of the data collected in Germany had not been completed; therefore, the results and conclusions of these studies will be presented in a later report.

Research on Prototype Model AH1FWS

Backward Transfer of Emergency Touchdown Maneuvers

The rationale and procedures for assessing backward transfer of skills are fully described by Cross and Gainer (1985). Briefly stated, the backward transfer paradigm is a relatively low-cost procedure designed to measure the degree to which flying skills transfer from an aircraft to a flight simulator. The paradigm requires that an experienced aviator fly the specified maneuver in the simulator without the benefit of simulator practice. Subjects must meet two criteria. First, the subjects must demonstrate proficiency in the aircraft on the tasks of interest, and second, they must have no experience flying the flight simulator. Backward transfer occurs if the aviator is able to perform the maneuver in the simulator to a desired criterion level of proficiency. Such a finding indicates that positive transfer in the reverse direction, from the simulator to the aircraft, is likely; however, the procedure provides no method to estimate the magnitude of positive transfer.

The absence of backward transfer, on the other hand, indicates that the aviators are unable to perform adequately in the flight simulator. Such a finding points to potential problems with either the design or the functioning of the flight simulator, thus signaling the need for further study of the flight simulator's characteristics. To the extent possible, the reasons for low backward transfer should be remedied prior to the initiation of resource intensive transfer-of-training studies.

During December 1984, the prototype AH1FWS at Fort Rucker was upgraded from a Q Model Cobra to a Fully Modernized Cobra (FMC). The upgraded prototype provided a unique opportunity to conduct portions of the backward transfer study. First, none of the local aviators had ever flown the FMC version of the AH1FWS and, second, none of them had flown any AH1FWS for over one year. In addition, the aviators serving as instructor pilots (IPs) for the AH-1 Aviator Qualification Course (AQC), conducted at Fort Rucker, are the only group of AH-1 aviators who routinely perform certain maneuvers, to touchdown, in the aircraft. Citing safety factors, the Army, in 1983, prohibited practice to touchdown of five emergency maneuvers (Department of the Army, 1983), except in accordance with the Program of Instruction (POI) for the AQC. Because these aviators were proficient performing the emergency maneuvers in the aircraft, but naive with respect to performing them in the flight simulator, they provided an almost ideal group of subjects for the conduct of the backward transfer research.

Method

Maneuvers. The researchers identified eight emergency touchdown maneuvers for the investigation of backward transfer; the eight maneuvers are:

- Standard Autorotation (SA, ATM Task 3001),
- Low-Level Autorotation (LLA, ATM Task 3002),
- Low-Level High-Speed Autorotation (LLHSA, ATM Task 3005),
- Simulated Right Antitorque Failure (SRAF, ATM Task 3004),
- Simulated Dual Hydraulics Failure (SHF, ATM Task 3003),
- Manual Throttle Operation (MTO, ATM Task 1056),
- Stability and Control Augmentation System Off Flight (SCAS, ATM Task 1059), and
- Shallow Approach to a Running Landing (SARL, ATM Task 1030).

Full descriptions of each maneuver and their performance standards can be found in the AH-1 Aircrew Training Manual (ATM; Department of the Army, 1984a). The first five maneuvers are prohibited by the Army's moratorium; the other three are included to provide a broader sample of performance on emergency procedures in the AH1FWS.

Subjects. Sixteen AH-1 IPs served as subjects for the study. All subjects were assigned to the AH-1 AQC at Fort Rucker, Alabama, and were selected on the basis of their availability from other work duties. The selected IPs were highly experienced aviators in terms of both total rotary-wing flight hours ($\underline{M}$ = 3875, $\underline{SD}$ = 1675.5) and total AH-1 hours

($\underline{M}$ = 2285.9, $\underline{SD}$ = 1079.1). In addition, they reported supervising an average of 55.3 ETMs per week (SD = 38.5) and performing an average of 18.8 ETMs per week (SD = 26.1) during the performance of their instructor duties.

Two Standardization Instructor Pilots (SIPs) assigned to the Directorate of Evaluation and Standardization (DES) served as subject matter experts (SMEs) during the development of the experimental procedures and as evaluators during the collection of the experimental data. These two aviators had flown an average of 4350 total rotary-wing flight hours and an average of 3950 total AH-1 hours. Their duties as DES SIPs included conducting periodic evaluations of the capabilities of the AQC IPs.

Gradeslips. The researchers worked with the DES SIPs to develop a gradeslip for each of the eight maneuvers identified for the research. The Pilot Performance Description Record (PPDR) (Greer, Smith, & Hatfield, 1962; Prophet & Jolley, 1969) served as a model for developing the gradeslip. First, each maneuver was divided into logical segments. Then the DES SIPs identified the flight parameters considered to be important for evaluating performance during each maneuver segment. Descriptive scales were developed that identified the ideal performance and the range of acceptable performance for each parameter. The scales were designed so that the evaluators could easily mark the magnitude and direction of deviations from ideal performance.

As an example, Figure 1 presents the gradeslip for Standard Autorotation. The maneuver is divided into five discrete segments. Each segment consists of rating scales for describing performance on each of several parameters during that segment. For example, airspeed, altitude, and technique are considered the three parameters important in evaluating aviator performance during entry into the Standard Autorotation. The ATM requires that an aviator enter the Standard Autorotation at 100 knots of airspeed, plus or minus 10 knots. The SIPs were trained to mark the point on the scale corresponding to the performance of the subjects. That is, the triangle was marked if the standard was met, the second line on the scale to the left of the triangle was marked if the subject entered at 96 knots, and the appropriate box ("SLOW" or "FAST") was marked if the subject exceeded the acceptable tolerance (less than 90 or more than 110 knots).

In addition, the evaluators provided a subjective rating of overall performance on each maneuver. For this purpose, a 13-point scale employing verbal anchors of "Very Poor," "Average AQC IP," and "Excellent" was provided at the bottom of the gradeslips. The evaluators were instructed to derive an overall rating, after the termination of each maneuver, based on the information they had recorded on the descriptive scales.

STANDARD AUTOROTATION

ID#: ____________ TRIAL: ________

COACHING: [ ] Yes [ ] No

FRONT SEAT [X] BACK SEAT [ ]

COMMENTS

OVERALL RATING

AVERAGE PIC

UNSAT -5 -4 -3 -2 -1 +1 +2 +3 +4 +5 EXCELLENT

ENTRY AIRSPEED	SLOW	-10	-8	-6	-4	-2	+2	+4	+6	+8	+10	FAST
ALTITUDE	LOW	-100	-80	-60	-40	-20	+20	+40	+60	+80	+100	HIGH
TECHNIQUE	YES	NO										
DESCENT ROTOR RPM	LOW	CORRECT	HIGH									
AIRSPEED	SLOW	-5	-4	-3	-2	-1	+1	+2	+3	+4	+5	FAST
DECELERATION AIRSPEED AT 100 FEET	SLOW	-5	-4	-3	-2	-1	+2	+4	+6	+8	+10	FAST
ALTITUDE	LOW	-15	-12	-9	-6	-3	+3	+6	+9	+12	+15	HIGH
AMOUNT	LITTLE	-5	-4	-3	-2	-1	+1	+2	+3	+4	+5	MUCH
PITCH/PULL INITIAL ALTITUDE	LOW	5	6	7	8	9	16	17	18	19	20	HIGH
INITIAL AMOUNT	LITTLE	5	4	3	2	1	1	2	3	4	5	MUCH
TECHNIQUE	SLOW	5	4	3	2	1	1	2	3	4	5	ABRUPT
HEADING	LEFT	5°	4°	3°	2°	1°	1°	2°	3°	4°	5°	RIGHT
TOUCHDOWN TOUCHDOWN ATTITUDE	LEVEL	5	4	3	2	1	1	2	3	4	5	TAIL SKID
CUSHION	LITTLE	5	4	3	2	1	1	2	3	4	5	MUCH
LANDING	HARD	5	4	3	2	1						
GROUND SLIDE	MUCH	5	4	3	2	1						
GROUND TRACK	LEFT	5	4	3	2	1	1	2	3	4	5	RIGHT

Figure 1. Gradeslip for Standard Autorotation.

Collectively, the descriptive scales served three purposes. First, they provided an accurate description of each subject's performance that could be used to identify the aspects of each maneuver that proved most difficult for the subjects. Second, the descriptive scales served as guides for the evaluators in deriving overall performance ratings for each maneuver immediately after the termination of that maneuver. Finally, the scales and the overall ratings provided information about the criteria employed by the DES SIPs when evaluating aviator performance.

Data Collection. Data collection was completed within four days, during which time each subject received one checkride in the AH-1 aircraft, followed by a checkride in the AH1FWS on the next day. During each checkride, the subjects were required to perform one iteration of each of the eight maneuvers in a predetermined order. The order of maneuvers was counterbalanced among subjects based on a partial Latin Square design. Aircraft checkrides averaged 50 minutes in length, whereas the AH1FWS checkrides averaged 110 minutes. The difference in session length was attributed primarily to differences in the rating procedures employed in the aircraft and the AH1FWS.

Several features of the AH1FWS allowed the SIPs to more accurately record descriptions of performance in the AH1FWS than was possible in the AH-1 aircraft. First, only one SIP observed and evaluated each maneuver in the aircraft, whereas both SIPs evaluated all maneuvers performed in the AH1FWS. During AH1FWS checkrides, one SIP was stationed at the operator's station in the pilot's cockpit while the other SIP occupied the copilot/gunner's (CPG) station. This arrangement allowed one SIP to operate the AH1FWS and observe both the subject and the flight parameters in the pilot's cockpit and on the console. It allowed the other SIP to monitor the flight controls and the flight parameters in the CPG cockpit and on the console. Second, the operators' consoles and the AH1FWS's replay feature allowed the SIPs to verify and correct observations they had made while the subject was performing the maneuver. The SIPs recorded separate descriptions of each maneuver as it was executed, and then collaborated to obtain an accurate description and overall rating for the maneuver. During their collaboration, they were encouraged to replay the maneuver as many times as necessary to ensure accurate data.

Immediately following each checkride in the AH1FWS, the subject was interviewed by a researcher to obtain information about (a) the subject's opinions concerning the AH1FWS and (b) the simulator characteristics that may have affected performance on the eight maneuvers. The interviews were intended to provide information about the systems and to identify potential modifications to the AH1FWS.

Results

To conduct the data analyses, the overall rating scale was transformed to a linear scale ranging from 1 (Very Poor) to 13 (Excellent). A rating of 7 was anchored to the performance expected of an average AQC IP. That is, the overall performance rating scale was anchored to the performance that the SIP expected from the average AQC IP in the AH-1 aircraft. Use of the 13-point bipolar scale on the gradeslips facilitated marking by the SIPs and made the overall rating scale consistent with the bipolar format of the descriptive scales on the gradeslips.

Tables 1 and 2 present the overall performance ratings for all subjects and maneuvers in the AH-1 aircraft and in the AH1FWS. Twenty-three (18%) of the 128 maneuvers performed in the aircraft received ratings of "Very Poor." The low ratings were due to the subjects' failure to meet ATM standards (14%), requiring SIP assistance (3%), or missing the runway (<1%). The average rating across all subjects and maneuvers in the aircraft was 5.2. In contrast, 105 (82%) of the maneuvers performed in the AH1FWS were rated as "Very Poor." The majority of these ratings, however, were not attributable to failure to meet standards. Of the maneuvers performed in the AH1FWS, 43.5% (56) resulted in crashes of the simulator and 11.5% (15) terminated short of the runway. Only 27% (34) received "Very Poor" ratings because the subject failed to meet standards. In many cases, the subjects simply could not maintain control of the AH1FWS during critical portions of the maneuvers.

Similar results were apparent in direct comparisons between performance in the AH-1 aircraft and performance in the AH1FWS. The mean overall ratings collapsed across all subjects were significantly lower in the AH1FWS than in the AH-1 aircraft for all maneuvers except SRAF. Although the trend toward decreased performance in the AH1FWS was also evident for the SRAF maneuver, the difference was not statistically significant. In addition, the performance decrement seen in the AH1FWS was manifested by all subjects. That is, the average performance across all eight maneuvers was significantly worse for all 16 subjects in the AH1FWS than in the AH-1 aircraft. Although a few instances occurred (7 of 128) in which a subject received a higher rating for his performance in the AH1FWS than in the AH-1 aircraft, none of the subjects received consistently higher scores in the AH1FWS than in the AH-1 aircraft. Furthermore, aircraft performance did not accurately predict subsequent performance capability on the first trial in the AH1FWS (r = .37, n.s.), in that those subjects who performed best in the AH-1 aircraft did not necessarily perform best in the AH1FWS.

Posttest interviews allowed the subjects to identify the characteristics of the AH1FWS that contributed to their poor performance. Table 3 presents the most prominent responses and the percentage of subjects making the responses. These data indicate that the visual system was the single most important factor contributing to decreased performance capabilities in the AH1FWS. However, discrepancies between

Table 1

Performance Ratings for Each Subject and Maneuver in the AH-1 Aircraft

Subject	MTO	SHF	SCAS	SRAF	LLA	SARL	LLHSA	SA	M	SD
1	5.0	2.0	7.0	4.0	5.0	7.0	1.0	12.0	6.2	2.6
2	7.0	8.5	6.0	8.0	8.0	8.0	10.0	6.0	7.7	1.3
3	12.0	9.0	10.0	10.0	3.0	10.0	6.0	7.5	8.4	2.9
4	5.0	7.0	6.0	3.5	1.0	7.0	1.0	5.0	4.4	2.4
5	3.0	1.0	7.0	4.0	5.0	9.0	1.0	1.0	3.9	3.0
6	4.0	3.5	5.0	1.0	2.0	5.0	1.0	4.0	3.2	1.6
7	1.0	6.5	1.0	4.0	2.0	5.0	1.0	3.0	2.2	1.6
8	6.0	5.0	2.0	6.0	4.0	3.5	3.0	11.0	4.8	1.6
9	1.0	5.0	8.5	1.0	4.0	10.0	6.0	1.0	5.4	2.8
10	1.0	6.0	10.0	6.0	5.0	10.0	10.0	6.5	6.8	3.1
11	1.0	1.0	7.0	1.0	6.0	5.0	6.0	12.0	4.5	3.1
12	8.5	5.5	5.0	1.0	8.5	6.0	4.0	5.5	5.5	2.4
13	4.5	1.0	7.0	1.0	1.0	5.0	9.0	5.0	4.2	3.0
14	6.0	5.0	7.0	1.0	4.0	5.0	5.5	8.0	4.6	2.5
15	5.0	7.0	8.0	9.0	7.0	12.0	6.0	8.5	7.8	2.1
16	10.0	6.0	6.0	2.0	7.0	7.0	7.5	5.0	6.3	2.3
MEAN	4.7	4.8	6.4	4.2	4.5	7.3	5.1	6.0	5.2	---
SD	3.3	2.6	2.4	3.1	2.4	2.4	3.3	3.4	3.4	---

Table 2

Performance Ratings for Each Subject and Maneuver in the AH1FWS

Subject	MTO	SHF	SCAS	SRAF	LLA	SARL	LLHSA	SA	M	SD
1	1.0	1.0	4.0	10.0	1.0	7.0	1.0	1.0	3.2	3.5
2	1.0	1.0	1.0	1.0	1.0	7.0	1.0	1.0	1.8	2.1
3	1.0	1.0	1.0	5.0	7.0	1.0	1.0	1.0	2.2	2.4
4	1.0	1.0	1.0	1.0	1.0	7.0	1.0	1.0	1.8	2.1
5	1.0	5.0	1.0	11.0	1.0	4.0	1.0	1.0	2.8	3.6
6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	5.0	1.5	1.4
7	1.0	1.0	1.0	1.0	1.0	7.0	1.0	1.0	1.8	2.1
8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0
9	1.0	1.0	1.0	1.0	1.0	7.0	1.0	1.0	1.8	2.1
10	1.0	7.0	7.0	1.0	1.0	8.0	5.0	1.0	3.1	3.0
11	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0
12	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0
13	1.0	1.0	1.0	1.0	1.0	3.5	1.0	1.0	1.3	0.9
14	1.0	1.0	7.0	1.0	4.0	10.0	1.0	1.0	2.9	3.6
15	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0
16	1.0	4.0	5.0	1.0	1.0	5.0	1.0	1.0	2.0	1.8
MEAN	1.0	1.8	2.2	2.4	1.6	4.5	1.2	1.0	1.9	---
SD	0.0	1.8	2.2	3.3	1.6	3.2	1.0	0.0	0.8	---

Table 3

Summary of Posttest Interviews

Percent	Comments
100.0	Visual screens blurred when near ground
93.8	Unable to accurately perceive altitude when near ground
87.5	AH1FWS provides insufficient visual cues to maintain position during hover
81.2	Entry points were difficult to determine for most maneuvers
75.0	The AH1FWS and aircraft collective systems react differently to similar inputs
68.8	Peripheral vision in AH1FWS was not effective
62.5	Rates of closure and descent were difficult to determine in the AH1FWS
62.5	The AH1FWS cyclic system was more sensitive than the cyclic system in the AH-1 aircraft
62.5	The nose of the AH1FWS pitched up excessively during autorotations
50.0	The AH1FWS did not provide appropriate kinesthetic and proprioceptive feedback
37.5	Experienced motion sickness or disorientation in the AH1FWS
25.0	The AH1FWS exhibited inappropriate heading changes in response to throttle changes
18.8	Vibrations in the seat shaker were not realistic
12.5	Focusing on the left window created a tendency to drift left

the handling qualities of the AH1FWS and the AH-1 aircraft also contributed to the subjects' inability to perform the maneuvers successfully in the AH1FWS.

Discussion

The low degree of backward transfer observed for the eight emergency maneuvers indicates that a number of deficiencies exist in the AH1FWS, particularly within the visual system and the handling qualities of the flight controls. Furthermore, the AH1FWS and the AH-1 aircraft seem to require different sets of flight and perceptual skills for performance. That is, the subjects in this study could not successfully apply the same skills in the AH1FWS that they employed daily to fly the AH-1 aircraft.

These data do not reflect the full extent of the differences between the simulator and the aircraft, nor do they provide a means to estimate the effect that the simulator deficiencies have on the transfer of training from the AH1FWS to the AH-1 aircraft. However, the backward transfer data do indicate that the AH1FWS is not an AH-1 aircraft and probably should not be employed as such. The present study provides evidence that (a) deficiencies exist in the AH1FWS that will have an impact on the utility of training conducted in that device and (b) these deficiencies need to be addressed empirically through transfer-of-training studies. The transfer-of-training studies are necessary to obtain data of sufficient quality to design training programs that will effectively and efficiently employ the AH1FWS within aviation field units.

The dramatic results of the backward transfer study of ETMs raised several questions; the questions include the following:

- What are the magnitude and direction of the visual perceptual biases affecting perception of altitude in the AH1FWS?
- Would aviators of moderate flight experience have problems in the AH1FWS similar to those experienced by the high-time IPs?
- Would the Laser Image Generation (LIG) visual system installed on production models of the AH1FWS produce any appreciable differences in performance when compared to the Camera Model System (CMS)?
- How much practice and time would field unit aviators require to reach a proficient level of performance on various tasks in the AH1FWS?
- To what extent do field unit aviators experience simulator sickness during sessions in the AH1FWS?

These questions are the focus of additional studies conducted during the next major data collection effort. The studies were conducted in the Federal Republic of Germany employing USAREUR resources.

Research on the Production Model AH1FWS

During July and August, 1985, a team of five ARIARDA and Anacapa Sciences, Inc. (ASI) personnel conducted studies of the production model AH1FWS employing field unit aviators as subjects. In order to take maximum advantage of the support provided by USAREUR, the research team designed and conducted studies addressing a wide range of topics, including:

- in-simulator skill acquisition,
- backward transfer,
- estimation of absolute altitudes in the AH1FWS,
- identification of the tasks for which unit aviators maintain proficiency during normal mission flying, and
- the extent and symptomatology of simulator sickness experienced in the AH1FWS.

Flight data were collected at both of USAREUR's AH1FWS sites (Fleigorhorst Army Airfield and Illesheim Army Airfield). The subjects were selected from aviators attending regularly scheduled training sessions at the simulator sites. Since USAREUR doctrine required all Cobra units to incorporate the AH1FWS into their flight training programs, each field unit rotated through its designated simulator site approximately once every five weeks. This arrangement facilitated data collection because it permitted the researchers to remain at the two simulator sites and systematically select and test subjects as the aviators reported for training.

The research team finished collecting data and returned to Fort Rucker by September 1, 1985. Coding and computer entry of the data began immediately and was completed by December, 1985; however, none of the data analyses had been completed at the end of the contract period. Therefore, results and conclusions from the studies investigating the production model AH1FWS are not presented here. The remainder of this report presents the rationale and procedures for each of the studies that were conducted in USAREUR. The studies include the following:

- Task Proficiency Survey,
- Estimation of Absolute Altitude,
- Simulator Sickness Questionnaire Survey, and
- Backward Transfer and In-Simulator Skill Acquisition.

Task Proficiency Survey

Need

In conducting the Task Proficiency Survey (TPS), two major assumptions were made. First, it was assumed that the AH1FWS may be used effectively to fulfill a portion of the training requirements for field unit aviators. Second, it was assumed that unit aviators maintain proficiency on certain tasks solely through the flying accomplished during support of the unit's mission. For this reason, field unit aviators present a unique situation when compared to AQC students. Within the institutional environment, all flying performed by students is for the purpose of practice. In contrast, within units, the aviators spend many of their annual flight hours supporting the unit's mission. In performing the mission requirements, unit aviators maintain proficient skills on a number of tasks that require no additional training.

Therefore, these tasks should not be incorporated into simulator-based skill sustainment training programs. The TPS was an initial step in identifying those tasks for which skills are maintained during normal mission flying and for which additional training in the AH1FWS is not necessary.

Method

All AH-1 aviators (N=128) attending training or research sessions at either AH1FWS site in Germany during the data collection period were required to complete the TPS. The TPS asked the respondent to use the following scale to rate each designated task:

X = Task is never performed (under this condition) during normal mission flying

1 = Frequent practice (beyond mission flying) is needed to maintain skill on task/condition

2 = A moderate amount of practice (beyond mission flying) is needed to maintain skill on task/condition

3 = Infrequent practice (beyond mission flying) is needed to maintain skill on task/condition

4 = No practice (beyond mission flying) is needed to maintain skill on task/condition

The survey listed 61 tasks performed from the pilot's station and 59 tasks performed from the CPG's station, including both ATM tasks and crew/team tasks. In addition, the survey required the respondents to rate the amount of practice, in addition to normal mission flying, required for each task when performed under each of four conditions: day, night unaided, night vision goggles (NVG), and mission oriented protective posture (MOPP) equipment.

Estimation of Absolute Altitudes

Need

Anecdotal evidence indicates that experienced AH-1 aviators overestimate absolute altitude in the AH1FWS. Interviews with various aviators revealed that the altitude cues provided by the simulator's visual system make the altitude of the AH1FWS appear to be greater than it actually is. Accurate altitude perception is critical when performing a number of maneuvers near the ground, including autorotations, antitorque failures, and NOE flight. Posttest interviews from the study investigating the backward transfer of emergency maneuvers verify the anecdotal evidence. Specifically, 15 of the 16 subjects participating in the study reported that the inability to perceive the simulator's altitude accurately, when near the ground, contributed significantly to performance difficulties.

Method

The research team conducted a study designed to determine the magnitude and direction of visual perceptual biases affecting the estimation of altitude in the AH1FWS. In addition, the design provided for direct comparisons between the biases evident in the LIG and CMS visual systems. Data for the altitude estimation study were collected at each of three sites: Fleigorhorst and Illesheim, Germany, and Fort Rucker, Alabama. The data at Fort Rucker were collected immediately before the team departed for Germany.

Subjects. Eleven aviators were selected at each site; the subjects were selected on the basis of their aircraft and simulator experience. The ideal subject had a moderate number of AH-1 flight hours and no experience in the AH1FWS. Table 4 presents the average flight experience of the subjects tested at each of the three sites.

Procedures. During data collection, the subjects occupied the pilot's station of the AH1FWS while an experimenter sat in the console operator's station. All flight instruments were either covered or deactivated. In addition, the subjects were requested not to touch the collective or the pedals to prevent them from obtaining any information from the controls or instruments about the simulator's altitude. No control inputs were required of the subjects.

The AH1FWS was placed in a stationary position over one end of the terrain board's stagefield with the simulator heading adjusted so that the subject could view the entire length of the runway. This position provided the subject with the maximum number of visual cues available in the stagefield environment. From this stationary position, the simulator was frozen in various vertical elevations above the terrain board to present visual scenes corresponding to 0, 3, 5, 10, 15, 20, 30, 50, and 100 feet in absolute altitude. Five trials of each altitude were presented to each subject for a total of 45 trials. Between trials, the experimenter reduced the simulator's visibility to zero and adjusted the

Table 4

Flight Experience (Hours) of Altitude Estimation Subjects

	AH-1 Aircraft		AH1FWS	
	Mean	Range	Mean	Range
Fort Rucker	510.3	130 - 1200	12.1	0 - 25
Fleigorhorst	489.7	125 - 1400	16.9	0 - 60
Illesheim	480.0	130 - 900	14.0	0 - 35

simulator to an altitude appropriate for the next trial. The experimenter then warned the subject that the trial was about to begin and returned the visual system to full visibility for five seconds. During the five second exposure, the subject was required to estimate the simulator's altitude above the stagefield and to report the estimation to the experimenter. All trials were completed for each individual subject without a break, and the data collection sessions averaged approximately 75 minutes in length. The order of presentation of the various stimuli was randomized for each subject.

Simulator Sickness Questionnaire

Need

During recent years, increased attention has been paid to motion sickness-like symptoms experienced by aviators during and after training sessions in flight simulators (McCauley, 1984). The syndrome has been termed simulator sickness to distinguish it from motion sickness, and its existence provides evidence of a bad simulation (Frank, Kennedy, Kellogg, & McCauley, 1983). The occurrence of simulator sickness may negatively affect the quality and amount of training accomplished in a simulator because of the following reasons:

- symptomatology may interfere with or retard learning in the simulator through distraction,
- delayed onset of symptoms may result in a safety hazard,
- use of the simulator may decrease because of the untoward side effects,
- confidence in training accomplished in the simulator may decrease, and
- adaptation to the cues producing simulator sickness may result in the development of responses that transfer negatively to the aircraft.

Previous literature indicates that simulator sickness may indeed be a problem for the use of flight simulators to train Army helicopter aircrews. However, no empirical data exist that define the propensity of the Army's rotary-wing flight simulators to induce simulator sickness. Only the self-reports obtained during the backward transfer study of ETMs indicate that rated AH-1 aviators may experience a significant degree of simulator sickness during their first exposure to the AH1FWS. During this study, 6 of 16 subjects reported experiencing either sickness or disorientation during a 1.5-hour checkride in the AH1FWS. Severe symptoms prevented two subjects from continuing the checkride. Although preliminary, these data indicate that (a) a potential problem might exist with the flight simulators fielded by the Army and (b) a comprehensive study of simulator sickness is required.

Method

The research team designed a questionnaire to investigate the incidence and prevalence of simulator sickness experienced by aviators training in the two AH1FWSs fielded in USAREUR. The questionnaire consists of five parts; the five parts are as follow:

- Section A: Personal Data,
- Section B: History of Motion Sickness,
- Section C: Simulator Sickness Symptoms,
- Section D: Tasks/Maneuvers Performed and Causal Factors, and
- Section E: Symptoms Experienced After Simulator Session.

The Simulator Sickness Questionnaire was distributed at both AH1FWS sites to aviators serving as subjects in the simulation studies and to all aviators attending normal training sessions during the period of data collection. The aviators were instructed to complete Sections A and B prior to entering the AH1FWS during their first session of the week. In addition, they were instructed to complete Section C and D for each of their simulator sessions during the training week. Therefore, some aviators completed only one copy of Sections C and D, whereas others completed as many as four. Finally, the aviators were instructed to complete and return Section E five days after their last simulator session of the week. Each section is described in detail below.

Section A: Personal Data. Section A requests demographic information and a detailed account of the individual's previous flight and simulator experience. In addition, the individual identified his highest ratings and qualifications in various Army aircraft. A total of 158 aviators completed Section A.

Section B: History of Motion Sickness. The researchers designed this section to determine the susceptibility of unit aviators to motion sickness in a variety of situations known to produce motion sickness, including actual flight. Additionally, several questions in this section identified any recent illnesses or injuries that may have contributed to the subject's report of simulator sickness symptoms during the AH1FWS sessions reported in Sections C, D, and E. A total of 158 aviators completed Section B.

Section C: Simulator Sickness Symptoms. In Section C, the aviators provided information about the symptoms they were experiencing just before, during, and immediately after each AH1FWS session. The subjects indicated the level of severity (none, slight, moderate, and severe) for each of 28 symptoms experienced during the three time periods. In addition, the respondents plotted the time course of the severity of any symptoms manifested during the simulator session. A total of 155 aviators completed 298 copies of Section C.

Section D: Tasks/Maneuvers Performed and Causal Factors. Section D was designed to identify the tasks/maneuvers and simulator characteristics contributing to the symptoms of simulator sickness experienced in the AH1FWS. The respondents listed the tasks/maneuvers that they performed during each 10-minute interval of each simulator session and identified any of 14 characteristics of the AH1FWS that caused or contributed to symptoms they had reported in Section C. A total of 155 aviators completed 298 copies of Section D.

Section E: Symptoms Experienced After the Simulator Session. Section E provided the aviators with an opportunity to report any symptoms of simulator sickness that they may have experienced after their last session, including (a) those symptoms that occurred during the session and persisted long after the session ended and (b) those symptoms whose onset did not occur until after the last simulator session had ended. Respondents completed Section E five days after their last AH1FWS session. A total of 79 aviators completed and returned Section E.

Backward Transfer and In-Simulator Skill Acquisition

Need

The results of the backward transfer study of ETMs raised several important questions concerning the ability of AH-1 aviators to perform tasks/maneuvers in the AH1FWS and the subsequent transfer of any training conducted in the AH1FWS to the AH-1 aircraft. As previously stated, the backward transfer study revealed that highly experienced aviators could not successfully perform ETMs during their first exposure to the AH1FWS. As a result of this finding, the researchers designed and conducted an in-simulator skill acquisition study to address the following issues:

- Would the backward transfer data collected with the prototype model AH1FWS generalize to the production model?
- Would the backward transfer results hold true for other maneuvers?
- Can field unit aviators learn to perform maneuvers to an adequate level of proficiency in the AH1FWS?
- How many trials will field unit aviators require to reach proficiency in the AH1FWS on selected tasks?
- Can NOE tasks be performed adequately in the AH1FWS?

Method

Subjects. The researchers selected 40 aviators from the AH1FWS training sites to serve as subjects for the in-simulator skill acquisition study. The subjects were systematically assigned to four groups of ten aviators each. The selection criteria ensured that the subjects were qualified and current in the AH-1 aircraft and had a minimum of experience in the AH1FWS. The AH1FWS had been in operation at both Fleigorhorst and Illesheim for several months; therefore, almost all aviators had been exposed to the simulator prior to data collection. Thus, the subject selection criterion was changed from simulator naive to minimum AH1FWS experience. Unit IPs identified those aviators in each unit with the fewest hours in the AH1FWS.

Maneuvers. One purpose of the study was to investigate the backward transfer and in-simulator skill acquisition of other tasks in addition to the eight tasks previously studied. The additional tasks were selected to provide a broad performance sample; the tasks include tactical, NOE, and standard contact maneuvers. Performance was assessed on a total of 15 different maneuvers performed from the pilot's station and 5 of the same tasks performed from the CPG's station. Each of the four groups of subjects was assessed on five maneuvers. Table 5 presents the tasks performed by each group.

Procedures. Each subject participated for five consecutive days (Monday through Friday), during which time the aviator completed 10 practice iterations in the AH1FWS on each of the five tasks assigned to the subject's group. On Day 1, the subject completed a checkride in the AH1FWS; the checkride consisted of one iteration of each of the five maneuvers and then nine consecutive practice iterations of one of the maneuvers. On Days 2 through 5, each subject performed 9 practice iterations of another maneuver until 10 iterations of all five maneuvers had been completed. The order in which the subjects executed the various maneuvers during the checkride and the practice iterations was counterbalanced according to a partial Latin Square design.

Table 5

Maneuvers Performed By Each Group

Group 1 (Pilot's Station)	Group 2 (Pilot's Station)
Right Antitorque Failure	Low-Level High-Speed Autorotation
Standard Autorotation	Shallow Approach To A Running Landing
Terrain Flight Approach	SCAS Off Flight
VHIRP	Hovering Tasks
Unmasking/Firing/Masking	Normal Approach to Pinnacle

Group 3 (Pilot's Station)	Group 4 (Copilot/Gunner's Station)
Dual Hydraulics Malfunction	Standard Autorotation
Low-Level Autorotation	Shallow Approach To A Running Landing
Manual Throttle Operation	Hovering Tasks
Terrain Flight Takeoff	Normal Approach To Stagefield
NOE Acceleration/Deceleration	Low-Level Autorotation

Performance was assessed in the AH1FWS by two SIPs assigned to the USAREUR Aviation Safety and Standardization Board (UASSB). The procedure was identical to that used to assess aviator performance during the previous backward transfer study conducted at Fort Rucker. Two SIPs evaluated all maneuvers performed in the AH1FWS; one SIP occupied the console operator's station in the pilot's cockpit, while the other SIP occupied the crew station opposite the subject. The second evaluator occupied the CPG station for Groups 1, 2, and 3 and the pilot's station for Group 4. During the execution of a maneuver, each evaluator recorded the subject's performance using the descriptive scales of the gradeslips. After terminating the maneuver, the subject's intercom system was disconnected while the evaluators discussed each segment of the maneuver in order to arrive at a collaborative description and overall rating of the subject's performance. During this discussion, the evaluators employed the playback feature of the AH1FWS as often as necessary to ensure the accuracy of the data that they recorded. After the evaluators concluded their discussions, the subject's intercom system was reconnected, and the AH1FWS was reinitialized to begin the next iteration of the maneuver. The subjects received no instruction or feedback about their performance during the first three trials of a maneuver. During trials 4 through 10, however, the evaluators provided instruction to each subject in an effort to improve the subject's performance as quickly as possible.

Two SIPs were trained by the researchers and provided all of the evaluations at the Illesheim site. However, UASSB personnel assigned to the Fleigorhorst site maintained responsibility for duties other than data collection and were unable to dedicate the same two individuals for the entire data collection period. Therefore, four SIPs were trained to serve as evaluators at Fleigorhorst to ensure that at least two qualified evaluators were present throughout the data collection period. Gradeslips from the previous study were also adopted for the eight ETMs, whereas new gradeslips were developed for the additional maneuvers.

Project Status

Work Completed

All data collected to date for the Short-Term Path for simulator research project have been entered into ARIARDA's computer.

Work Projected

Analyses of the data collected in the Federal Republic of Germany will be conducted. In addition, a separate technical report will be completed by September 1986 that will include the results of the data analyses. Submission of the report to ARIARDA will satisfy all contractual requirements for the project.

References

Cross, K. D., & Gainer, C. A. (1985). An enumeration of research to determine the optimal design and use of Army flight training simulators (Technical Report ASI479-066-85). Fort Rucker, AL: Anacapa Sciences, Inc.

Cross, K. D., Ryan-Jones, D., Bickley, W. R., McCracken, J. H., McMullen, R. L., Wright, R. H., Keenan, J. B., & Millard, S. L. (1984). Aviator training requirements and simulation fidelity (Research Note). Fort Rucker, AL: Anacapa Sciences, Inc.

Department of the Army. (1983). Termination of touchdown emergency procedures in rotary-wing aircraft (Message 327140OZ). Washington, DC: HQ, Department of the Army.

Department of the Army. (1984a). AH-1 Aircrew Training Manual (Field Circular 1-213). Washington, DC: Department of the Army.

Department of the Army. (1984b). Aircrew Training Manual Commander's Guide (TC-134). Washington, DC: HQ, Department of the Army.

Directorate of Training and Doctrine. (1984). Request for Research Support (Disposition Form). Fort Rucker, AL: Directorate of Training and Doctrine, U.S. Army Aviation Center.

Frank, L. H., Kennedy, R. S., Kellogg, R. S., & McCauley, M. E. (1983). Simulator sickness: Reaction to a transformed world (NAVTRAEQUIPCEN TN-65). Orlando, FL: Naval Training Equipment Center.

Greer, G. D., Smith, W. D., & Hatfield, J. L. (1962). Improving flight proficiency evaluation in Army helicopter pilot training (Technical Report 77). Fort Rucker, AL: Human Resources Research Office.

McCauley, M. E. (Ed.). (1984). Research issues in simulator sickness. Washington, DC: National Academy Press.

Prophet, W. W., & Jolley, O. B. (1969). Evaluation of the integrated contact-instrument concept for Army fixed-wing flight instruction (HumRRO Technical Report 69-26). Alexandria, VA: Human Resources Research Organization.

U.S. Army Audit Agency. (1982, 1 March). Report of audit. Synthetic flight training system (Audit Report SO 82-6). Washington, DC: U.S. Army Audit Agency.

U.S. Army Audit Agency. (1985, 23 August). Report of Audit. Followup audit of synthetic flight training system (Audit Report SO 85-18). Washington, DC: U.S. Army Audit Agency.

DEVELOPMENT OF A 1984-85 VERSION OF THE
ARMY FLIGHT APTITUDE SELECTION TEST

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This research project is a part of a continuing U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) effort to increase the effectiveness of the tests used to select applicants for the Army Initial Entry Rotary Wing (IERW) training program.

Background

The Army's original selection battery, the Flight Aptitude Selection Test (FAST), was developed in response to the unacceptably high attrition rates in the flight training program during the 1950s. The FAST was composed of two test batteries, one for officer applicants and one for enlisted/civilian applicants. Each battery yielded a fixed-wing and a rotary-wing aptitude score for each applicant (Kaplan, 1965). The FAST, implemented in 1966, resulted in a substantial reduction in the IERW attrition rates.

In 1975, the U.S. Army Aviation Center requested a revision of the FAST due to (a) a decrease in the validity of the FAST (Eastman & McMullen, 1978a), (b) the large number of errors in scoring the FAST, (c) the excessive amount of time required to administer the FAST, and (d) the elimination of fixed-wing training for initial entry students. The goal of the revision was to develop a single, effective battery with fewer, shorter, and more reliably scored subtests (Eastman & McMullen, 1978b).

The methodological approach chosen for the revision was to select the most effective subtests from the FAST, and then to select the most effective items from each subtest for inclusion in a Revised FAST (RFAST). Factor analyses and multiple regression analyses were used to select 7 of the 12 FAST subtests for retention. Subsequently, item difficulties and item discrimination coefficients were analyzed to identify specific subtest items to be retained. The length of each subtest was reduced to approximately one-half the original length. The RFAST became operational in 1980.

Project Objectives

The objectives of this project are to evaluate the RFAST and to develop a more effective battery of selection tests. The specific technical objectives of this research project are to:

- conduct a detailed statistical analysis of the RFAST,
- identify an improved criterion measure of student performance in IERW,

- identify the abilities required to complete IERW successfully,
- identify the abilities being assessed by the RFAST subtests,
- develop an improved version of the Army's FAST, including an alternate form, and
- validate both forms of the FAST against performance in IERW.

Research Approach

The research project is being conducted in four phases. The first phase is designed to evaluate the reliability, validity, and factorial structure of the RFAST and its subtests. The required analyses include (a) the computation of item difficulty and discrimination indices, (b) the computation of reliability coefficients for each subtest and the total battery, (c) a factor analysis of the 200-item battery, and (d) the computation of validity coefficients for each subtest and the total RFAST scores. Previous validation efforts have used a pass-fail criterion, but this dichotomy has been found to be an insensitive measure of training performance. Therefore, the identification of an improved criterion measure is required before the validity analyses can be conducted.

The second phase of the research is designed to determine if the RFAST assesses the full range of abilities that are required to complete IERW training. This evaluation requires (a) the conduct of a task analysis to identify the requisite abilities, (b) the quantification of the relative importance of the requisite abilities, and (c) the conduct of an analysis to identify the requisite abilities that are measured satisfactorily by subtests on the RFAST.

The third phase of the research project consists of traditional test development activities, including:

- development of an experimental battery of subtests to assess the abilities that are required for successful performance in IERW training,
- administration of the subtests to a sample of flight students and analysis of test results to identify unsatisfactory items and to determine optimum time limits, and
- administration of the experimental battery to a large sample of general-population subjects and analysis of the test results to evaluate the psychometric characteristics of the individual subtests and the interrelationships among the subtests.

The final phase will involve the development and validation of two parallel versions of the new FAST. Based on the item and subtest analyses in phase one, subtests to be retained from the current RFAST will be selected and modified as necessary to increase their reliability. The retained subtests will be combined with the new subtests to form the parallel versions of the validation battery. The new versions will be administered to flight students entering IERW training. The students' performance will subsequently be monitored during training and correlated with their performance on the battery. When the parallel batteries have been equated and the predictive validity of the new versions has been established, all the required ancillary materials (e.g., test administration manuals, answer sheets, and scoring manuals) will be prepared for implementation.

Project Status

Work Completed: Phase 1. The statistical analyses of the RFAST have been completed. The results indicate that the current RFAST is a heterogeneous battery composed of six homogeneous subtests and one heterogeneous subtest. The heterogeneous subtest, Self-Description, is uncorrelated with the total battery score. With the exception of the Self-Description subtest, all subtests have acceptably high reliability coefficients, ranging from .64 to .88. The internal consistency coefficient for the total battery is .90 (Lockwood & Shipley, 1984). The retest correlation of the RFAST is .66, which would generally indicate very marginal reliability. However, the low coefficient is mitigated by the retest intervals which extended from less than two months to more than two years. The average retest score increased by 17 points (.95 standard deviation), indicating a need for an alternate form for use when retesting is required (Smith & McAnulty, 1985).

Efforts to evaluate criterion measures resulted in the derivation of a "benefit resulting from exposure to training" measure (Lockwood & Shipley, 1984). The derived measure is a transformed ratio of actual flight training time to scheduled flight training time. The multiple correlation between the RFAST subtests and the benefit criterion measure yielded a validity coefficient of .21 for the initial validation sample and .11 for the cross-validation sample. The simple correlation between RFAST total score and the benefit criterion was .17 (r = .25 corrected for range restriction and criterion attenuation). Although the validity coefficients are statistically significant, the low percentage of variance accounted for by the current RFAST indicates the battery has limited utility in predicting IERW performance. A technical report (Lockwood & Shipley, 1984) has been prepared and submitted to ARIARDA to document the first phase of research.

Work Completed: Phase 2. A procedure to identify the ability requirements for successful completion of IERW has been developed and the data collection and analyses have been completed. The procedure required experienced IERW instructor pilots (IPs) to (a) identify the tasks that are most indicative of successful performance in the primary and instrument phases of IERW, and (b) judge the type and importance of the abilities that are required to perform each task. The ability definitions and rating technique developed by Fleishman and his associates (e.g., Theologus & Fleishman, 1973) were used to obtain IP judgments of the ability requirements for each task. The task-ability ratings for each IP were then transformed to a normally distributed, equal-interval scale using the method of successive intervals (Hays, 1967). Analyses of the transformed ratings indicated that 24 abilities from the psychomotor, perceptual, language, and cognitive domains were required for successful performance in IERW.

Concurrently, research psychologists, using the Fleishman ability requirements technique, determined that three RFAST subtests adequately assess three of the required perceptual abilities. Eleven ability constructs were selected for new subtest development on the basis of (a) potential for reliable and valid measurement, and (b) amenability to assessment in the current test format. A test specifications matrix was developed to guide the Phase 3 activities in developing an improved version of the FAST battery. A technical report (McAnulty, Jones, Cohen, & Lockwood, 1984) has been prepared and submitted to ARIARDA to document the second phase of research.

Work Completed: Phase 3. Phase 3 activities are partially complete. Nine new subtests have been developed to measure 11 of the cognitive and perceptual abilities identified in the second phase as requirements for the successful completion of IERW. The subtests are designed to measure:

- decision making,
- memorization,
- selective attention,
- information ordering,
- problem sensitivity,
- deductive reasoning,
- inductive reasoning,
- flexibility of closure,
- speed of closure,
- perceptual speed, and
- spatial orientation.

Eight of the subtests comprise two or three sections and require 5 to 20 minutes to administer. The ninth subtest, called the Flight Planning Test (FPT), is a complex, cognitive-perceptual test that comprises seven sections and requires approximately 90 minutes to administer. The FPT is designed primarily to measure decision-making and memorization abilities, but additional cognitive and perceptual factors (e.g., selective attention) are systematically included in the subtest items. The FPT is designed to yield measures of learning ability and information load effects as well as standard psychometric measures.

The nine subtests and a test critique were administered to 69 subjects during the preliminary testing of the battery. These data were used to revise the items and subtests, and to refine the administrative procedures (time limits, written and verbal instructions, etc.) to meet the design specifications. The revised experimental battery, that included four standardized tests as marker variables, was administered to 290 subjects located at three military installations in the southeastern United States. The experimental battery required approximately eight hours to administer, including breaks. The data from 273 subjects (17 subjects were eliminated for failing to complete the battery, failing to give a reasonable effort, failing to follow test procedures, or prior exposure to test materials) have been entered into a computer data base and the entries have been verified in preparation for further analyses.

Work Projected. Current efforts involve the evaluation of the tests and the reduction of the experimental battery into two equivalent forms. Three subtests from the RFAST will be revised and incorporated into the selection battery. The entire battery will then be validated against performance in IERW. The development and validation of the selection battery will be completed by December, 1987.

References

Eastman, R. F., & McMullen, R. L. (1978a). The current predictive validity of the flight aptitude selection test (ARI Field Unit Research Memorandum 78-2). Fort Rucker, AL: U.S. Army Research Institute for the Behavioral and Social Sciences.

Eastman, R. F., & McMullen, R. L. (1978b). Item analysis and revision of the flight aptitude selection tests (ARI Field Unit Research Memorandum 78-4). Fort Rucker, AL: U.S. Army Research Institute for the Behavioral and Social Sciences.

Hays, W. L. (1967). Quantification in psychology. Belmont, CA: Brooks/Cole Publishing Co.

Kaplan, H. (1965). Prediction of success in Army aviation training (Technical Research Report 1142). Washington, D.C.: U.S. Army Personnel Research Office.

Lockwood, R. E., & Shipley, B. D., Jr. (1984). Evaluation of the Revised Flight Aptitude Selection Test (Technical Report ASI 479-020-84). Fort Rucker, AL: Anacapa Sciences, Inc.

McAnulty, D. M., Jones, D. H., Cohen, R. J., & Lockwood, R. E. (1984). Identification of the abilities required for effective helicopter training performance (Technical Report ASI 479-046-84[B]). Fort Rucker, AL: Anacapa Sciences, Inc.

Smith, R. L., & McAnulty, D. M. (1985). Test-retest reliability of the Revised Flight Aptitude Selection Test (RFAST) (ARI Field Unit Draft Research Report). Fort Rucker, AL: U.S. Army Research Institute for the Behavioral and Social Sciences.

Theologus, G. C., & Fleishman, E. A. (1973). Development of a taxonomy of human performance: Validation study of ability scales for classifying human tasks. JSAS Catalog of Selected Documents in Psychology (Ms. No. 326), 3, 29.

REVISION/VALIDATION OF THE INDIVIDUAL READY RESERVE AVIATOR PROGRAM OF INSTRUCTION: UH-1 AIRCRAFT

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Background

It has been estimated that between 1.3 and 1.8 Army rotary-wing aviators per cockpit seat would be required to sustain operations in any major conflict (Department of the Army, 1979). Currently, there is only one active duty aviator per aircraft seat in the Army inventory. This shortfall of Army aviators would be made even greater by a migration of officers from flying positions to staff positions during a major mobilization.

In 1978, the Department of the Army created the Individual Ready Reserve (IRR) Aviator Training Program as a means for eliminating the aviator shortfall that otherwise would exist during a major mobilization. The IRR Aviator Training Program is designed to fill the cockpit seats with individuals who once served successfully as Army aviators but subsequently chose not to remain on active duty. The fundamental premise underlying the IRR Aviator Training Program is that it is less costly to retrain former aviators and to maintain their flying skills through periodic refresher training than it is to train and maintain a larger force of active duty aviators.

The Army Reserve Personnel Center (ARPERCEN), formerly the Reserve Component Personnel and Administration Center (RCPAC), was given the responsibility for administering the IRR Aviator Training Program. This program differs from the Army Reserve and National Guard training programs in that the IRR Aviator Training Program requires participation only during a single period each year, rather than the monthly participation required by the other reserve programs. As initially designed, the program required that IRR aviators be assigned to specific field units and that they report to the assigned unit for a 19-day training period once each year at the outset of the program. Each unit commander was made responsible for developing a program to train the IRR aviator assigned to that unit. This arrangement proved unsuitable because ARPERCEN had no means of standardizing or evaluating the type and quality of training that the IRR aviator received at the assigned unit.

In 1979, the Deputy Chief of Staff for Operations (DCSOPS), in conjunction with Forces Command (FORSCOM) and ARPERCEN, requested the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA), Fort Rucker, Alabama, to develop a standardized IRR Aviator Training Program. The specific tasks that ARIARDA was requested to accomplish are as follow:

- to evaluate the amount of deterioration in the flying skills of IRR aviators,

- to determine the amount and nature of training needed to correct this deficiency, and
- to develop a program for accomplishing the required training in a cost-effective manner.

ARIARDA personnel commenced work on the assigned project by conducting a mail survey of (a) IRR aviators who had attended one or more on-site training periods and (b) active duty personnel who had been directly involved in training one or more IRR aviators. The survey resulted in two clear-cut and important findings. First, it was found that the flying skills of the typical IRR aviator had deteriorated substantially during the period away from active duty. Although the survey provided no precise measure of the amount and type of skill deterioration, the results clearly indicated that a significant amount of refresher training was necessary to increase IRR aviators' flying skills to an acceptable level. Second, the survey results showed that the type and amount of training received by IRR aviators varied greatly from one installation to another. Training at some installations consisted of little more than self-study of military publications. At other installations, the entire training program consisted simply of passive rides in the copilot seat of a helicopter during routine mission training exercises. Overall, there was an apparent lack of a standardized and systematic training program.

The survey results and information from subject matter experts (SMEs) were used by ARIARDA personnel to develop a preliminary version of a Program of Instruction (POI) for the IRR Aviator Training Program (Allnutt & Everhart, 1980; Everhart & Allnutt, 1981). The POI consisted of two training phases. Phase 1 consisted of training in basic flight maneuvers and academic study of a wide range of topics. Phase 2 consisted of refresher training on Phase 1 maneuvers and academic topics, additional flight training in special and tactical maneuvers, and academic training in terrain analysis and map interpretation. All flight maneuvers trained in Phase 1 and Phase 2 were selected by FORSCOM.

The preliminary version of the POI was used to train a sample of 17 IRR aviators on Phase 1 maneuvers; the 19 days of training were conducted at Fort Rucker by experienced IPs. One year after the Phase 1 training period, six of the original 17 aviators returned to Fort Rucker for 19 days of Phase 2 training. The preliminary version of the POI proved to be generally effective, but the results revealed a number of ways in which the POI could be improved. The POI was revised in accordance with these findings.

Copies of the second version of the POI were distributed to field units, along with a questionnaire designed to provide feedback on the POI's effectiveness. IPs were requested to use the POI and complete the questionnaire. An analysis of the questionnaire results revealed that two problems clearly compromised the effectiveness of the POI.

- Due to the lack of preparation by IRR aviators prior to their arrival at the unit, an unacceptably large portion of the 19-day training period was spent studying academic topics.
- An excessive amount of IP time was required to complete the academic instruction specified in the POI.

It was the need to eliminate these problems that led to the initiation of the present project.

Project Objectives

This project was designed to address the problems revealed by the questionnaire results. The specific objectives of this project are as follow:

- to develop self-study materials that IRR aviators can use at home or at the unit training site to complete some or all of the academic preparation,
- to modify the academic portion of the POI to reduce the amount of IP time required to administer the training, and
- to evaluate the revised POI in a controlled environment.

Research Approach

The research plan for the project identified five general tasks that must be accomplished to fulfill the objectives of this project. These tasks are discussed below under separate headings. A description of both the task and the outcome is presented for each task.

Definition of Academic Training Requirements. The purpose of this task is to define the academic topics that must be covered in the academic portion of the training program, and for each topic, to denote the specific knowledge that IRR aviators must possess in order to complete the course successfully. This task was accomplished by a team of SMEs composed of experienced IPs and experts in training technology.

The consensus of SME opinion was that the academic units for Phase 1 training should provide the student aviator the knowledge necessary to pass the pilot's oral examination as outlined in TC 1-135[1] (Department of the Army, 1980), the Aircrew Training Manual (ATM) for the UH-1 aircraft. It was also agreed that academic units for Phase 2 training would be limited to map interpretation and terrain analysis. The order, content, and number of academic units in the original POI were revised to cover more thoroughly the germane academic topics. The revised POI consists of 12 academic units for Phase 1 and two academic units for Phase 2.

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[1]TC 1-135 was subsequently revised and published as FC 1-211.

Development of Academic Training Materials. The original POI required 40 hours of IP lectures to cover the academic topics. The primary objective of this task is to develop a training approach and requisite materials that eliminate the requirement for IP involvement in academic training. An approach considered highly desirable is to provide IRR aviators with the opportunity to complete some academic study at home, prior to their arrival at the unit training site. Another desirable approach is to provide the IRR aviators with self-study materials that they can study at the training site during proctored study periods. Since the amount of time IRR aviators will devote to home study is uncertain, a combination of the two training approaches is employed; that is, each IRR aviator will be provided an opportunity to engage in home study and an incentive for doing so. However, because the amount of home study cannot be controlled, the program must be designed such that all or any part of the academic training can be accomplished through self-study at the unit training site.

Another factor considered in developing academic training materials is that individual IRR aviators can be expected to differ greatly in their need for academic training. Individual differences in the need for academic training stem from differences in the amount of flight time logged by the aviators, differences in the time that has transpired since the aviators have flown regularly, and differences in the aviators' fundamental abilities. Hence, it is essential that academic training materials be developed that enable individual aviators to (a) study only the topics on which their knowledge is deficient and (b) proceed through the training as swiftly as their capabilities permit.

Three types of materials were developed: a comprehensive set of reference materials, a detailed study guide, and a user's guide containing a set of diagnostic examinations. The use of the materials is explained in the following description of the general training concept.

- Step One--The reference materials and study guide, consisting of 12 units from Phase 1 and two units from Phase 2, are sent to the IRR aviators' homes about four weeks before they are scheduled to arrive at the training site. The IRR aviator is instructed that home study is not mandatory but that time spent on home study will increase the amount of on-site time that can be spent on inflight instruction. Aviators who choose to engage in home study are instructed to complete the work specified in the study guide.

- Step Two--The IRR aviators are required to complete a diagnostic (paper-and-pencil) examination as soon as they arrive at the training site. The examination contains 12 Phase 1 subtests covering 12 academic topics. A score of 90% or greater on any subtest excuses the IRR aviator from further study on the academic topic covered by the subtest.

- Step Three--An IRR aviator who fails to score at least 90% on any subtest is required to complete the self-study material specified for that topic in the study guide. Once the self-study has been completed, the IRR aviator is required to take a second examination on the topic. Any IRR aviator who fails to score at least 90% on the examination is directed to review the study material more thoroughly and is tested again on the same topic. Any IRR aviator who fails to score at least 90% on the third examination is provided one-on-one tutoring by an IP until the IP judges that the IRR aviator has sufficient knowledge about the topic. This procedure is repeated until self-study of all 12 academic topics has been completed.

Development of Inflight Training Plan. The goal in developing an inflight training plan is to enable IRR aviators to relearn flying skills as rapidly as is commensurate with safety. The flying tasks/maneuvers to be taught were specified by FORSCOM. The Phase 1 tasks/maneuvers include most of the tasks/maneuvers that must be mastered to qualify for Flight Activity Category (FAC) 2 positions. The FAC 2 positions are flying assignments in which an aviator must maintain basic flying skills. Some training on instrument tasks is required, but only to the extent necessary to enable an IRR aviator to recover safely in the event of inadvertent exposure to instrument meteorological conditions (IMC). In Phase 2, IRR aviators are provided refresher training on all Phase 1 tasks/maneuvers and are trained on a set of tactical and special tasks.

Conduct On-Site Evaluation of POI. The objective of this task is to evaluate the POI's effectiveness when used to train a representative sample of IRR aviators under realistic training conditions. The research plan developed for this project stipulates that: (a) a total of 48 IRR aviators are to be trained at the U.S. Army Aviation Center (USAAVNC), Fort Rucker, Alabama; (b) each month for six consecutive months, a group of eight IRR aviators are to receive training on 19 consecutive days; (c) the last group of aviators are to complete training on 19 November 1982; and (d) the 48 IRR aviators are to return to USAAVNC for refresher training and Phase 2 training in 1983. Critical questions addressed by the evaluation are listed below.

- How much of the study guide will the average IRR aviator complete during home study?
- Are the study guide and reference material comprehensive in their coverage of academic topics?
- Are the study guide and reference material sufficiently clear and easy to use?
- How much time do aviators require to complete the self-study of each academic training unit?
- How many flying hours do IRR aviators require to relearn the requisite flying skills?

Revise the POI. The objective of the final task is to use the information from the evaluation to refine the POI. The revision of the Phase 1 POI was completed in July of 1983. The revision of the Phase 2 POI was completed in June of 1984.

Project Status

Work Completed

First Year Aviator Training. Forty-seven IRR aviators participated in training during the first year. Flight time for hands-on flight training averaged 21.0 hours per aviator. The aviators required approximately 20 hours of proctored self-study to complete academic training.

First Year Findings. The demographic characteristics and flight experience of the 47 aviators trained the first year varied widely. The age of the IRR aviators varied from 28 to 47 years, with a median age of 34 years. The median amount of flight time logged prior to the start of IRR training was 1622 hours, with a range of 235 to 4300 hours. The time that had transpired since the aviators left active Army service varied from 1 to 19 years, with a median of 7.5 years.

All aviators were able to pass the pilot's oral examination after completing the academic training portion of Phase 1 training. On the average, Phase 1 academic training required 7.6 days to complete, with a range of 5 to 12 days. Two demographic characteristics were related to the number of days required to complete Phase 1 academics. The number of days required to complete Phase 1 academic training increased as a function of the number of years that had elapsed since the aviator left active Army service, and decreased as a function of the number of study guide units completed by the aviator prior to training. These two demographic characteristics were used in a mathematical equation that proved to be both statistically reliable and practically useful in predicting the days required to complete academic training. Total military flight experience was not related to the days required to complete academic training.

When given initial checkrides, the 47 aviators performed 14% of all tasks to ATM standards. On the average, 17 hours of flight training were required to relearn the flying skills needed to complete a Phase 1 checkride.

Two demographic characteristics were related to flight hours required to pass a Phase 1 checkride. The number of hours required to complete Phase 1 flight training increased as a function of the amount of time that had elapsed since the aviator had left active Army service, and decreased as a function of the aviator's total number of military flight hours. These two demographic characteristics were used in a second mathematical equation that proved to be both statistically reliable and practically useful in predicting the hours required to successfully pass a Phase 1 checkride.

Forty-five of the 47 aviators completed Phase 2 academics during the first training year. Twenty-four of the 47 aviators also successfully completed a Phase 2 checkride during the first 19-day training period. The average flight hours required to complete Phase 2 training was 4.3, with a range of 1.0 to 9.1 hours.

The findings indicate that approximately 94% of all IP time was spent in flight training or related activities, such as preflight and debriefings. Most of the remaining six percent of an IP's time was devoted to administrative paperwork.

Student assessment of the program reveals that the POI was acceptable to IRR aviator trainees. Ninety-eight percent of the students indicated that the POI was adequate or more than adequate as a training program for IRR aviators.

The results of the first training year demonstrate that the program has significantly reduced the requirements made on IP training and, at the same time, greatly increased the amount of training accomplished during the 19-day training program. Using the previous POI, many IRR aviators were unable to complete all of Phase 1 training during the 19-day training period. In contrast, all of the aviators trained with the new POI were able to complete Phase 1 training, and one-half of them were able to complete both Phase 1 and Phase 2 training during the first 19-day training period.

In summary, it seems safe to conclude from the first year results that the revised POI is acceptable to IRR aviators and that the POI will result in a significant reduction in both the IP and IRR aviator time necessary to complete training.

Second Year Aviator Training. All 47 IRR aviators were contacted four months prior to the commencement of the second year of training to determine if they could participate in the second-year training. Twenty-four of the 47 aviators trained during the first year agreed to participate in the second year of training. Most of the remaining aviators were unable to attend due to civilian job conflicts or because they had joined reserve units. Time for hands-on flight training averaged 20 hours per aviator. The aviators required an average of 20 hours of proctored self-study to complete the academic training.

Second Year Findings. The demographic characteristics of the 24 aviators trained during the second year were very similar to the demographic characteristics of the 47 aviators trained in the first year. The median age of the aviators was found to be 35 years, with a range of 29 to 44 years. The median amount of flight time logged prior to the start of the second 19-day training period was 1213 hours, with a range of 600 to 3100 hours. The time that had transpired since the last flying experience with the active Army varied from 2 to 12 years, with a median of 9 years.

When given initial checkrides after one year of no practice, the 24 aviators performed 45% of all tasks to ATM standards. An average of 14 hours of flight training was required to successfully complete a Phase 1 checkride. Twenty-two of the 24 aviators completed both Phase 1 and Phase 2 training during the second year; 15 of the 24 aviators had completed both Phase 1 and Phase 2 training during the first year.

The findings of the second year suggest that proficiency in some flight skills is maintained throughout a one-year period of no flying. Also, there was an increase in the proportion of aviators who were able to complete both Phase 1 and Phase 2 training during a 19-day training period. However, the findings suggest that two 19-day training periods, separated by one year, is not enough time for some aviators to complete the training program.

In summary, the findings of the second year of training indicate that the revised POI continues to meet the goals of the IRR Aviator Training Program while reducing the requirements for IP resources. Also, the findings contribute to the understanding of the factors that affect the retention of flight skills.

Research Products. A study guide, a user's guide, and a set of reference materials were developed for the UH-1H aircraft. In addition, modified versions of these documents were developed for the OH-58A and OH-58C aircraft. During the fourth contract year, the training materials for all three aircraft were revised and updated to reflect changes made in the Operator's Manuals, Aircrew Training Manuals, and several other reference publications.

The draft final report on the IRR project was completed by Anacapa Sciences, Inc. (ASI) and reviewed by ARIARDA during the first half of the fourth contract year. The draft final report, entitled "Evaluation of a Revised Individual Ready Reserve (IRR) Aviator Training Program: Final Report," was revised based on comments by the ARIARDA reviewers and submitted as a contract deliverable on 25 June 1985. The three sets of training materials described above were also submitted as contract deliverables on 25 June 1985.

Two technical papers based on the results of the IRR research were presented at the 28th Annual Meeting of the Human Factors Society on 24 October 1984. The papers are entitled "Conserving Instructional Training Resources Through Use of the Personalized System of Instruction," and "Retention of Helicopter Flight Skills: Is There a 'Critical Period' for Proficiency Loss?" The papers were published in the proceedings of the meeting.

The delivery of the products described above completed all contractual requirements for this project.

References

Allnutt, M. F., & Everhart, C. D. (1980). Prototype training program for Individual Ready Reserve (IRR) UH-1 aviators (Working Paper FR-FU-80-10). Fort Rucker, Alabama: U.S. Army Research Institute Field Unit.

Department of the Army. (1979). Army Aviation Personnel Requirements for Sustained Operation Study - Final Report, Volume 1. Fort Monroe, VA: U.S. Army Training and Doctrine Command.

Everhart, C. D., & Allnutt, M. F. (1981). Training program for Individual Ready Reserve (IRR) UH-1 aviators. Phase I (revised) and Phase II (Working Paper FR-FU 81-13). Fort Rucker, AL: U.S. Army Research Institute Field Unit.

Everhart, C. D., Krausz, A. E., Wick, D. T., & Ruffner, J. W. (1985). User's Guide: UH-1H Training Program for Individual Ready Reserve (IRR) Aviators. Fort Rucker, AL: U.S. Army Research Institute Field Unit.

Everhart, C. D., Wick, D. T., & Ruffner, J. W. (1985). Study Guide: UH-1H Training Program for Individual Ready Reserve (IRR) Aviators. Fort Rucker, AL: U.S. Army Research Institute Field Unit.

Krausz, A. E., Everhart, C. D., Wick, D. T., & Ruffner, J. W. (1985). User's Guide: OH-58A Training Program for Individual Ready Reserve (IRR) Aviators. Fort Rucker, AL: U.S. Army Research Institute Field Unit.

Krausz, A. E., Everhart, C. D., Wick, D. T., & Ruffner, J. W. (1985). User's Guide: OH-58C Training Program for Individual Ready Reserve (IRR) Aviators. Fort Rucker, AL: U.S. Army Research Institute Field Unit.

Krausz, A. E., Wick, D. T., & Ruffner, J. W. (1985). Study Guide: OH-58A Training Program for Individual Ready Reserve (IRR) Aviators. Fort Rucker, AL: U.S. Army Research Institute Field Unit.

Krausz, A. E., Wick, D. T., & Ruffner, J. W. (1985). Study Guide: OH-58C Training Program for Individual Ready Reserve (IRR) Aviators. Fort Rucker, AL: U.S. Army Research Institute Field Unit.

Ruffner, J. W., Wick, D. T., & Bickley, W. T. (1984). Retention of Helicopter Flight Skills: Is There a "Critical Period" for Proficiency Loss? Proceedings of the Human Factors Society Annual Meeting, San Antonio, TX.

Wick, D. T., Millard, S. L., & Cross, K. D. (1985). _Evaluation of a Revised Individual Ready Reserve (IRR) Aviator Training Program: Final Report_ (Technical Report ASI 479-058-85). Fort Rucker, AL: Anacapa Sciences, Inc.

Wick, D. T., Ruffner, J. W., & Bickley, W. R. (1984). Conserving Instructional Training Resources Through Use of the Personalized System of Instruction. _Proceedings of the Human Factors Society Annual Meeting_. San Antonio, TX.

DEVELOPMENT OF A PEER COMPARISON PROGRAM

Dr. D. Michael McAnulty, Project Director

Background

This project was initiated in response to a request from the School Secretary, U.S. Army Aviation Center, to the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) for support in developing an algorithm to select course honor graduates based on the "whole person" concept. At the initial meeting in March, 1985, the School Secretary indicated a desire to augment the academic grade criterion used to select honor graduates in the new Aviation Officer Advanced Course (AVNOAC). The AVNOAC is a five-month advanced training course for captains and promotable first lieutenants. The stated purposes of the augmented program are:

- to motivate students to maximize their military as well as their academic efforts, and
- to identify students who have high potential at an early stage of their career.

Specifically, the School Secretary was interested in using peer assessments by the AVNOAC students as a component in the honor graduate selection algorithm. The peer assessments were to evaluate aspects of the students' performance that were not reflected in their academic averages. Instructor ratings were not considered as a potential component in the selection algorithm because of the limited interaction between the students and the school cadre.

Project Objectives

Following a review of the peer assessment literature and the AVNOAC syllabus, a briefing was presented to the School Secretary that summarized the primary peer assessment methods and proposed a "peer comparison" (PC) methodology for use in the AVNOAC. The School Secretary agreed to support the following research objectives:

- identify the most important military qualities that could be assessed by peers during the AVNOAC,
- develop a PC technique for use in the AVNOAC, and
- experimentally evaluate the PC technique prior to implementation.

Research Approach

This research was conducted in three phases. In the first phase, a military qualities survey was conducted to identify the five most important qualities to be used in the peer comparisons. The survey asked senior aviation officers to rate a list of primary military qualities as dimensions for evaluating student performance and for identifying students with high career potential. The second phase involved the development of three project assessment instruments (the PC form, a faculty advisor rating form, and a student critique). The third phase involved the experimental administration and evaluation of the PC technique in the AVNOAC.

Project Status

Work Completed

Military Qualities Survey. Following a search of the literature and a review of current Army student evaluation dimensions, definitions of 14 primary military qualities (e.g., adaptability, initiative, judgment, leadership, responsibility, and supervision) were compiled for evaluation by senior aviation officers at Fort Rucker, Alabama. Several important military qualities (e.g., tactical knowledge) were excluded because they were evaluated by academic grades or were not likely to be demonstrated during the AVNOAC. The list of military qualities and an overview of the research plan were sent to 16 colonels who were asked to rate each quality on four scales:

- importance to the performance of captains,
- importance to the performance of senior officers,
- probability of demonstration during the AVNOAC, and
- degree of overlap with the other qualities.

Eleven of the surveys were completed and returned. Three of the qualities (leadership, judgment, and responsibility) had consistently high ratings and were selected as peer comparison dimensions. Seven of the remaining 11 qualities were clearly perceived as being inappropriate dimensions for obtaining peer comparisons. Appearance and cooperation were selected as the final two peer comparison dimensions.

Evaluative Instrument Development. Three evaluative instruments were developed for use in this project. The PC form was developed from the results of the military qualities survey, a combination of the peer nomination and peer ranking techniques (e.g., Kane & Lawler, 1978), and a psychophysical method called the paired comparison technique (e.g., Engen, 1971, pp. 51-54). On the PC form, each section member (a class is divided into two sections) is required to nominate and rank order five peers on the basis of their potential as Army aviation officers. The section member then makes paired comparisons of the nominees on the five military qualities that were selected from the military qualities survey.

A Faculty Advisor Rating (FAR) form was also developed to obtain independent evaluations of the students' potential as Army aviation officers. Each AVNOAC faculty advisor supervises approximately six students. The advisors used the FAR to estimate where each of their students would place (i.e., percentile rank) in an average group of 100 captains.

Finally, a student critique form was developed to ascertain student attitudes toward the peer comparison program. The students are asked to rate the fairness, utility, aversiveness, and difficulty of various aspects of the program. They are also asked to rate their global attitude toward the implementation of the program and to offer additional comments or recommendations.

Experimental Administration. Peer comparisons were obtained on an experimental basis (i.e., PC scores would not be used to select the honor graduates) from sections 1 (n = 41) and 2 (n = 40) of AVNOAC 85-2 on 3 and 8 July, 1985. A second set of PC ratings and the student critiques were collected from sections 1 and 2 on 31 July and 5 August, 1985, respectively. The faculty advisors provided percentile rankings on each of their students. The final academic averages (AVGs) were also obtained by the School Secretary's office.

A PC score was computed for each class member by summing the rank score (five points for first rank, four points for second rank, ... one point for fifth rank) from each nominating peer with the number of favorable comparisons on each military quality. The sum was then divided by the maximum possible score to enable direct comparisons between sections. The resulting PC scores could range from 0.0 (no nominations) to 1.0 (ranked first by all peers and always favorably compared with the other nominees).

The results of the first administration were somewhat mixed. The PC scores ranged from 0.0 to .92 in Section 1 and from 0.0 to .75 in Section 2. The scores indicate a high consensus among the members of the class in identifying peers with the highest potential as aviation officers. The scores for the first and second data collections were highly correlated (Section 1 = .96 and Section 2 = .86), indicating a high degree of reliability over time. Combining the scores from both data collections in both sections, the class members were in agreement on the top 10 percent and the lower 75 percent of the class.

The summed scores were then correlated with the FARs and AVGs. The PC correlations with the FAR are .45 and .33 in Sections 1 and 2, respectively. The PC correlations with the AVGs are .55 and .29 in Sections 1 and 2, respectively. These correlations are sufficiently high to show an expected relationship between observations of the same individuals. At the same time, the correlations are sufficiently low to indicate that the PC score is measuring a unique perspective of the class members.

Finally, the responses to the PC critique were tabulated. The overall reaction of the class members to the PC program was negative: a majority indicated that the PC was very biased, slightly or not at all useful, and slightly or not at all predictive of future performance. Furthermore, 72% of the respondents were either very or extremely unfavorable toward the implementation of the program. Although the reactions to these items were more negative than expected, the responses may be confounded by other student evaluations that were being conducted concurrently (a surreptitious attempt by the class leaders to evaluate the section members had been discovered just before the second data collection; there was also evidence of attempted subterfuge in completing the PC form by seven members of Section 1). The responses to the other critique items reflected combinations of positive, negative, and neutral attitudes without any attitude representing a majority opinion.

The School Secretary reacted favorably to the results of the first experimental administration, although he recognized the problems that had been encountered. The School Secretary agreed to support another experimental administration of the PC in which the class members would be advised in advance of the impending assessments, a longer period of time would elapse between data collections, and no other evaluations would be permitted. In addition, some minor changes were made to the data collection forms (e.g., changes to the military quality definitions suggested on the critiques, using a complete counterbalance of the order of presentation of military qualities and pairs of nominees, and substituting a five-digit roster code for the social security number to protect student privacy).

The PC was administered to 49 students in Section 1 and 51 students in Section 2 of AVNOAC 86-1 on 16 December, 1985. No analyses were conducted pending a second data collection.

Work Projected

A second data collection effort will be conducted in March, 1986, to obtain additional PC ratings and student critiques. The FARs and AVGs for AVNOAC 86-1 will also be obtained for analysis. It is expected that a final briefing and recommendation will be presented to the School Secretary by August, 1986.

References

Engen, T. (1971). Psychophysics II. Scaling methods. In Kling, J. W., & Riggs, L. A. (Eds.) Experimental psychology (3rd ed.). New York: Holt Rinehart, and Winston.

Kane, J. S., & Lawler, E. E. III. (1978). Methods of peer assessment. Psychological Bulletin, 85, 555-586.

EVALUATION OF A FLIGHT SURGEON COURSE SYLLABUS CHANGE

Dr. D. Michael McAnulty, Project Director

Background

In November 1983, the Directorate of Flight Training (DOFT) revised the syllabus for the Flight Surgeon training program by deleting a solo flight and substituting a formal checkride evaluation at the 14-hour flight level. The revision was designed as a preventive safety measure: there had recently been a dramatic increase in the frequency of engine failures in the training helicopter (TH-55) fleet and a Flight Surgeon student had recently experienced an accident during his solo flight. However, the Army Aeromedical Activity (AAMA) contended that the syllabus change could be detrimental to the Flight Surgeon program. As a result, DOFT implemented the syllabus change on a one-year trial basis and included the U.S. Military Academy (USMA) and the Army Reserve Officer Training Corps (ROTC) Cadet Summer Training programs in the trial revision. Subsequently, DOFT requested that the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) assist in evaluating the effects of the Flight Surgeon Course syllabus change.

Project Objectives

A preliminary investigation was conducted (a) by collecting and analyzing previous Flight Surgeon training records and TH-55 helicopter performance, and (b) by interviewing representatives of AAMA, the Army Safety Center, the Aviation Medicine Department, the Office of Accident Prevention (OAP), and Aviation Contract Employees, Inc. (ACE). (ACE conducts the Flight Surgeon and Cadet Summer Training programs.) The conclusion drawn from the investigation was that, although the degree of risk is relatively small, a solo flight was an unnecessarily hazardous criterion for nonaviation students unless the syllabus change resulted in negative effects on the training programs. The investigation identified three areas of potential negative impact. The evaluation of these three areas constitutes the technical objectives of the project:

- evaluate the effect of the syllabus change on the recruitment of Flight Surgeons,
- evaluate the effect of the syllabus change on the attitude and performance of the Flight Surgeons during training, and
- evaluate the effect of the syllabus change on the professional performance of the Flight Surgeons.

Research Approach

In January 1984, DOFT conducted an in-progress review (IPR) with representatives of AAMA, ACE, OAP, ARIARDA, and the Directorate of Evaluation and Standardization (DES). At that meeting, an evaluation approach was submitted for each of the specific objectives. First, an "Incentive Factors Survey" was developed to address the recruitment issue. The survey requires the Flight Surgeons to rate the importance of several factors, including the opportunity to fly solo, on their decision to apply for the Flight Surgeon Program. The "Incentive Factors Survey" approach was approved by the Director of DOFT, who requested that the survey also be adapted for the USMA and ROTC classes.

Two approaches were proposed to assess the performance of the Flight Surgeons during flight training. First, routine evaluation records would be reviewed to determine their utility for comparing Flight Surgeon performance under the solo and checkride training criteria. Second, a "Flight Training Survey" would be developed to obtain instructor pilot (IP) ratings of Flight Surgeon performance, ability, attitude, and motivation during training. Both approaches were approved for the Flight Surgeon Course.

Finally, a "Critical Incident Survey" was proposed to assess the effect of the syllabus change on professional performance. The survey would be administered to experienced Flight Surgeons attending an advanced training course at Fort Rucker. The Flight Surgeons would be asked to identify specific incidents in which their solo (or lack of solo) experience affected their professional performance. The Director of DOFT requested further development and evaluation of this approach before granting approval.

Project Status

Work Completed

Recruitment Evaluation. Three "Incentive Factors Survey" forms (one each for the Flight Surgeon, USMA, and ROTC classes) were developed to assess the relative importance of the major recruitment incentives in each student's decision to apply for flight training. The students were required to distribute 100 points among the factors that positively influenced their decisions. The surveys were administered to 88 Flight Surgeons in Classes 84-2, 84-3, and 85-1; to 102 USMA cadets in Classes 84-1 and 84-2; and to 57 ROTC cadets in Class 84-3. The results of the first survey administration were documented in an internal memorandum (McAnulty, 1984) that was submitted to ARIARDA.

The solo flight opportunity was a major recruiting incentive to only a few of the Flight Surgeon students; in some cases, it was a disincentive to apply for the program. The opportunities to receive flight training, to enhance the student's military career, and to study aviation medicine were generally perceived as more important incentives. Most, if not all, of the students would probably have applied for the program even knowing that the syllabus had been changed. The solo flight opportunity was even less important as a recruitment incentive to the USMA and ROTC cadets. The cadets were evaluating a career in Army aviation and they perceived that successful completion of the summer training program would enhance their chances of assignment to the Aviation Branch. If they were assigned to aviation, they would be able to fly solo during regular flight training. It is unlikely that the syllabus change will have any negative effects on the USMA and ROTC programs.

Training Performance Evaluation. The course grade folders for Flight Surgeon Class 83-3 were obtained and the daily grades for attitude, motivation, and overall performance were evaluated as potential training criteria. The psychometric characteristics of the grades were not indicative of reliable and valid measurement. The solo flight was relatively independent of training performance ratings and the attitude and motivation ratings were homogeneous and inflated. The routine records were not considered adequate as criteria for evaluating the syllabus change.

A "Flight Training Survey" form was developed to obtain IP ratings of each student's attitude, motivation, ability, and performance during flight training. The IPs were asked to rate the average level of each attribute and the direction and degree of change, if any, in the attributes during training. Finally, the IPs were asked to describe any attitudinal or performance effects that could be attributed to the syllabus change. The survey was administered to the IPs of Flight Surgeon Classes 84-2, 84-3, and 85-1. The results of the first administration of the survey were documented in an internal memorandum (McAnulty & Millard, 1984) that was submitted to ARIARDA.

The results of the "Flight Training Survey" indicate that the attitudes, motivation, and performance of the Flight Surgeon students trained under the checkride syllabus were not only satisfactory but generally exemplary. Most of the students exhibited at least a very positive attitude, exerted at least a high level of effort, and performed to the maximum that their abilities permitted. There were exceptions, but these were either not attributable to the syllabus change or did not result in negative training effects. The survey results were corroborated by the high success rate (98%) on the checkride and by the compliments paid to the three classes by their IPs and Flight Commanders. The validity of the survey data was also supported by the pattern of variable intercorrelations, which is consistent with the literature on attitudes, motivation, and work performance.

Professional Performance Evaluation. Further development and evaluation of the critical incidents approach led to the conclusion that it was not feasible to evaluate the effects of the syllabus change on professional performance. This decision was based on the multiplicity of factors that influence professional performance and the lack of an absolute requirement for solo flight under the previous syllabus (i.e., nearly half the Flight Surgeons did not solo). With the concurrence of AAMA, further evaluation of professional performance effects was not attempted.

Conclusions. The results of the "Incentive Factors Survey" and the "Flight Training Survey" indicate that the change from a solo criterion to a checkride criterion would have few, if any, negative effects on the Flight Surgeon, USMA, or ROTC programs. Very few students indicated that the solo flight opportunity was an extremely important recruiting incentive. Likewise, the disappointment expressed by some students at not being permitted to solo was not manifested in poor attitudes, minimal effort, or unsatisfactory performance. The survey data certainly do not provide any compelling evidence to revert to a solo flight criterion. However, it was recommended that the three programs should continue to be monitored for any deterioration in application rates or student performance that could be attributed to the syllabus change.

A final research report, entitled "Evaluation of a Flight Surgeon Course Syllabus Change" (McAnulty, 1985), was prepared and submitted to ARIARDA to complete the project. Submission of the research report on 9 January 1985 fulfills all contractual requirements for this project.

References

McAnulty, D. M. (1985, January). Evaluation of a Flight Surgeon course syllabus change (Draft Research Report ASI 479-065-85(B)). Fort Rucker, AL: Anacapa Sciences, Inc.

McAnulty, D. M. (1984, February). Flight Surgeon recruitment incentive project (Internal ARI/ASI Memorandum). Fort Rucker, AL: Anacapa Sciences, Inc.

McAnulty, D. M., & Millard, S. L. (1984, May). Flight Surgeon training appraisal project (Internal ARI/ASI Memorandum). Fort Rucker, AL: Anacapa Sciences, Inc.

EVALUATION OF THE AVIATION RESOURCE MANAGEMENT SURVEY (ARMS) CHECKLIST

Dr. John W. Ruffner, Project Director

Background

According to the Army's "total force" concept, Reserve Component (RC) aviators serving in the U.S. Army Reserve (USAR) and the Army National Guard (ARNG) are required to train to the same standards and to maintain the same level of flight proficiency as aviators serving in the Active Component (AC). In order to meet this requirement, it is necessary for training managers responsible for planning, implementing, and evaluating RC training to manage the training resources available to them (e.g., aircraft, training time, flying hours, instructor pilots) as efficiently as possible. This is particularly true in light of the limited amount of time that is available for training RC aviators.

One of the ways in which the Army assists RC training managers in meeting this requirement is through the use of evaluation visits made by Aviation Resource Management Survey (ARMS) teams. As stated in Forces Command (FORSCOM) Regulation 350-3 (1984), the general purpose of the ARMS is to "evaluate the management of unit aviation programs, identify areas requiring additional emphasis, and provide staff assistance as necessary."

As defined by FORSCOM, the ARMS has four specific objectives:

- to assist commanders in identifying strengths and weaknesses in all aviation related programs;
- to assess the aviation support facility's (ASF) ability to support units assigned to train at the facility in accomplishing their mobilization mission;
- to assess the aviation unit's capability to operate safely, efficiently, and effectively, and to maintain aviation resources separate from the ASF; and
- to identify systematic problems and provide assistance when the capability to solve the problems is beyond the installation commander's realm of influence.

The office of the Deputy Chief of Staff for Training (DCST) in each of the five Continental U.S. Armies (CONUSAs) is responsible for conducting ARMS evaluations. According to FORSCOM Regulation 350-3 (1984), an ARMS is to be conducted at least once a year for each USAR facility and at least once every two years for each ARNG facility within the CONUSA.

Problem

Each CONUSA has its own procedure for carrying out the ARMS evaluation mission. There is a lack of standardization across the CONUSAs in the functional areas (e.g., safety, standardization, and training) that are evaluated, the procedures used by the ARMS teams to assess the facilities and units, and the standards for acceptable performance.

The First U.S. Army DCST, Aviation Division, has developed a checklist to be used by the ARMS team during its evaluation visits. The checklist originally was published in October 1983, and subsequently was revised in August 1985, as DA Pamphlet 95-1, Reserve Component Commander's Guide - Aviation Standardization and Training Program Evaluation and Aviation Resource Management Survey. The checklist draws heavily from two sources: (a) FORSCOM Form 14-1-R Reserve Component Aviation Resource Management Survey Checklist (1980), and (b) the U.S. Army Safety Center Guide to Aviation Resources Management for Aircraft Mishap Prevention (1984), but does not completely replicate either document.

The First Army checklist contains approximately 650 items divided into 12 major functional areas of evaluation:

- Aviation Safety Management,
- Facility/Unit Operations,
- Aviation Standardization and Training,
- Aircraft/Flightline Operations,
- Aeromedical Management,
- Air Traffic Control (ATC) Management/Training,
- Aircraft Crash Rescue and Fire Fighting,
- Petroleum, Oil, Lubricants (POL) Facilities and Operations,
- Maintenance Management,
- Aviation Armament,
- Aviation Life Support Equipment (ALSE), and
- Physical Security.

The items within each of the functional areas describe a condition or state that is required for the facility or the units to fulfill their missions. The items were written by aviation subject matter experts (SMEs) who are knowledgeable about the operational requirements for RC support facilities and about the mobilization mission requirements of RC units.

The DCST, First U.S. Army, has expressed concern about several deficiencies in (a) the content and organization of the checklist, (b) the manner in which the checklist is used to evaluate the status of each RC facility and unit, and (c) the quality and utility of feedback from the checklist that is given to command personnel. Consequently, during the second quarter of FY85, the DCST requested that the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) provide research support to evaluate the content and organization of the checklist and the procedure used to administer it. Anacapa Sciences, Inc. (ASI) began work on the project on 3 June 1985.

Project Objectives

The general objective of the ARMS Checklist project is to perform a systematic evaluation of the content and organization of the First U.S. Army ARMS checklist, the procedures used to administer the checklist, and the procedure used to provide feedback from the ARMS evaluation to command personnel. Three specific objectives for the project are:

- to develop a standard checklist based on objective criteria,
- to develop a standard procedure to administer the checklist, and
- to develop a microcomputer-adaptable data analysis and management system, based on findings from ARMS visits, for command and control of USAR and ARNG units.

Research Approach

A research plan was developed and submitted to ARIARDA in December 1985. The research plan identifies nine general research tasks that must be accomplished to fulfill the objectives of the project. The research tasks are:

- identify problems with the checklist content, organization, and administration procedure;
- develop a preliminary checklist information data base;
- collect and analyze SME ratings of the checklist items;
- perform a preliminary revision of the checklist;
- develop functional area weighting criteria;
- perform a preliminary on-site evaluation of the checklist;
- perform a second revision of the checklist;
- perform a final on-site evaluation of the checklist; and
- prepare the final checklist and data base.

Project Status

Work Completed. At the end of the fourth contract year, the first two tasks had been completed. A brief description of the work that has been accomplished is presented in the paragraphs that follow.

Following the initiation of the project, the project director met with representatives of the Aviation Division, First Army DCST at Fort Meade, Maryland, in June 1985, to review the content of the checklist and to discuss the procedures followed during an ARMS evaluation. As a result of the meeting, the following major deficiencies in the checklist were identified.

- The content of the ARMS checklist and the procedure used to evaluate checklist items are not standardized.

- There is a considerable amount of redundancy in content among functional areas.

- There is no systematic way of differentiating those items that are critical to mission success from those that are trivial.

- The items in the checklist are not organized in such a manner that an evaluator who is not familiar with the content of a functional area can proceed smoothly through the items.

- There is no systematic way to manage information about the performance of facilities/units on individual checklist items (e.g., identify commonly occurring deficiencies across facilities and units over a period of time).

In August 1985, the ASI Project Director accompanied the First Army ARMS team during its evaluation of the USAR facility and unit at Fort Devens, Massachusetts. During the evaluation, the project director observed the techniques used by the team members to assess specific checklist items and the manner in which the team members combined information on the checklist items into a rating of satisfactory/unsatisfactory. In addition, the project director discussed the team members' assessment of the checklist and solicited suggestions for improving the content of the checklist and the procedure used to administer it.

In August 1985, work was initiated to develop a data base containing (a) the items in the ARMS checklist, (b) the functional areas under which the items are classified, and (c) the publications to which each item refers.

The data base was structured so that information could be added at a later date. The information will include, but will not be limited to, the following items:

- the location in the facility/unit at which the item was evaluated,

- the person(s) at the facility/unit consulted by the evaluators for checklist information,

- SME ratings of the degree to which the item can be objectively observed and evaluated,

- SME ratings of the relative importance of the item for evaluating a functional area and the criticality of the item for facility/unit mission success, and

- USAR and ARNG facilities/units at which a deficiency on that item occurs.

The "search" and "sort" capabilities of the data base program will be used to group items having similar content, reference publications, reference personnel, and evaluation locations as a first step in reorganizing the checklist. Following the revision and subsequent validation of the checklist and procedure, these capabilities can be used by command personnel to detect trends in critical deficiencies among different types of facilities/units. The statistical capabilities of the data base program (e.g., rating category percentages, mean, standard deviation) can be used to identify those items that are (a) relatively easy to observe and evaluate using current procedures (detectability), (b) important for evaluating a particular functional area (importance), and (c) critical for accomplishing the facility/unit mission (criticality).

Work Projected. SME ratings of the detectability, importance, and criticality of each of the checklist items will be obtained and analyzed by the end of June 1986. SME ratings of the relative importance of each of the functional areas will be obtained and analyzed by the end of July 1986. It is anticipated that the final report summarizing the project activities will be available about 1 October 1986.

References

First U.S. Army (1985). Reserve component commander's guide - aviation standardization training program evaluation and aviation resource management survey (DA Pamphlet 95-1). Fort Meade, MD: Department of the Army.

U.S. Army Forces Command (1984). Specialized training in FORSCOM active component and reserve component units (Regulation 350-3). Fort McPherson, GA: Department of the Army.

U.S. Army Forces Command (1980). Reserve component aviation resource management survey checklist (FORSCOM Form 14-1-R). Fort McPherson, GA: Department of the Army.

U.S. Army Safety Center (1984). Guide to aviation resources management for aircraft mishap prevention. Fort Rucker, AL: Department of the Army.

DEVELOPMENT OF AN INTERACTIVE VIDEOTAPE FOR TRAINING AH-1S PREFLIGHT INSPECTION

Mr. Claude O. Miles and Mr. Jerome L. LaPointe, Project Directors

Background

During Aviator Qualification Course (AQC) training in the AH-1S aircraft, all student aviators must learn to perform a thorough preflight inspection of the aircraft. At present, preflight inspection training is accomplished through classroom instruction and individualized instruction at the flightline. Classroom training consists of group lectures in which the preflight inspection procedures are described and the aircraft components to be inspected are illustrated with 35-mm slides. The classroom instruction is augmented by "hands-on" training at the flightline. Prior to each flight, the AQC student is required to perform a preflight inspection of the aircraft under the direct supervision of his/her instructor pilot.

In February 1985, the Commander of Company A, Aviation Training Brigade, requested assistance from the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) in developing a more effective method for training AQC students to perform preflight inspections. Specifically, the request was for a training method that (a) reduces the demands on classroom instructors and instructor pilots and (b) reduces the amount of time aircraft are occupied in accomplishing preflight inspection training.

In response to this request, project personnel performed a careful study of the training requirements, the training constraints, and the capabilities and costs of alternative training approaches/media. The results of the study led project personnel to conclude that the training requirements can be accomplished most cost effectively using interactive videotape training.

Project Objectives

The general objective of this project is to develop a more effective method for training AQC students to perform a preflight inspection of the AH-1S aircraft. The specific objectives are to develop an interactive videotape training package with the following features:

- self-instructional--training accomplished with minimum input by instructors and training-equipment technicians,
- self-paced--enables student to proceed through training at a self-determined rate,
- comprehensive--training encompasses all phases of a preflight inspection and all components of the aircraft that must be inspected,

- test and feedback capability--automated testing of students' knowledge of inspection procedures and feedback on correctness of responses,
- remediation capability--automated remedial instruction when student responds incorrectly to test items, and
- capacity for low-cost modification--capability to modify audio and/or video content at relatively low cost to accommodate future changes in the aircraft and/or the preflight inspection procedures.

Project Status

Work Completed

Summarized below are tasks that had been accomplished by the contract termination date: 31 December 1985.

Prepare Instructional Narrative. A detailed instructional narrative was prepared by Anacapa Sciences, Inc. (ASI) personnel and by an experienced AH-1 instructor pilot, who served as a subject matter expert (SME) throughout the project. The narration provided instruction on the inspection of each of the following:

- weapon system carriers and components,
- weapon system switch position,
- right-front side of aircraft (Area 1),
- right-rear side of aircraft (Area 2),
- left-rear side of aircraft (Area 3),
- left-front side of aircraft (Area 4), and
- nose section of aircraft (Area 5).

Storyboard Development. A detailed storyboard for the videotape was developed, reviewed by ARIARDA personnel, and refined. The storyboard specified detailed requirements for both the audio and video portions of the videotape. For each segment of narration, the storyboard specified (a) estimated time consumed by the segment and (b) the characteristics of the visual materials to be displayed during the narration. The visual materials specified included: 35-mm color slides, video segments (panning aircraft components), alphanumeric text produced by a character generator, and special effects (overlays, highlights, etc.) that must be produced during the videotape post-production process. The storyboard also specified the questions, answers, and remedial feedback to be incorporated in the videotape.

Filming. Upon approval of the storyboard, project personnel supervised a team of photographers in shooting the 35-mm slides and videotape footage specified in the storyboard.

Equipment Procurement. Prior to the onset of this project, ARIARDA had purchased a Sony SMC 70 microcomputer and monitor to interface with a videodisc player. To provide the required capability for the present project, it was necessary to augment the Sony equipment available in the ARIARDA inventory with a Panasonic AG 6200 random access tape player, a videotape interface card for the Sony microcomputer (manufactured by Whitner Educational Services), and a superimposer unit that enables computer generated graphics to be superimposed on videotape imagery.

Software Development. The software development effort was commenced but not completed during the contract period. The primary objective of the software development effort is to provide the capability to present questions on the TV monitor, accept students' answers via computer keyboard or light pen, inform students about the correctness of their answers and provide remediation when a question is answered incorrectly. The software under development must provide the following capabilities:

- overlay graphics (symbols and alphanumerics) onto the videotape imagery,
- menu selection of the section of the training program to be presented,
- random selection from a pool of questions about each section of the training program,
- acceptance of responses to questions via keyboard or light pen,
- simple feedback when correct answer is given, and
- automatic search and playback of the appropriate segment of the videotape to provide remediation for incorrect answers to questions.

Selection of Post-Production Contractor. Bids were solicited from four post-production firms in the Southeastern United States. The bid judged most favorable to the government was submitted by Reider Film and Television, Inc., Atlanta, Georgia.

Work Projected

The tasks that must be accomplished in order to complete this project are as follow:

- complete all post-production work, including expert narration,
- produce off-line check videotape,
- review off-line check videotape and modify as necessary,
- produce master videotape and six copies,
- complete the development of requisite software, and
- develop written procedures to instruct users about the start-up and shutdown of equipment.

DEVELOPMENT OF A VIDEODISC VERSION OF
ADVANCED MITAC TRAINING EXERCISES

Mr. Claude O. Miles and Mr. Jerome L. LaPointe, Project Directors

Background

Proficiency in map interpretation and the ability to navigate accurately by means of visual pilotage are of paramount importance when flying at nap-of-the-earth (NOE) altitudes on the modern battlefield. There is little or no margin for error when flying at NOE altitudes due to restricted visibility incurred by the masking effects of terrain, vegetation, and other obstacles. However, a study conducted by the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) in 1975 revealed that a large percent of Army aviators were deficient in the map interpretation skills necessary for accurate navigation at NOE altitudes (Fineberg, Meister, & Farrell, 1978). In an effort to alleviate this recurring problem, ARIARDA sponsored an effort to develop new training methods and materials aimed at improving aviators' map interpretation and navigation skills. The end result was the development of a prototype basic Map Interpretation and Terrain Analysis Course (MITAC). This course focused on the key principles that must be understood in order to navigate accurately when flying at NOE altitudes.

The initial version of MITAC (MITAC I) was designed to be administered by a trained instructor. A self-instructional version of the basic MITAC (MITAC II) was developed for use in unit training. This package was later converted to the Training Extension Course (TEC) format for use in the Beseler Que/See.

The MITAC navigational exercises require students to perform a preflight map study of the area of operations, listen to a commentary on preflight map study, view the filmed route, and simultaneously mark checkpoint positions on the map. Students are then required to check and score their performance, and watch the film a second time while listening to a debriefing commentary.

An evaluation conducted by ARIARDA revealed that students who underwent MITAC training were able to navigate NOE routes in one-half the time required by conventionally trained students and, moreover, committed two-thirds fewer navigational errors than conventionally trained students (Holman, 1977). Subsequently, it was recommended that all aviators with NOE flight requirements undergo basic MITAC training. Presently, student aviators in the Army's Initial Entry Rotary Wing (IERW) course receive basic MITAC in the academic portion of their training.

In 1977, Anacapa Sciences, Inc. (ASI), Santa Barbara, California, was contracted to develop a set of Advanced MITAC lessons aimed at exposing students to more difficult exercises than those developed for the initial version. Specifically, the advanced exercises were designed to expose students to a greater variety of topography, seasons, and maps (including maps compiled by foreign cartographers). Thirteen Advanced MITAC exercises were developed that exposed students to (a) various types of topography in Arizona, Idaho, Kentucky, and Germany, (b) summer and winter foliage, and (c) clear and snow-covered terrain. Exportable self-instructional training packages for these lessons included:

- annotated 16-mm color filmed routes,
- preflight and debriefing commentaries recorded on audio cassettes,
- a self-instructional manual,
- map plates, and
- map plate overlays used for scoring performance.

In 1982, interest was directed toward laser videodiscs as an alternative medium for presenting MITAC training material. As a result, ARIARDA assigned ASI the task of producing a demonstration laser videodisc of one of the Advanced MITAC lessons for use in comparing the videodisc format with the presently used film/audio-cassette format. In May 1982, an evaluation revealed the following advantages of the videodisc format:

- high quality video and audio reproduction;
- no degradation with normal use;
- the capabilities of automatic picture and chapter stop, freeze frame, slow or fast motion, frame-by-frame forward or reverse stepping, and rapid access to any frame or chapter on the disc;
- two audio tracks that can be used individually or simultaneously;
- thirty minute programming in the Constant Angular Velocity (CAV) mode or 54,000 individual frames per side;
- limited interaction capability; and
- reduction of cost for equipment (videodisc player vs 16-mm stop-action projector).

The main disadvantage of videodisc format is the large investment in time and resources required to produce the videodisc master. However, the cost effectiveness of the videodisc format is greatly influenced by the number of copies to be produced from the master disc; since reproduction costs are not excessive, the total cost per disc (including mastering costs) is not great when there is a requirement for numerous copies.

Project Objective

The evaluation of the prototype disc led to the conclusion that the advantages of laser videodiscs more than offset the disadvantages and that videodisc constitutes an excellent training medium for MITAC. As a result, ARIARDA directed ASI to convert the 13 Advanced MITAC lessons from 16-mm film to videodisc format and to provide complete supplementary exportable self-instructional packages containing supplementary course materials. The production of the videodiscs was executed in three phases.

Project Status

Work Completed

All work in preparing the videodisc version of MITAC has been completed. The four-phase effort is summarized below.

Phase 1: Program Design/Production. Program design and production procedures included the definition of detailed program objectives, the development of storyboards specifying picture and sound sequences, and the production of videotapes (from 16-mm film) and audio tapes of program segments.

Phase 2: Premastering. The company chosen for premastering and overseeing disc development was Digital Video Corporation in Orlando, Florida. Digital Video Corporation produced the one-inch Type C videotapes to be submitted for mastering and replication. Premastering included the transfer of program material from tape, film, and slides onto a one-inch videotape. Color and contrast correction, cue instructions, and editing were accomplished during this phase.

Phase 3: Mastering and Replication. The production of the videodiscs was performed by 3-M in St. Paul, Minnesota. The master tapes received from Digital Video were checked for adherence to specifications. The master discs were then pressed and replicated in specified quantities. Check discs were sent to Digital Video and ASI to be checked for conformance to specifications and for errors that might have occurred during the premastering or mastering and replication phases. The problems encountered were corrected prior to the reproduction of the requisite number of copies.

Phase 4: Development of Support Materials. During the fourth and final phase, ASI personnel produced all the support materials required to implement the training package. The materials developed include:

- 25 copies of a laminated map and legend plate,
- 25 copies of a map-plate overlay,
- 25 copies of a self-instructional manual,
- 25 laminated contour templates, and
- 25 copies of a performance measurement chart master.

Work Projected

No further work on this project is planned at this time. However, it is probable that further evaluation of the videodisc training package will be conducted.

References

Fineberg, M., Meister, D., & Farrell, J. P. (1978). An assessment of the navigation performance of Army aviators under nap-of-the-earth conditions. Fort Rucker, AL: U.S. Army Research Institute for the Behavioral and Social Sciences.

Holman, G. L. (1978). Effectiveness of a map interpretation and terrain analysis course on nap-of-the-earth navigation training of crewchief/observers. Fort Rucker, AL: U.S. Army Research Institute for the Behavioral and Social Sciences.

DEVELOPMENT OF AN UPGRADED BASIC MITAC
USING INTERACTIVE VIDEODISC

Mr. Claude O. Miles, Project Director

Background

During nap-of-the-earth (NOE) flight, an aviator flies at varying speeds as close as possible to the earth's surface--preferably flying around obstacles instead of over them--to escape radar or optical detection by a potential enemy. Visual pilotage is extremely important in maneuvering the aircraft and in maintaining geographic orientation; this is a skill that requires specialized training (Fineberg, Meister, & Farrell, 1978). Among the factors that make NOE navigation different and more difficult than navigating at higher altitudes are:

- a limited viewing distance when operating in close proximity to the ground,
- the perspective at which checkpoint features are viewed,
- the difference in perspective between the map representation and the point of regard of the NOE navigator,
- the need for more precise navigation and map interpretation, and
- the need for rapid association of map features with their real-world counterpart.

Tests have shown that checkpoint identification--the most critical factor to successful mission planning--appears to be the primary and most critical error made in NOE navigation. Tests also indicate that experience from flight at higher altitude does not transfer to NOE navigation. This finding is due primarily to the fact that the visual environment at NOE altitude differs greatly from the visual environment at higher altitudes.

Specialized training is needed to ensure proficiency and mission success in NOE navigation (Fineberg, Meister, & Farrell, 1978). In response to this need, the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) developed and implemented a system for training Army aviators in the critical skills required to navigate successfully and maintain NOE orientation in a high threat environment. This training course, referred to as the Map Interpretation and Terrain Analysis Course (MITAC), was designed to teach students to interpret 1:50,000-scale topographic maps and to use this knowledge to maintain accurate geographic orientation when flying at NOE altitudes (Bickley, 1978). Specifically, MITAC teaches students the cartographic rules and principles governing map compilation, the symbols used to portray features on the map, and the methods used to associate topographic features with their counterpart on the map. Cinematic exercises are used to train students to navigate at NOE altitude, taking advantage of concealment or "masking" of the aircraft afforded by vegetation and terrain.

The program is presented in 13 instructional units. The course begins with an introductory lesson in which students are taught the basic principles of cartography and map reading, and continues through more complex exercises requiring the students' NOE navigation skills. A series of color 35-mm slides are provided for use in teaching the convention and selection criteria in compiling 1:50,000-scale topographic maps, as well as fundamental map reading. A special text entitled "Map Interpretation in NOE Flight" is also provided to supplement the course material. The features covered by the slides include:

- hydrography,
- vegetation,
- transportation lines,
- buildings,
- miscellaneous cultural features, and
- terrain relief

A narration recorded on cassette tapes is provided to supplement the slides. In this portion of the program, the student is taught:

- the basis for the classification of roads,
- the coding criteria for vegetation,
- the methods and rules employed in delineating relief and drainage,
- the conventions used when portraying cultural features, and
- generalization and displacement practices in cartographic drafting (Cross & Rugge, 1980).

The performance oriented exercises emphasize analysis of terrain features and their representation on the map. The student conducts NOE mission planning, identifying checkpoints and assessing terrain masking. A scenario is provided by means of cinematic simulation in which the students might experience the practical application of the principles they are taught. The exercises begin with a preflight briefing; students then perform navigation training exercises. The navigation training exercises require students to maintain orientation and mark checkpoints on a map while viewing a motion picture film of routes flown at NOE. The exercises include:

- a contour analysis exercise,
- preflight terrain exercises,
- along-track orientation exercises,
- cross-track orientation exercises, and
- corridor orientation exercises.

All navigation exercises are followed by a postflight debriefing that requires students to view the filmed route a second time while listening to a prerecorded commentary that describes the topographic features along the filmed route that are most useful for maintaining geographic orientation.

MITAC is presently being implemented at the U.S. Army Aviation Center (USAAVNC) and is used for NOE training of Initial Entry Rotary Wing (IERW) students and some unit aviators. MITAC was evaluated at USAAVNC and found to be effective in teaching the skills required for NOE navigation (Holman, 1978). Holman's study revealed that a group of IERW students trained with MITAC navigated NOE routes with twice the speed and one-third the errors when compared with an equivalent group of IERW students not trained with MITAC.

Project Objectives

In September 1983, ARIARDA requested that the basic MITAC course be revised and converted to an interactive videodisc format. The objectives of this effort are to expand and improve the quality of the original course and to provide a more effective and sophisticated medium for presenting the training. Since videodisc technology affords many capabilities not available with the presently used audio/visual equipment, a decision was made to convert the entire course to the videodisc format.

Project Status

Work Completed. Work on this project commenced with a comprehensive review of literature on interactive videodisc technology. Project personnel also attended videodisc workshops in Atlanta, Georgia, and Fort Rucker, Alabama. Videodisc information concerning the development and presentation of interactive videodisc training was obtained and reviewed to assess the capabilities of various systems and to determine how they can best be utilized to accomplish MITAC training. Sony is the videodisc system chosen by ARIARDA and Anacapa Sciences, Inc. (ASI) for the project.

The MITAC illustrated lectures manual for infantrymen is being used as a guide in developing a comprehensive series of illustrated lectures for basic MITAC. The information contained in the manual is being edited and rewritten, making it applicable to Army aviator training. The lectures include in-depth sections on hydrography, vegetation, terrain relief, transportation lines, buildings, and miscellaneous cultural features. Test questions and remedial feedback are being written to test and reinforce a student's understanding and retention of information presented in the exercises. The course also requires programmer support during the various stages of development. The programmer task is to assist in the flow charting and branching processes necessary for developing an interactive training program.

An exhaustive list of slides needed to supplement the commentaries has been compiled. Some of the necessary slides have been taken, and additional photo missions are being planned to obtain the remaining slides.

Work Projected. Upon completion of the revision of the illustrated lecture commentary, slides will be grouped with the script and the preproduction tasks will be performed. During the preproduction phase, storyboards will be developed that specify key technical information necessary for the development of the products. This communication medium will provide information and instructions concerning:

- Video description
  --35-mm slides
  --videotape
  --computer-generated graphics
- Special effects
  --highlighting
  --zoom shots
  --closeups
  --panning
  --graphic overlays
- Computer-generated text
  --introduction
  --menus
  --credits
- Narration

An interaction flow chart and computer program will be created to use as a guide in developing the products.

The post-production phase will be executed at a studio. This will include laying video and slides on one-inch master videotapes. Graphics and other information will also be transferred to videotape during this phase. Following the completion of the one-inch master videotapes, a time code will be placed on the tapes. The videotapes will then be edited for content and technical accuracy. Following the editing phase, the one-inch master tapes will be used to create interactive videodiscs.

References

Bickley, W. R. (1978). Evaluation of an achievement test for map interpretation in nap-of-the-earth flight. Fort Rucker, AL: U.S. Army Research Institute for the Behavioral and Social Sciences.

Cross, K. D., & Rugge, S. M. (1980). Map interpretation and terrain analysis course for infantrymen: Illustrated lectures. Santa Barbara, CA: Anacapa Sciences.

Fineberg, M. L., Meister, D., & Farrell, J. P. (1978). An assessment of the navigation performance of Army aviators under nap-of-the-earth conditions. Fort Rucker, AL: U.S. Army Research Institute for the Behavioral and Social Sciences.

Holman, G. L. (1978). Effectiveness of a map interpretation and terrain analysis course on nap-of-the-earth navigation training of crewchief/observer. Fort Rucker, AL: U.S. Army Research Institute for the Behavioral and Social Sciences.

AN ASSESSMENT OF THE EFFECTIVENESS OF TRAINING HELICOPTER INITIAL ENTRY STUDENTS IN SIMULATORS

Mr. Steven L. Millard, Project Director

Background

Students entering the Army's Initial Entry Rotary Wing (IERW) course learn their basic contact flying skills in the TH-55 aircraft--a small two-place helicopter the Army uses exclusively for training. After 50 hours of inflight training in the TH-55, IERW students receive 125 hours of training in the UH-1H aircraft. To achieve instrument qualification, students must complete 40 hours of instruction in the UH-1 flight simulator. After becoming qualified in the UH-1 aircraft, students may join an operational unit as a UH-1 aviator or enter qualification training in another aircraft type.

There is a clear and pressing need to consider alternatives to training basic flight skills in the TH-55 helicopter. The reasons for this need are explained below.

Cost/Availability of Training Aircraft. The TH-55 is the only helicopter in the Army's inventory that requires high octane aviation fuel. In the event of a major fuel shortage, high octane fuel could become costly enough or scarce enough to disrupt the Army's IERW training program. Furthermore, maintaining a separate fleet of aviation fuel trucks and an aviation fuel contract is burdensome and expensive.

A more important concern is the impending end of the useful life of the TH-55. At present, no new TH-55 aircraft are being acquired to replace those in the aging fleet. A phase-out of the TH-55 would require the Army to select from among three options: the acquisition of a new training aircraft to replace the TH-55, the conduct of primary flight training in an aircraft that is now in the Army inventory, or training helicopter initial entry students in simulators (THIESIS).

It seems unlikely that a decision will be made to purchase a new training helicopter. The Department of Defense has resisted proposals to develop and produce aircraft that are to be used solely for training. Furthermore, the Army has a strong desire to channel all available resources into operational equipment (Roscoe, 1980).

The replacement of training in the TH-55 with training in an operational helicopter is not a promising option, because most operational Army helicopters are far more costly and consume considerably more fuel than the TH-55 (Grice & Morresette, 1982). Based upon initial cost and fuel consumption alone, it appears that the OH-58 is the only helicopter in the Army inventory that is even marginally suitable for use in conducting primary flight training.

There are no data available for use in evaluating the feasibility of replacing training in the TH-55 with training in a flight simulator; the research reported here has been designed to provide the data needed to assess this option.

Availability of Other Training Resources. Because of limited training resources at Fort Rucker, the Army is unable to accommodate a large and sudden surge in the training load. During the mobilization of Army aviation for the Vietnam War, IERW graduates exceeded 5,000 per year. During this period, primary flight training in the TH-55 was conducted at Fort Wolters, Texas; only the advanced phases of IERW were conducted at Fort Rucker. When the Army phased down pilot training, all IERW training was consolidated at Fort Rucker, and the number of IERW graduates was reduced to fewer than 1,000 per year. The current IERW training load--about 2,000 students per year--severely taxes the usable airspace and physical facilities at the Army Aviation Center (USAAVNC). In the event of another major mobilization, USAAVNC would be hard pressed to increase the number of graduates to that of the Vietnam era without exceeding the capacity of existing airspace, stagefields, and other physical facilities at Fort Rucker. The reactivation of Fort Wolters is a feasible option, but a very costly one. It is possible that a more cost-effective option is to increase the training capability of Fort Rucker by increasing the amount of training that is conducted in flight simulators.

Project Objectives

The specific technical objective of this research is to assess the extent to which contact flight training in a simulator equipped with an external visual system transfers to a UH-1H aircraft for initial entry flight students. A factor complicating the accomplishment of this objective is the absence of a UH1FS equipped with a visual system. The lack of a UH1FS with a visual system necessitates the use of a simulator for a different aircraft--the AH1FS, the CH47FS, or the UH60FS. Therefore, a secondary objective of this project is to identify the existing simulator that is the best surrogate for a UH1FS with a visual system.

Research Approach

Overview. A group of ten student aviators were trained on basic flight tasks in the AH-1 flight simulator (experimental group). A matched group of ten student aviators received conventional training in the TH-55 aircraft (control group). Then, members of both the experimental group and the control group progressed through the same training sequence throughout IERW training in the UH-1 aircraft. Data on academic grades, flight grades, flight hours, and setbacks were recorded for both groups throughout training. In addition, questionnaire data were collected from both students and instructor pilots (IPs) at critical points throughout training.

Selection of a Flight Simulator. As was stated above, there are no UH1FSs with visual systems in the Army inventory, so it was necessary to select from among the available flight simulators with visual systems--the CH47FS, the UH60FS, and the AH1FS--the one most similar to the UH-1. The AH1FS was clearly the best option. The AH-1 and UH-1, manufactured by the same company, are both single-engine, single-rotor, two-bladed, skid-type aircraft. Moreover, the AH-1 instrumentation is nearly identical to the instrumentation in the UH-1H. Although the airframe and flight characteristics of the two aircraft differ considerably, the magnitude of the differences in the flight simulator can be (and were) reduced considerably by adjusting selected parameters in the AH1FS equations of motion.

Subjects. A total of 10 experimental group subjects was selected from an IERW class. Experimental group subjects were selected randomly from class members who had no prior flight instruction. Once the experimental group subjects were selected, a matched sample of 10 control group subjects was selected from the same class. Factors used in selecting a control group counterpart for each experimental group subject include: RFAST score, age, sex, source of commission, and prior flight instruction (none). To avoid an impact on the appointment and date of rank of WOCs, all subjects selected for this research were commissioned officers.

Method. The 10 control group subjects received conventional primary flight training in the TH-55 aircraft (eight weeks, 50 TH-55 hours); the 10 experimental group subjects received all their primary flight training in the AH1FS (eight weeks, 40 AH1FS hours). Both groups were trained by Aviation Contractor Employees (ACE) IPs--civilian IPs who administer primary training to all IERW trainees. Both groups of subjects received classroom instruction of the type currently administered during the primary phase of IERW training except that the aircraft-specific classroom instruction administered to the experimental group subjects dealt only with the UH-1H aircraft. At the completion of primary training, the 20 subjects received the same sequence of instruction in the UH-1 aircraft throughout the remaining phases of IERW instruction: UH-1 transition training, basic and advanced instruments training, unaided night and night vision goggle (NVG) training, and combat skills training.

Since these students were a part of an experimental program, a special setback/elimination policy was adopted. In essence, the policy dictates that no experimental group subject could be eliminated from training during the UH-1 transition phase. Should a student's performance indicate a lack of proficiency usually associated with elimination, the student would be returned to the primary phase of training and progress through a normal IERW training cycle.

Data Collection. Comprehensive data files were maintained on all students, experimental and control, from the onset to the termination of IERW training. The types of data compiled include: academic grades, daily flight grades, checkride scores, flight hours to solo, flight hours to complete each training phase, number completing the training phase on time, number of setbacks, and number of eliminations. In addition, data were compiled from questionnaires designed to assess students' and IPs' opinions about the relative strengths and weaknesses of the simulator trained students.

Results. Analyses of the data collected throughout the seven phases of IERW training indicate that there are no significant differences between the experimental group and control group aviators on any of the criterion measures. Overall, the data show that receiving primary flight training in the AH1FS did not significantly handicap members of the experimental group during the remaining stages of IERW training.

Conclusions. While the data support the feasibility of conducting primary training in a visual flight simulator, the research was conducted in an AH1FS, modified to be as similar as possible to the UH1FS. It seems likely that the performance of the experimental subjects would improve by using a UH1FS equipped with a visual system; therefore, upon completion of the feasibility study, a decision was made to develop a visual system for an existing UH1FS. Upon installation of the visual system, a second feasibility study, as well as additional simulation training research, will be conducted.

Project Status

Work Completed. All analyses of the data collected during the initial feasibility study have been completed, and a draft report describing the results has been written. Additionally, members of the School of Engineering at the University of Alabama have completed the development of a visual system for the UH1FS, and members of the Department of Gunnery and Flight Simulation (DGFS) at USAAVNC have designated a UH1FS for installation of the visual system.

Work Projected. It is currently projected that installation of the visual system in the UH1FS will begin in September 1986. Following the installation of the visual system and the implementation of additional engineering design modifications, the conduct of the second feasibility study, as well as additional simulation training research, will begin. It is expected that the follow-on research will begin during the third quarter of FY87.

References

Grice, J. J., & Morresette, J. R. (1982, January). Increasing efficiency of mobility fuels. U.S. Army Aviation Digest.

Roscoe, S. (Ed.). (1980). Aviation Psychology. Ames, Iowa: The Iowa State University Press, p. 194.

VALIDATION OF AIRCREW TRAINING MANUAL REQUIREMENTS

Dr. John W. Ruffner, Project Director

Background

With the passage of the Aviation Career Incentive Act of 1974, Congress and the General Accounting Office imposed on all military services a requirement to "justify" their flying hour programs in order to receive continued funding. In June 1976, the Comptroller General of the United States reviewed the flying hour programs of the military services and criticized the Army's inability to justify its program. The other services were able to show how flight hours were being used, but the Army was unable to provide satisfactory documentation for the use and benefits derived from the 80 flying hours allotted annually for each aviator.

As a result of the Comptroller General's report, the Vice Chief of Staff of the Army directed that a task force be formed to develop a program that specifies, for each type of aircraft, how the flight hours allocated annually should be used to maintain individual proficiency and combat readiness. A task force from the Army Training and Doctrine Command (TRADOC) was created in 1976 to develop the Aircrew Training Manual (ATM) program (Lovejoy & Presley, 1980).

An ATM was developed for each operational aircraft in the Army inventory. The ATM for each aircraft lists (a) the individual flying tasks that must be performed satisfactorily during qualification training, mission training, and refresher training; (b) the flight hours and academic hours allotted to specific subject areas within each type of training; and (c) the standards for the satisfactory performance of each flight task. In addition, the ATM specifies the minimum number of times each ATM task should be performed (i.e., practice iterations) and the minimum number of hours that should be flown by mission ready aviators during each six-month period of continuation training. The purpose of continuation training is to maintain aviator currency and individual proficiency in an aircraft.

The minimum number of iterations and flight hours required to fulfill the ATM continuation training requirements depends on the Flight Activity Category (FAC) selected for the aviator by the unit commander. Aviators who are placed in FAC 2 positions need only fly the number of iterations and flight hours required to maintain proficiency in basic flight tasks. Aviators placed in FAC 1 positions must be capable of performing combat, combat support, or combat service support missions. Hence, FAC 1 aviators must maintain proficiency in both (a) basic flight tasks and (b) the tactical tasks appropriate for the type of aircraft (e.g., utility) flown by the aviator and the type of unit (e.g. troop support) to which the aviator is assigned.

Unit commanders are responsible for establishing a training task list for each FAC 1 and FAC 2 position (Department of the Army, 1980). Ordinarily, the unit commander's training task lists correspond closely with the task lists presented in the ATMs. However, training tasks may be added to or deleted from the ATM task lists if the commander judges that such additions/deletions will enhance the aviators' combat readiness.

Need

The ATM iteration and flying hour requirements were subjectively estimated by the subject matter experts (SMEs) who served on the TRADOC task force. The number of iterations for each task and the number of flying hours specified in the ATMs represent the SMEs' best estimate of the minimum necessary to maintain individual flight proficiency over a six-month period of continuation training. However, until now, no attempt has been made to confirm empirically the SMEs' subjective estimates. Since the cost of flying hours continues to increase, a need exists to determine empirically the minimum number of ATM task iterations and the minimum number of flying hours required to maintain individual flight proficiency. Empirical data on the iteration and flight hour requirements are needed to help Army decision makers determine the most effective ways to use the limited number of flying hours available to them. In 1980, the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) was tasked by the Army Aviation Center (USAAVNC) Directorate of Evaluation and Standardization (DES) to validate the semiannual ATM task iteration requirements for continuation training.

Project Objectives

The ATM Requirements Validation research has three specific objectives:

- to determine whether the minimum number of semiannual task iterations specified in the ATMs are appropriate for the maintenance of individual aviator proficiency on FAC 2 tasks,
- to identify the tasks for which changes in the iteration requirements are needed to achieve training effectiveness, and
- to determine if the number of iterations required to maintain proficiency depends on the total number of flight hours an aviator has logged during his career.

Research Approach

Because of time and resource constraints, the scope of the ATM Requirements Validation project was limited to the investigation of semiannual task iteration requirements for a FAC 2 continuation training program. Iteration requirements for FAC 2 aviators apply directly to FAC 1 aviators, who also must maintain proficiency in FAC 2 tasks.

A field experiment conducted at USAAVNC was designed to meet the project objectives. A total of 79 staff aviators assigned to FAC 2 positions served as subjects in the experiment. Staff aviators were selected as subjects because they do not fly as a regular part of their duty assignments, but are required to meet ATM semiannual task iteration and flying hour requirements.

The subjects were assigned to one of four groups--a control group and three experimental groups--such that the mean number of rotary-wing flight hours logged prior to the outset of the study was approximately the same for each group. At the beginning of the six-month period, subjects were given initial checkrides by USAAVNC Standardization Instructor Pilots (SIPs) to establish their baseline level of performance.

Subjects assigned to the control group were prohibited from all flying during the six-month period following the initial checkride. Subjects assigned to the three experimental groups were required to complete either 2, 4, or 6 practice iterations of 47 FAC 2 contact and terrain flight tasks during the six-month period. All practice iterations were performed in the UH-1 helicopter. Fourteen of the tasks were procedural tasks; 33 were psychomotor tasks.

Half the subjects assigned to an experimental group were scheduled to fly during the first three months of the test period; the other half were scheduled to fly during the second three months. Staff IPs supervised and graded performance on all practice flights.

At the end of the six-month period, each subject was given a final checkride by an SIP to measure level of performance on each of the tasks. Performance data were collected during both checkrides and practice flights. Practice flight data were retained for later analysis.

In addition to flight performance data, data were collected on the aviators' confidence in their ability to perform each task. Aviators rated their confidence to perform each task to ATM standards both before and after the initial and the final checkride. Confidence data were analyzed to determine the relationship between confidence level and checkride scores at the beginning and at the end of the test period.

Project Status

Work Completed. For the purpose of data analysis, subjects were divided into two flight hour groups of approximately equal size: (a) those with less than 900 total rotary-wing flight hours, and (b) those with more than 900 hours. Analysis of initial checkride scores indicated that there were no significant performance differences among the control and experimental groups prior to the six-month test period.

Performance data were analyzed in an analysis of variance using checkride scores as the dependent variable. The number of iterations and flight hour groups were treated as between-subjects independent variables; tasks and checkrides (initial and final) were treated as within-subject independent variables.

The results show that there is no significant difference between average pretest and posttest performance scores for either control group or experimental group subjects. In other words, the performance of the control group subjects (no practice) did not degrade significantly during the six-month period; nor did the performance of experimental group subjects improve as a result of the practice iterations they received. This finding is true regardless of the number of total rotary-wing flight hours logged and whether the tasks are psychomotor or procedural. The data suggest that, during a six-month training period, proficiency on the 47 contact and terrain flight tasks evaluated does not degrade appreciably even with no practice whatsoever. The results are consistent with previous research on the retention of psychomotor flight skills (e.g., Mengelkoch, Adams, & Gainer, 1960; Prophet, 1976).

Factor analysis of the final checkride performance data suggests that there are six independent sets of tasks that underlie overall checkride performance. The descriptive labels for the task sets are listed below:

- emergency tasks,
- terrain flight tasks,
- hovering tasks,
- high-angle approach tasks
- procedural tasks, and
- basic airwork tasks.

Overall performance can be estimated reliably using as few as 10 tasks sampled from the six task groups.

Overall checkride performance at the end of a six-month period is not reliably predicted by (a) the number of hours flown by the subjects during the last 6 or 12 months, (b) initial checkride scores, (c) the length of the no-practice period, or (d) aviators' self-rated confidence. In short, the results of this research do not support the requirement for aviators to perform the current minimum number of ATM FAC 2 contact and terrain flight task iterations over a six-month continuation training period. However, sufficient data are not available to generalize the results to (a) training periods longer than six months or (b) instrument tasks, emergency tasks, night tasks, or mission specific tasks.

A technical paper based on the results of the research was presented at the 27th Annual Meeting of the Human Factors Society on 11 October 1983. The paper was entitled "Factors Affecting Flight Skill Retention of Active Duty Army Helicopter Pilots."

The final report, entitled "Validation of Aircrew Training Manual Practice Iteration Requirements," was submitted to ARIARDA as a contract deliverable on 2 November 1983. Submission of the final report fulfilled all contractual requirements for this project.

References

Department of the Army. (1980). Aircrew Training Manual Commander's Guide (TC 1-134). Washington, DC: Department of the Army.

Lovejoy, R. K., & Presley, W. N. (September 1980). Aircrew Training Manuals. Aviation Digest.

Mengelkoch, R. F., Adams, J. A., & Gainer, C. A. (1960). The forgetting of instrument skills as a function of the level of initial proficiency (NAVTRADEVCEN TR 71-16-18). Port Washington, NY: U.S. Naval Training Device Center.

Prophet, W. W. (1976). Long-term retention of flying skills: A review of the literature (HumRRO Technical Report 76-35). Alexandria, VA: Human Resources Research Organization.

IDENTIFICATION OF PREREQUISITES AND SELECTION CRITERIA FOR AH-64A ADVANCED ATTACK HELICOPTER CREW MEMBERS

Mr. Theodore B. Aldrich, Project Director

Background

Army aviators selected to fly the AH-64A attack helicopter will encounter a greater workload and a greater division of labor between the pilot and copilot/gunner (CPG) than they have encountered in any previous Army helicopter.

The CPG position features a target acquisition and detection system (TADS) composed of high technology components that include forward looking infrared (FLIR), a video day television viewing system, and direct view optics. A laser range finder and an airborne laser tracking and target cueing system will aid the CPG in reducing target acquisition time and in accomplishing the target acquisition functions under adverse visibility conditions. The TADS interfaces with a fire control system that enables the CPG to fire the Army's new HELLFIRE missile in several different modes. A doppler navigation system interfaces with the TADS and the fire control computer; the operation of the doppler requires the CPG to perform a host of complex tasks. Finally, redundant controls are provided in the front crew station to enable the CPG to fly the aircraft when the mission or situation warrants (Hughes Helicopters, 1979).

The most striking example of the new technology in the pilot's crew station is the Pilot's Night Vision System (PNVS). The PNVS provides the visual information the pilot needs to fly the aircraft during darkness and under other adverse visibility conditions. The Integrated Helmet and Display Sight System (IHADSS) presents information to the pilot on a one-inch diameter, helmet-mounted cathode ray tube. This display, generated in part by the FLIR sensor mounted in the nose of the aircraft, provides flight instrument symbology superimposed on a thermal "real world" contact display. The flight instrument symbols provide information about heading, altitude, airspeed, engine power management, attitude, and trim. The FLIR image on the IHADSS allows the pilot to stay "outside the cockpit" while flying under conditions of restricted or limited visibility. The AH-64A pilot has an exacting and demanding job flying nap-of-the-earth (NOE) in poor visibility conditions because the PNVS field-of-view is limited to 40 degrees. In addition to controlling the aircraft, the pilot must perform air-navigation tasks, weapon control and firing, emergency procedures, and must remain cognizant of the functions being performed by the CPG and the other combatants within the battle area (Hughes Helicopters, 1979).

During development of the AH-64A, two tentative decisions were made about the selection and training of AH-64A crewmembers. First, it was decided that, initially, AH-64A trainees would be selected from the population of Army aviators who demonstrated a high level of proficiency in the AH-1 aircraft (Hipp, 1978). The assumption underlying this early decision was that highly proficient AH-1 aviators are likely to possess the abilities required to perform effectively in the AH-64A. Second, the Army planned to train all AH-64A aviators to perform both the pilot and the CPG functions (Browne, 1981). This decision was based on (a) a desire for maximum operational flexibility and (b) the assumption that individuals who possess the abilities to perform effectively in one crew position also will be able to perform effectively in the other crew position.

Need

The AH-64A subsystems are so different and so much more complex than the subsystems in other Army helicopters that there is a strong reason to suspect that effective performance in the AH-64A may require that AH-64A crewmembers possess abilities above and beyond those required to perform effectively in other Army helicopters. Hence, there is a need to determine whether AH-64A crewmembers must possess unique abilities and, if so, to develop tests that can be used to select individuals who possess the requisite abilities (Human Resource Need, undated).

There is reason to question the assumption that there is a high degree of commonality in the abilities required for effective performance in the two AH-64A crew positions. Because of the differences in the tasks performed in the two crew positions and because of the differences in the subsystems used to perform these tasks, it is altogether possible that effective performance in the two crew positions may require different sets of abilities that are rarely found in the same individual. As a consequence, there is a need to determine whether or not the abilities required to perform effectively in the pilot position differ in type or extent from the abilities required to perform effectively in the CPG position. If it is found that different abilities are required, a need will exist to develop tests for selecting individuals with the requisite sets of abilities.

Project Objectives

As is suggested by the title, the general objective of this project was to define prerequisites and selection criteria for AH-64A crewmembers. The specific technical objectives follow:

- identify for each crew position the critical crew functions required to perform the attack helicopter mission,
- determine the critical crew functions, if any, that are unique to the AH-64A,
- develop for each crew position the predictors of the abilities required to perform the critical functions,

- validate the predictors against performance measures in the AH-64A crew training program, and
- cross-validate the predictors against performance measures in the AH-64A crew training program.

Research Approach

The original approach developed for this project differed from the traditional approach to aviator selection test development. Instead of a detailed analysis of the aviator tasks, the project capitalized on a number of task analyses that already had been performed for the AH-64A (Applied Sciences Associates, 1981; Singer Company, 1977; Applied Psychological Services, 1982). Plans for developing the AH-64A selection test did not address the entire inventory of AH-64A crew functions because it was assumed that a large proportion of the AH-64A crew functions are the same as those in the AH-1 aircraft. It was further assumed that the same fundamental abilities underlie the functions that are common to the two types of aircraft. If the assumptions are valid, there is no need to develop test instruments to assess common abilities. Since all candidates for AH-64A qualification training were to be successful AH-1 aviators, it was presumed that all candidates would possess an acceptable level of common abilities. Therefore, the original approach in this project called for development of selection measures based on crew functions and underlying abilities that are unique to the AH-64A aircraft.

Originally, a job sample test development approach to AH-64A selection was chosen to complement a separate project that was developing test instruments for selecting students to the attack (AH-1) training track. That test development effort was based on AH-1 crew functions, so the resulting test instruments would assess the abilities underlying AH-1 crew functions (Myers, Jennings, & Fleishman, 1982). It was thought that, if the Army decides at some future time to select AH-64A aviators from the general population of flying students, it would be possible to base the selection decision on a combination of tests: (a) the fundamental abilities tests developed to select trainees for the attack helicopter training track and (b) the job sample tests developed during this project to assess the job-specific abilities that AH-64A aviators must possess above and beyond the abilities required to pilot the AH-1 aircraft.

Job sample tests were deemed more appropriate for selecting AH-64A crewmembers from among operational aviators who already have demonstrated that they possess the requisite abilities for flying. Moreover, the high technology hardware associated with the unique AH-64A crew functions provides an identifiable source of job sample test content.

Project Status

Work Completed. Project personnel became thoroughly familiar with the AH-64A attack mission and completed a comprehensive review of the research literature on aviator selection. Task lists and task analyses conducted during the design and production of the AH-64A system were collected and used to compile a composite list of AH-64A crew functions.

The composite list of AH-64A crew functions was formatted into a survey instrument and administered to 27 AH-64A subject matter experts (SMEs). The SMEs rated 146 pilot functions and 88 CPG functions on four dimensions: difficulty to learn, probability of deficient performance, frequency of performance, and likelihood that deficient performance will have serious consequences.

The survey data were entered into a computerized data file. Descriptive statistics were produced for all 234 ratings. Problems were encountered in attempting to combine the results from the four survey scales into one overall measure of criticality. A two-way analysis of variance with replications was performed on the survey data. The significant interaction effects between scales and functions prevented summing mean ratings to derive overall criticality scores for the pilot and copilot functions. Mean ratings and standard deviations were graphically plotted for each of the 146 pilot functions and 88 CPG functions for the four survey scales. Review of the eight plots revealed that the SMEs used the full range of ratings on three of the scales:

- difficulty of learning,
- frequency of performance during combat missions, and
- likelihood that deficient performance will have serious consequences.

Ratings on the fourth scale (frequency of deficient performance) were confined to a relatively narrow range.

Based upon the data groupings in the first three scales, a decision tree was developed for identifying the critical AH-64A crew functions. The fourth scale was dropped from the analysis under the decision tree approach.

The decision tree methodology consisted of four steps:

- select crew functions that are unique to the AH-64A and eliminate crew functions that are similar to the AH-1;
- select crew functions in the top levels of the "difficulty of learning" scale and eliminate crew functions in the lower level(s);
- select crew functions in the top levels of the "frequency of performance during combat missions" scale and eliminate crew functions in the lower level(s); and

- select crew functions in the top levels of the "likelihood that deficient performance will have serious consequences" scale and eliminate crew functions in the lower level(s).

Sixty-five of the pilot functions were categorized as similar and 81 were categorized as unique. Among the copilot/gunner functions, 12 were categorized as similar and 66 were categorized as unique.

Two decision trees were developed. Overall mean ratings and standard deviations for each rating scale were used to establish quantitative limits for each branch of the decision tree. The pilot function decision tree consists of four different levels (branches) of the "difficulty to learn" scale, three different branches of the "frequency of performance" scale, and three different branches of the "likelihood that deficient performance will have serious consequences" scale. The copilot/gunner decision tree consists of three different branches of the "difficulty to learn" scale, three different branches of the "frequency of performance" scale, and three different branches of the "likelihood that deficient performance will have serious consequences" scale. Thus, there are (4x3x3) 36 levels in the final step of the pilot function decision tree and (3x3x3) 27 levels in the final step of the copilot/gunner function decision tree.

Each pilot and copilot/gunner function was entered into the decision tree using the following procedure:

- the mean rating on the "difficulty to learn" scale was used to assign the function to the proper branch of the "difficulty to learn" portion of the tree;
- from that level, the mean rating on the "frequency of performance" scale was used to assign the function to the proper branch of the "frequency of performance" scale; and
- from that level, the mean rating on the "likelihood that deficient performance will have serious consequences" scale was used to assign the function to the proper branch of the "likelihood that deficient performance will have serious consequences" scale.

The final step resulted in the sorting of the 146 pilot functions into 36 different levels of criticality and the 88 copilot/gunner functions into 27 different levels of criticality.

AH-64A aircrew qualification training started at Fort Rucker on 1 January 1985. Identification of the critical crew functions and development of the predictor test battery was not completed in time to select the first students for training. Thus, the Army reverted to traditional personnel selection procedures.

In August of 1985, the basic requirement for the project changed. The Army projected that the policy of entering only experienced AH-1 aviators into the AH-64A training would result in an excessively aged population of combat qualified AH-64A aviators. Accordingly, on 28 August, the U.S. Army Aviation Center (USAAVNC) tasked the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) to determine whether new graduates (turnaround students) from the Initial Entry Rotary Wing (IERW) training course could be entered directly into AH-64A training without experience in the AH-1. Moreover, ARIARDA was tasked to develop a methodology for selecting IERW students for the training.

With the change in requirements, ARIARDA terminated work by Anacapa Sciences, Inc. (ASI) on AH-64A selection and assigned the work to in-house scientists working on IERW selection problems. ARIARDA researchers developed a new set of objectives and a new approach to the identification of prerequisites and selection criteria for the AH-64A.

ASI researchers provided several products from the original project that assisted ARIARDA in developing the objectives and the research approach for the redirected project. The list of products includes:

- a composite list of AH-64A crew functions,
- raw data results from the survey in which AH-64A SMEs rated crew functions,
- descriptive statistics for all of the ratings,
- a computerized file of the survey data,
- graphic plots of the mean ratings and standard deviations for the pilot and CPG functions for the four survey scales, and
- the two decision trees with the pilot and CPG functions sorted into the different levels of criticality.

Redirection of the project and transfer of the products listed above to ARIARDA scientists terminated ASI's contractual requirements in support of this project. ARIARDA used the products provided by ASI and traditional IERW selection measures, such as student grades, Armed Services Vocational Aptitude Battery, and Revised Flight Aptitude Selection Test scores, to develop a prototype selection algorithm for use in selecting IERW graduates for AH-64A training. The prototype algorithm was provided to USAAVNC in December 1985.

Work Projected. Future work on AH-64A aviator selection awaits ARIARDA validation of the selection algorithm.

References

Applied Sciences Associates, Inc. (1981). AH-64 Final Trade-Off Analysis Report. Fort Bliss, TX: Applied Sciences Associates, Inc.

Browne, E. M. (1981). An interview with the AAH PM, the advanced attack helicopter. U.S. Army Aviation Digest, 5-8.

Hipp, J. H. (1978). Personnel initiation. U.S. Army Aviation Digest, 18-19.

Hughes Helicopters. (1979). Proposed Specification Change Notice (PSCN) No. 50. Volume 1 - YAH-64 (pilot/CPG training plan (Hughes Technical Report No. 50).

Human Resource Need. (undated). Prerequisites and selection criteria for assignment to the AH-64 advanced attack aircraft (HRN RCS CSGPA-1337). Fort Rucker, AL: U.S. Army Aviation Center.

Myers, D. C., Jennings, M. C., & Fleishman, E. A. (1982). Validation of cognitive and perceptual tests for assigning pilots to different missions. Washington, D.C.: Advanced Research Resources. May 1982.

Singer Company. (1977). AH-64 concept formulation study (Report No. LR 859). Binghamton, NY: Singer-Link.

DEVELOPMENT OF A METHODOLOGY FOR GENERATING A FLIGHT GRADING SYSTEM

Mr. Theodore B. Aldrich, Project Director

Background

Instructor pilots (IPs) responsible for training in the Combat Skills course of the Army's Initial Entry Rotary Wing (IERW) training program expressed considerable dissatisfaction with the gradeslip currently being used to assess student performance. The IPs requested that the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) provide support in developing and evaluating an improved gradeslip (Shipley, 1981). Preliminary investigation revealed that the gradeslip was only one part of a more general problem. As a result, project personnel recommended that the project be expanded to encompass all aspects of the Combat Skills grading system. The project description presented below reflects the intention to investigate the full range of problems associated with the Combat Skills grading system.

Need/Problem

Many of the traditional problems associated with flight grading systems are manifest in the U.S. Army's flight training program. Four problems are considered especially crucial. First, daily flying lessons and periodic check flights within the IERW training program are graded using a four-increment scale (A, B, C, or U). The standards for the four increments are stated in descriptive terms and allow for a range of individual IP judgments. The regulation prescribing the grading procedures calls for criterion-referenced grading; and yet, the same regulation (U.S. Army Aviation Center, 1970) directs IPs to adjust grading standards to correspond to the student's phase of training.

Second, the gradeslip lists the maneuvers to be graded, but the rationale for including the maneuvers on the gradeslip is obscure. In addition, the maneuvers listed on the gradeslip do not correspond exactly with either the maneuvers contained in the training syllabus or those listed in the Aircrew Training Manual (ATM). Apparently, this lack of correspondence is the result of the training managers' failure to modify the gradeslip in step with changes to the training syllabus. This failure raises questions about training managers' requirements for grade information and suggests that management information requirements for grades be identified and specified during the design of the grading system.

Third, there are a number of human factors design deficiencies in the gradeslip. Grouping of items is not functional and a large number of graded items are crowded onto a small form by reducing the type size below established legibility standards.

Finally, the Combat Skills IPs receive limited and ineffective training on performance evaluation and grading. New IPs develop their individualized set of evaluation criteria based upon informal discussions with more experienced IPs and upon their own experience from flight school and operational flying assignments.

Project Objectives

This project originally had two broad objectives. The first objective was to develop and implement an improved grading system for the Combat Skills course. The second objective was to test a methodology for developing improved flight grading systems. A key attribute of this methodology is that experienced IPs would play an important and continuous role in all aspects of the design process.

A set of secondary objectives, aimed at eliminating specific deficiencies in the present grading system, was to be addressed during the development of the improved grading system. The secondary objectives were:

- define specific grading criteria and standards,
- design a gradeslip that satisfies management information requirements and complies with human factors standards,
- develop a grading scale that contributes to interrater reliability and allows the IP to accurately record the grades in accordance with the established standards, and
- develop a training program that instructs IPs and check pilots on how to grade flight performance accurately and consistently.

Research Approach

The approach to be followed in this project is described below in three phases: design and pretest, test and evaluation, and implementation.

Design and Pretest. Design of the grading system was to be accomplished through a series of consensual decision-making design meetings involving eight Combat Skills IPs and four IPs assigned to key training directorates at the U.S. Army Aviation Center (USAAVNC). Design features, such as the scale, the items to be graded, the system for calculating an overall grade, the frequency of grading, and the format for the gradeslip were to be established by the IPs during consensual decision-making design meetings. Project personnel planned to accomplish the following tasks prior to the first design meeting:

- conduct an audit of the training management information system for the purpose of documenting the requirements for flight grades,

- perform a content analysis of the combat skills maneuvers,
- develop human factors specifications to be used as constraints for the design of the gradeslip, and
- develop grading system design guidelines.

The results from these tasks were to be provided to the IPs as guidelines and factors to be considered in their design decisions.

The program called for the IPs who designed the grading system to pretest the system by participating in flight tests in an instrumented helicopter. Results of the flight tests were to be reported at subsequent design meetings and used to refine the grading system design. The flight tests also would be used to refine procedures to be used in the test and evaluation phase.

A program to train IPs on the new grading procedures and materials would be developed as the prototype grading system design neared completion. Plans called for using videotapes, recorded during the flight tests, as visual aids in the program.

Test and Evaluation. The approach to be followed during the test and evaluation phase featured operational use of the prototype grading system during simultaneous inflight grading of students by two IPs. Prior to the inflight grading, the participating IPs would be introduced to the prototype grading system through a training program developed earlier. The inflight grading would be performed initially in the Method of Instruction (MOI) course used to train rated aviators to be Combat Skills IPs and subsequently in the Combat Skills Course of Instruction (COI) with actual students. After each flight, the two IPs were to resolve their differences in grading through discussion of the student's performance on the graded items. Videotape recordings of the inflight maneuvers would be used to assist the IPs in resolving their differences.

Additional pairs of IPs would grade the recorded maneuvers based only on the information they derived from viewing the videotapes. Differences in grades, assigned during the video grading, would be resolved through consensual decision making.

A fundamental assumption underlying this project was that the discussions IPs engaged in to resolve differences in assigned grades would reveal valuable information about performance criteria and standards. Consequently, project personnel planned to be present at all discussions that IPs engaged in to resolve grading differences. This procedure would permit the recording of information bearing on (a) the set of flight parameters that IPs consider in evaluating performance on a given maneuver and (b) the relationship between assigned grades and the amount by which a flight parameter deviates from its command or "nominal" value.

The data compiled during this phase of the project would be used to define tentative performance criteria and standards for each Combat Skills maneuver to be graded. In addition, the data on initial assigned grades would be used to measure the level of interrater reliability existing prior to the introduction of the new grading system. The products that were expected to result from the approach described above include:

- a listing of the individuals/agencies who use information on flight grades and the purposes for which they use the information,
- a listing of the flight maneuvers to be graded by Combat Skills IPs,
- a definition of the performance criteria and standards for each maneuver to be graded,
- a description of all grading procedures and materials,
- a description of the flow of information on grades throughout the training management system, and
- a program for training Combat Skills IPs to use the recommended grading procedures and materials.

Implementation. The third phase of the project was implementation of the new grading system throughout the Combat Skills course. The training program on grading and performance evaluation would be administered to all Combat Skills IPs. Thereafter, the training program would be taught regularly as a part of the MOI course so that new IPs could be instructed properly on the subject of grading and performance evaluation.

Project Status

Work Completed. Considerable planning was completed for this project. An issues paper was written that reviews the relevant performance measurement literature and discusses the problems encountered when developing a new grading system within an operational environment. An analysis of the deficiencies in the existing grading system was completed, and a set of design criteria for the new system was developed. Included in the design criteria are the major human factors considerations that constrain and guide grading system design.

A plan for conducting the project was prepared in the form of a task flow diagram. Resources required for the duration of the project were spelled out in fine detail. Manpower and logistic resources were estimated for each step of the project on a weekly timeline.

One of the primary resource requirements identified for the project was an instrumented UH-1 helicopter and an instrumentation package to support the inflight tests. An available helicopter and an instrumentation package adaptable for the project were located, and preliminary commitments of support were obtained.

IP manpower was another key resource required for this project. A briefing on the research plan was presented to a group of Combat Skills IPs; the plan received their tentative endorsement. A subsequent briefing was presented to the Lowe Training Division Commander who is responsible for the Combat Skills course. He stated that he could not commit the required IPs to the project because IP resources constituted only 75% of the authorized manning level. He suggested that project personnel further investigate the utility of the instrumented helicopter and informally discuss the grading system problems with IPs on an as-available basis until IP strength was increased to a level that would allow assignment of IPs to the project.

Rather than delay the project, a decision was made to conduct a pilot study using ARIARDA and Anacapa Sciences, Inc. (ASI) IP resources and an instrumented helicopter available from the U.S. Army Aviation Test Activity at Cairns Field. The objectives of the pilot test were to investigate the feasibility of the following:

- engaging IPs in consensual decision-making exercises leading to the design of a prototype gradeslip,
- using the prototype gradeslip for inflight grading,
- recording student performance on videotape in flight, and
- grading student performance from videotape collected in flight.

A series of consensual decision-making meetings with the three IPs from ARIARDA/ASI was conducted from January through March 1983. The consensual decision-making approach to the design of a gradeslip proved to be very time consuming. Eighteen separate meetings were required before the three IPs completed their gradeslip design.

ARIARDA contracted with the Aviation Test Activity for technical support and five hours of flying time in the instrumented helicopter. Project personnel identified performance measurements to be collected and consulted with Aviation Test Activity personnel about the optimum placement of three video cameras. One camera was mounted on the nose of the helicopter and recorded a forward field-of-view 87 degrees wide. A second camera was mounted above and to the rear of the pilot's head and was directed at the student pilot. A third camera was focused on a specially constructed "little theater" in which an array of repeater flight instruments could be video recorded. All three cameras were connected to video recorders. A time signal generator was provided to project a time onto each recording.

The IPs assigned to the project designed a combat skills test mission to be flown in the instrumented helicopter. The mission consisted of 44 segments and was planned to fill a two-hour period.

Lowe Division officials, responsible for the Combat Skills course, provided fledgling IPs to serve in the test as volunteer student pilots. Video cameras and recorders were operated during two flight tests. During the first flight test, the cameras directed toward the subject and the little theater were connected to two-hour recorders and were operated continuously. The nose camera was connected to a 30-minute recorder that operated intermittently during critical performance segments. Two IPs graded the subjects' performance and entered their grades on the prototype gradeslip. After the flight, the IPs discussed the subjects' grades and reached consensus to resolve many of their differences. A third IP viewed the videotapes, graded the students' performance, and provided comments about the utility of the videotapes. The IP was able to grade the students from information acquired solely through the videotapes. There was a high degree of agreement between the grades provided by the IP who viewed the videotapes and the grades provided by the IPs who observed the flight. As a result of the comments collected from the IPs who performed the grading on the first flight test, minor redesign of the prototype gradeslip was accomplished.

Review of the videotapes resulted in the identification of several changes required to improve the quality of the recordings. Recommended modifications include:

- improve the focus and/or lighting for the camera directed at the little theater,
- dampen the vibration for the camera directed at the subject pilot,
- troubleshoot and repair the pitot pressure line to the airspeed indicator in the little theater, and
- substitute a different multiplex unit and/or time signal generator in order to provide readable time codes on both the little theater and subject pilot videotapes.

The Aviation Test Activity personnel agreed to implement the above improvements for the second test flight. The multiplex unit previously used to combine video from the little theater camera and the student camera onto one recorder was eliminated. Each camera was linked to an independent two-hour recorder. Also, the recorder for the nose camera was changed to provide a full two-hour capability. Without the multiplex unit, the time code appeared on only two of the tapes. However, the three video recordings were initiated by a single switch and were in close synchrony from the start. A different camera was installed for the "little theater" scene. The camera position was moved closer to the panel so the instruments could be read more clearly.

During the second test flight, the two IPs exchanged the flight position they filled during the first flight, with one serving as the IP at the controls (left seat) and the other as the IP observing from behind the left seat. The videotapes from all three cameras were of improved quality in comparison to those of the first flight. Flight test results were discussed with the Aviation Test Activity planners and agreement was reached that the flight test portion of the pilot study had been completed.

The primary products from this project are (a) a detailed research plan and (b) an estimate of resources required to conduct the full-scale project. The detailed research plan and estimate of resources, "A Methodology for Developing a Flight Grading System" (Resource Estimate ASI479-011-82) was provided to ARIARDA in September 1982.

In addition, a draft report was written that describes the procedures and results of the pilot study that was conducted while awaiting resources required to conduct the full-scale project. The draft report includes:

- a content analysis of the combat skills maneuvers;
- human engineering criteria for design of the gradeslip;
- a description of the consensual decision-making process used to design a prototype gradeslip;
- a critique of the prototype gradeslip;
- a description of the instrumented helicopter; and
- a discussion of the results from (a) the inflight grading and (b) the postflight grading from the videotape.

Summary findings from the pilot study that are included in the draft report are listed below.

- A Combat Skills gradeslip can be designed by involving a group of IPs in a series of consensual decision-making meetings. However, the number of meetings and the time required to accomplish this effort are greater than originally estimated.
- IPs are able to grade student performance by reference to videotapes of student performance recorded in flight. Video and audio recording from the test missions provide enough detail to accomplish grading.
- IPs are able to grade from a jump seat located behind the left pilot's seat. In fact, both IPs commented that they were able to observe student performance better from the jump seat location.
- The Aviation Test Activity is not able to provide the technical support required to provide an instrumented helicopter on a dedicated daily flight schedule, as required by the project research plan.
- The video recordings have good potential value for use in developing instructional material for courses on grading to be presented to newly assigned IPs.

The draft report was provided to the ARIARDA point of contact for use in planning other performance evaluation research. Upon submission of the draft report, work on the project was terminated because the resources required to accomplish the full scope of the research could not be provided.

Work Projected. Future directions to be taken in applied research directed toward improving the flight grading system at the USAAVNC will be defined by ARIARDA when Army requirements for the research are assigned higher priorities and resources are provided.

References

Shipley, B. D. (20 January 1981). Memorandum for record. Subject: Request for Assistance to Develop New Grading System for Combat Skills. Army Research Institute Field Unit, Fort Rucker, AL.

U.S. Army Aviation Center. (16 December 1970). The uniform flight grading system (Regulation 350-16). Fort Rucker, AL: USAAVNC.

ASSESSMENT OF THE RELATIONSHIP BETWEEN ANTHROPOMETRIC SIZE OF ARMY HELICOPTER PILOTS AND PILOTS' ABILITY TO PERFORM VARIOUS FLIGHT TASKS/MANEUVERS

Dr. Kathleen A. O'Donnell, Project Director

Background

The cockpit of an aircraft provides a finite amount of space in which a person must successfully perform all necessary operations. Because the amount of space is finite, minimum and maximum standards of operator body size must exist for operational efficiency, comfort, and injury avoidance. A single measure of size (such as height) is not sufficient for determining whether a person's body size is acceptable for safe and comfortable control of an aircraft. For example, it is possible that a person will meet the minimum height requirement for an aircraft, but not have the leg or arm length necessary to accomplish full control movements in the aircraft. This possibility led to a change in the standards required for entry into the Army flight training program.

In May 1980, the Surgeon General's Office issued a change to the Medical Fitness Standards for Flying Duty Classes. This change replaced the minimum height criterion of 64 inches with the following anthropometric standards:

- 68 to 76 inches in height, or
- less than 68 inches in height with a minimum leg length (LL) of 70.75 cm and a combined measure of sitting height (SH) and functional arm reach (FAR) of 150.5 cm.

These standards were developed by the Human Engineering Laboratory (HEL) and the U.S. Army Aeromedical Research Laboratory (USAARL). They are based on static measurements taken in aircraft mockups and in stationary aircraft cockpits of the UH-1, OH-58, and AH-1 aircraft.

Need/Problem

The alteration of flight school selection standards was based on the minimum anthropometric measurements necessary to manipulate aircraft controls in a static situation. In addition, the minimum acceptable measurements were assessed separately for each control. There is a need to ensure that the new selection standards are adequate when the subject is placed in a dynamic situation (i.e., a flight situation in which the controls must be integrated).

Project Objective

The specific objective of this project was to ensure that student aviators who meet the new Army anthropometric standards are capable of operating all Army aircraft.

Research Approach

Subjects. Subjects were Commissioned Officers (COs) and Warrant Officer Candidates (WOCs) in the Army's Initial Entry Rotary Wing (IERW) Flight Training Course and the AH-1 Aviator Qualification Course (AQC) during calendar years 1980, 1981, 1982, and 1983. Subjects were divided into three groups. The short group included all IERW students with a height of 64 inches and below or with anthropometric measurements less than the following: 74.8 cm for LL, 158.9 cm for combined SH and FAR (SH + FAR). The control group included a random sample of IERW students with a height between 64.1 inches and 72.9 inches or with anthropometric measurements between the following: 74.8 and 89.3 cm for LL, 158.9 and 182.9 cm for SH + FAR. The tall group consisted of a random sample of IERW students with a height of 73 inches and above or with anthropometric measurements greater than the following: 89.3 cm for LL, 182.9 cm for SH + FAR.

A group of IPs were asked to identify any aircraft maneuvers and/or procedures on which short or tall students would be likely to experience difficulty due to their size. In addition, they were asked to provide an hour-level range, for each maneuver, within which poor performance might indicate a special difficulty. This was accomplished for three different aircraft--the TH-55, the UH-1, and the AH-1.

Three performance measures were used:

- daily grades on 26 maneuvers: 6 for the TH-55, 4 for the UH-1, 6 for the AH-1, and 10 for the OH-58;
- elimination from the IERW Flight Training Course; and
- setbacks received during the IERW Flight Training Course.

Repeated measure ANCOVAs were performed on the daily grade data and tests of proportions were performed on the elimination and setback data. Age and ability were used as covariates.

Results

The results indicate that aviator size does not affect flight performance in the Army rotary-wing flight training program. No statistically significant differences in flight performance were found among the three size groups (short, control, tall). Also, the results indicate that aviator size does not have a significant effect on likelihood of elimination from the flight training program. Although a statistically significant difference was found between the proportion of tall students with setbacks and the proportion of control students with setbacks (for total setbacks and flight deficiency setbacks), the difference was in favor of the tall students rather than showing a deficiency due to excessive height.

Project Status

All work on this project was completed with the submission of a final technical report entitled "Assessment of the Relationship Between Anthropometric Size of Army Helicopter Pilots and Pilots' Ability to Perform Various Flight Tasks/Maneuvers." The report was submitted in June 1984.

AN EXAMINATION OF ABILITY REQUIREMENTS FOR VARIOUS ROTARY-WING MISSIONS

Dr. Dennis H. Jones, Project Director, and Dr. D. Michael McAnulty

Background

The increasing specialization of rotary-wing missions and aircraft has precipitated a reanalysis of traditional strategies for assigning student aviators to one of four rotary-wing missions: cargo, utility, aeroscout, or attack. Current assignment strategies are based on pervasive anecdotal evidence that there are substantial differences in the ability requirements for the four missions. Specifically, the anecdotal evidence suggests that the ability requirements are greater for successful aeroscout and attack aviators than for aviators in the other two mission tracks. In view of this, the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) at Fort Rucker, Alabama, has sponsored two research efforts (Miller, Eschenbrenner, Marco, & Dohme, 1981; Myers, Jennings, & Fleishman, 1982) to determine the feasibility of a classification system based on differences in the ability requirements for the four missions. Although both research efforts provided unique insights into the types of abilities required for each type of mission, the analyses did not directly compare the ability requirements for each mission. For a classification system based on ability requirements to be feasible, it must be established that statistically significant differences exist among the four missions.

Project Objective

The objective of this project is to reanalyze the data collected by Myers et al. (1982) to determine whether a classification battery based on differences in ability requirements should be developed to assign aviators to the four rotary-wing missions. The specific goals of this project are as follow:

- evaluate the psychometric errors in the raters' distributions and, if necessary, transform the data;
- identify the ability requirements for each of the four rotary-wing missions;
- compare the ability requirements; and
- make recommendations about the utility of a classification system based on ability requirements.

Original Research Approach

The following sections describe the subjects and procedures used by Myers et al. (1982) in the original research design.

Subject Matter Experts (SMEs). The SMEs were all rated aviators with advanced training in their aircraft mission specialty. There were 11 SMEs for the cargo mission, 16 SMEs for the utility mission, 17 SMEs for the aeroscout mission, and 16 SMEs for the attack mission.

Procedure. Myers et al. (1982) had each SME rate the importance of each of 32 abilities from the language, perceptual, psychomotor, and cognitive domains on a set of previously selected mission tasks. Each mission had an independent task list, and the SMEs rated only those tasks for the mission in which they specialized. There were 10 tasks rated for the cargo mission, 15 tasks rated for the aeroscout and utility missions, and 20 tasks rated for the attack mission. There were three tasks common to all four missions: perform nap-of-the-earth (NOE) flight, perform tactical operations in a nuclear, biological, and chemical (NBC) environment, and identify US/Allied threat weapons and aircraft.

SMEs independently rated the importance of each task using the Ability Requirements Scale (ARS) developed by Fleishman and his colleagues (e.g., Theologus, Romashko, & Fleishman, 1973; Fleishman, 1975). An ARS value ranges from 1, representing the lowest level of an ability, to 7, representing the highest level of an ability. Benchmark tasks placed at various points on the scale indicate the level of an ability associated with selected scale values (e.g., Jones & McAnulty, 1984). In addition, each ARS form presents a concise definition of the ability and an explanation of how the ability of interest differs from other similar abilities. The ability rating approach has been shown to be effective in providing a reasonably valid set of descriptions for characterizing individual jobs or tasks (Fleishman & Hogan, 1978; Myers, Gebhardt, & Fleishman, 1979).

Procedures and Results of the Reanalysis

Replacement of Missing Data. The first task was to locate and replace all missing data using an abilities-by-raters matrix for each task. Each of the 104 missing ratings was replaced with the mean of the other raters. One rater from the cargo mission and two raters from the attack mission failed to rate the 32 abilities on one task. The remaining eight missing ratings were scattered across the missions.

Psychometric Evaluation of Ratings. Research by McAnulty and Jones (1984) found that ARS ratings exhibited distributional anomalies that were analagous to bias effects frequently encountered in performance appraisal ratings (e.g., Saal, Downey, & Lahey, 1980). McAnulty and Jones concluded that the ratings represented only an ordinal level of measurement despite the presence of an anchored, equal interval scale. The same pattern of results was found in the ARS ratings of the mission tasks. There were substantial differences in rater means and variances, and heterogeneity in the shapes of the rating distributions.

These results indicate individual differences in rater leniency/severity and range restriction.

Another technique used to assess psychometric rating errors is factor analysis. Ratings that are lacking in discriminant validity (affected by halo errors) are indicated by (a) high intercorrelations among the rating dimensions and (b) a general factor that accounts for a substantial proportion of the variance (Landy, Vance, Barnes-Farrell, & Steele, 1980). Both of these conditions were evident in the ability ratings in each mission. For example, a maximum-likelihood factor analysis (MLFA) with varimax rotation on the utility mission ratings resulted in a four-factor solution, with the first factor accounting for 45% of the variance. The three remaining specific factors, composed of cognitive, perceptual-language, and psychomotor abilities, respectively, accounted for only 19% of the variance.

These analyses indicate that the mission ability ratings are significantly affected by systematic rater bias that restricts the interpretability of the ratings. Previous research (McAnulty & Jones, 1984) found that a transform to normalize the rating distributions was an effective technique for removing systematic sources of error without distorting the task-ability relationships.

Transformation of Original Data. The original data were transformed using the Method of Successive Intervals (MSI) technique (Hays, 1967; McAnulty & Jones, 1984). The MSI technique transforms each rater's judgments to a normally distributed, standardized scale having a mean of zero and a standard deviation of approximately one. The method uses the cumulative proportion of ratings in each successive scale interval and the area under the normal curve to convert raw scores into z scores. The z scores for each rater were then added to the grand mean of the original data for each rater's mission (cargo = 3.38; utility = 3.57; aeroscout = 3.11; attack = 3.34).

The results of a MLFA with varimax rotation on the transformed utility mission data indicate that the systematic error was reduced by the transformation. Specifically, the general ability factor was replaced by two specific factors. In addition, the variance accounted for was more evenly divided among the factors. These findings were consistent for each of the four missions. That is, the general ability factors in the original data were replaced by more specific factors following the transformation (Jones & McAnulty, 1984).

These findings are interpreted as further evidence of the utility of the MSI technique for reducing systematic error in rating data. Furthermore, and perhaps most important, the ability requirements for the various rotary-wing missions can be interpreted and treated statistically as interval level data.

Comparison of Ability Requirements. Three analyses were conducted to compare the ability requirements among the missions. Analyses of variance (ANOVAs) were used to determine if there were significant mission-by-abilities interaction effects. It is the interaction effect that provides relevant information about differences in ability requirements among the missions (Jones & McAnulty, 1984).

In the first analysis, the rating data for each mission were collapsed across tasks and a three-way ANOVA was performed. The results indicate that there was a significant ability-by-mission interaction effect, but the interaction accounted for less than three percent of the variance. Furthermore, reducing the rating data by collapsing across tasks in each mission is appropriate only if there is no significant ability-by-task interaction effect within each mission. An ability-by-task-by-rater ANOVA was conducted for each mission and, in each case, the ability-by-task interaction was significant. This finding indicates that a comparison of ability requirements by averaging across tasks may lead to erroneous conclusions about differences or similarities among the missions.

The second analysis was a comparison of ability requirements for the three common tasks. The results indicate that there was a significant ability-by-mission interaction effect, but the effect accounted for less than one percent of the variance. Furthermore, the finding has limited generalizability because it is uncertain that the three common tasks impose the maximum ability requirements on the aviators.

The third ANOVA was conducted using ability ratings representing the highest rating across tasks. An ability-by-task matrix was developed and, for each ability, the highest rated task was selected to represent the ability. This procedure is intuitively appealing: If an aviator possesses a sufficient amount of ability to perform the most demanding task, the aviator must possess a sufficient amount of the ability to perform all critical mission tasks. A classification algorithm based on ability requirements should classify the student aviator by ensuring that the minimum amount of each ability possessed by the student is equal to or greater than the maximum amount of the same ability required to perform all tasks within the mission to which the aviator will be assigned. Furthermore, even though only one task within a mission requires a substantial amount of a certain ability, it is the ability requirement associated with that one task that establishes the minimum ability requirement for the mission. The results of the mission-by-abilities-by-raters ANOVA using the highest mean ability rating across tasks indicate that there was a significant effect for abilities but not a significant interaction between abilities and missions. The absence of a significant interaction effect indicates that there are no significant differences in abilities required for the four rotary-wing missions.

Recommendations. The analyses indicate that there is a high degree of similarity in ability requirements among the four missions. Although certain missions may consistently require a higher level of certain abilities, the results of the present research indicate that, across missions, there are substantial similarities in the magnitude of abilities and types of abilities required to perform the most demanding tasks. The results suggest that a classification system based on ability requirements could be expected to be no more successful than an assignment system that equally distributes the aviators (by ability) across the four missions.

It is possible, however, that differences in ability requirements among the missions do exist and that a classification system based on ability differences is a viable alternative. As suggested elsewhere (Jones & McAnulty, 1984), there are serious methodological problems in the research by Myers, et al. (1982) that may have precluded the identification of ability differences. For example, Myers, et al. (1982) selected tasks identified by the Aircrew Training Manual (ATM) for each mission and required SMEs to rate the abilities for a subset of these ATM "tasks." It is possible that substantially different ability profiles for each mission could be identified if the SMEs were required to rate specific tasks rather than broad, ambiguous ATM "tasks," such as "perform tactical operations in an NBC environment."

Project Status

A report entitled "An Examination of the Ability Requirements for Various Rotary Wing Missions" (Jones & McAnulty, 1984) has been delivered to ARIARDA. The delivery of the technical report fulfills the objectives of this project.

References

Fleishman, E. A. (1975). Toward a taxonomy of human performance. American Psychologist, 30, 1127-1149.

Fleishman, E. A., & Hogan, J. C. (1978, June). A taxonomic method for assessing the physical requirements of jobs: The physical abilities analysis approach. Washington, DC: Advanced Research Resources Organization.

Hays, W. L. (1967). Quantification in psychology. Belmont, CA: Brooks/Cole Publishing.

Jones, D. H., & McAnulty, D. M. (1984). An evaluation of the mission track assignment battery as a classification system for Army aviators. Phase I report: An examination of ability requirements for various rotary-wing missions (Draft Interim Report ASI479-052-5). Fort Rucker, AL: Anacapa Sciences, Inc.

McAnulty, D. M., & Jones, D. H. (1984). An evaluation of aviator training ability requirement scale rating. Paper presented at the 28th Annual Meeting of the Human Factors Society, San Antonio, TX.

Miller, J. T., Eschenbrenner, J., Marco, R. A., & Dohme, J. A. (1981). Mission track selection process for the Army Initial Entry Rotary Wing flight training program (Interim Report C#MDA903-82-C-0036). St. Louis, MO: McDonnell-Douglas Astronautics Co.

Myers, D. C., Gebhardt, D. L., & Fleishman, E. A. (1979). Development of physical ability performance standards for Army jobs (final report). Washington, DC: Advanced Research Resources Organization.

Myers, D. C., Jennings, M. C., & Fleishman, E. A. (1982). Validation of cognitive and perceptual-motor tests for assigning pilots to different missions: Job analysis findings (Interim Report 3075IR). Washington, DC: Advanced Research Resources Organization.

Saal, F., Downey, R., & Lahey, M. (1980). Rating the ratings: Assessing the psychometric quality of rating data. Psychological Bulletin, 88, 413-428.

Theologus, G. C., Romashko, T., & Fleishman, E. A. (1973). Development of a taxonomy of human performance: A feasibility study of ability dimensions for classifying human tasks. JSAS Catalog of Selected Documents in Psychology, 3, 15-26.

EFFECTS OF EXPANDING THE UH60FS PORTION OF THE UH-60A AVIATOR QUALIFICATION COURSE

George L. Kaempf, Project Director

Background

The Army has recently expressed concern about the dramatic increase, during fiscal year (FY) 1984, in the number of mishaps involving the UH-60A aircraft. Through 15 March 1984, the UH-60A had the highest Class A (as defined by Department of the Army, 1984a, p. 5) mishap rate of any helicopter in the Army's inventory (11.02 accidents per 100,000 flying hours). In contrast, the UH-60A mishap rate was only 4.81 for FY83 (Department of the Army, 1984b). Ten of the 19 Class A and B mishaps have been attributed to pilot error.

For this reason, the Department of Aviation Subjects (DOAS) recognized a need for improved training effectiveness during the transition phase of UH-60A pilot training. It was concluded that this improvement could possibly be achieved by expanding academic training, flight simulator training, or aircraft flight training. Furthermore, DOAS was directed by the Commanding General (CG) of the U.S. Army Aviation Center (USAAVNC) to increase the utilization rate of the UH-60 flight simulator (UH60FS). The UH60FS had previously been utilized only 55% of the total time it was available for training. DOAS chose to address both issues by proposing an increase in the flight simulator portion of the UH-60A Aviator Qualification Course (AQC) from 7.5 hours to 13.5 hours for each student. The present study was initiated to determine the feasibility and effectiveness of the increase in the amount of simulator training during the UH-60A AQC.

Prior to the implementation of the study, the UH-60A AQC was an 18-day course composed of academic classwork, 7.5 hours in the UH60FS, 7.6 hours in the UH-60A aircraft, and a 1.4-hour end-of-course checkride in the UH-60A. The first six training days (TD) were devoted exclusively to academics. Flight simulator and aircraft training periods were interspersed from TD 7 through TD 15; the last three days of the course were reserved for aircraft training and the checkride.

Until this research was initiated, the UH60FS was used strictly as an instrument and procedures trainer. During the first training period in the UH60FS, students were taught cockpit procedures (runup and shutdown). During subsequent simulator sessions, emergency procedures and instrument flight tasks were taught. Contact flight skills were taught only in the UH-60A aircraft.

Project Objectives

The objectives of this project were to:

- determine the effects of an extended training program in the UH60FS on the level of proficiency and rate of acquisition of flight skills in the UH-60A aircraft,
- determine if contact flight skills could be effectively taught in the UH60FS, and
- determine the rate of learning for specific tasks trained in the UH60FS.

Research Approach

A field experiment conducted at the USAAVNC, Fort Rucker, was designed to meet the project objectives. Sixteen students attending UH-60A AQC Class 84-11 served as subjects and were randomly assigned to one of two groups (N = 8/group). The control group was instructed in accordance with the current program of instruction (POI) for the UH-60A AQC. The experimental group received 6.0 hours of training in the UH60FS, in addition to the 7.5 hours of flight simulator training normally received during the UH-60A AQC. Otherwise, the training administered to the experimental group and control group was the same. The additional six simulator hours were broken down into four 1.5-hour periods administered between TD 2 and TD 5, during which the experimental group received instruction on contact flight skills. Table 1 presents the POI used to train the experimental group during the UH-60 AQC. The topics identified under periods 2, 3, 4, and 9 constitute the six additional hours of simulator training. However, both groups received instruction in the UH60FS on the topics identified under the remaining periods.

Four rated Army aviators served as data collectors/observers for the research. The data collectors accompanied students on their training flights in both the UH-60A and UH60FS; they recorded the number of practice iterations each subject completed for each task, the length of time spent executing each practice iteration, and the instructor pilot's (IP) subjective rating of the student's performance on each practice iteration. The IPs employed a seven-point rating scale (Wick et al., 1984) anchored to standards established by the Aircrew Training Manual (ATM) TC 1-138 (Department of the Army, 1981) to provide an assessment of student performance on each practice iteration.

Results

Initially, a traditional transfer-of-training approach was planned, in which the training time and the number of practice iterations required to reach a specific criterion level of performance in the aircraft were the dependent measures. The performance criterion was two

Table 1
Program of Instruction for UH60FS*

FS Period 1	Perform before takeoff checks (1502) Perform engine start and run-up procedures Perform emergency procedures for APU malfunction Perform aircraft shutdown
FS Period 2	Review previous period Use performance charts (1004) Prepare performance planning card (PPC) (1005) Perform before takeoff checks (1502) Perform ground taxi (1506) Perform takeoff to a hover (2001) Perform hover (power) checks (2002) Perform hovering turns (2003) Perform hovering flight (2004) Perform landing from a hover (2005) Perform normal takeoff (2501) Perform traffic pattern flight (3005) Perform before landing checks (3501) Perform (VMC) approach (3503) Perform after-landing checks (6501)
FS Period 3	Review previous period Perform simulated maximum performance takeoff (2502) Perform roll-on landing (3507) Perform standard autorotation (4002)
FS Period 4	Perform straight and level flight (3001) Perform climbs and descents (3002) Perform turns (3003) Perform deceleration/acceleration (3004) Perform fuel management procedures (3006) Perform navigation by pilotage and dead reckoning (3010) Perform go-around (3506) Perform high reconnaissance (3509) Perform confined area operation (3510) Perform pinnacle/ridgeline operations (3512) Perform flight with degraded AFCS off (4021)
FS Period 5	Perform instrument takeoff (4501) Perform radio navigation (4503) Perform holding procedures (4504) Perform unusual attitudes (4505) Perform NAVAID approach (4508) Perform VHIRP procedures (4510)
FS Period 6	Perform CIS operations (4517) (VOR, NDB, ILS)
FS Period 7	Perform CIS operations (4517) (Mission)
FS Period 8	Perform simulated hydraulic malfunction (4005) Perform simulated antitorque system malfunction (4006) Describe or perform emergency procedures (4010) Perform ECU malfunction (4002) Perform single engine roll-on (40[illegible]) Perform stabilator malfunction (4024)
FS Period 9	Review previous period

*Numbers in parentheses refer to task designations in TC 1-138.

successive practice iterations of a task rated by the IP as meeting all ATM standards (score of 6 or above). However, the data indicated that few aviators met or exceeded the criterion for proficiency on as many as half of the tasks, and in only one instance (experimental group performing emergency procedures in the flight simulator) did the mean rating for a group exceed criterion. In fact, the group means reached a level of 6 or more on only 8 of 35 tasks.

The failure of both the experimental and control groups to reach the criterion level of flight proficiency required that the criterion-based measures of performance be changed to include measures that more adequately described the subjects' progress through the course. Therefore, IP ratings of each iteration, the number of practice iterations completed, and the total amount of time each subject spent practicing each task were analyzed to determine the effects of extending the flight simulator portion of AQC training.

The IP ratings of performance were analyzed with a separate mixed design, two-factor analysis of variance (group x practice iterations) for each task. In each analysis, the type of group represented the between-subjects variable and the number of practice iterations represented the within-subjects variable. The results of the analyses revealed significant practice effects for 16 tasks. Specifically, the results indicated that, for these tasks, increased numbers of practice iterations resulted in improved performance by the subjects. There also was a significant difference in performance between the experimental and control groups on five of the tasks, including: the final leg of traffic patterns, holding patterns, electrical control unit (ECU) malfunctions, stabilator malfunctions, and emergency procedures. On all five tasks, the ratings for the experimental group were significantly higher than the ratings for the control group.

The times spent performing each iteration were summed to produce a total amount of time each subject spent practicing each task. These totals include all iterations by the subjects. The mean totals for each task completed were submitted to matched $\underline{t}$ tests. Significant differences were found for only two tasks. The experimental subjects practiced radio navigation in the UH60FS longer than the control subjects, and the control subjects spent significantly more time practicing stabilator malfunctions in the aircraft than experimental subjects.

Analysis of the total number of practice iterations for each task practiced by both groups in the UH-60A aircraft and the UH60FS indicate that the experimental group completed more practice iterations for 24 of 36 tasks performed in the UH-60A aircraft and 10 of 13 tasks performed in the UH60FS. Compared to the control group, the experimental group completed approximately 10% more practice iterations in the aircraft and 30% more practice iterations in the flight simulator. These data might be interpreted as reflecting the instructors' judgments that the experimental group required more practice to correct performance deficits; however, IP performance ratings provide no evidence to support this interpretation. The instructors did not rate the experimental group's performance significantly lower than the control group's performance on any task. In fact, the experimental subjects performed better on all five tasks that produced significant group differences in proficiency ratings. In addition, the subjects in the experimental group generally received higher ratings than the control group subjects. Students receiving the additional UH60FS training met ATM standards on 52.9% of their practice iterations compared to 38.2% for the control subjects. In short, if the instructors required subjects in the experimental group to execute more practice iterations in order to improve substandard performance, then they did not reflect this opinion in their ratings of the subjects' performance.

A more plausible interpretation is that additional simulator training allowed the subjects to utilize their subsequent training hours more efficiently. Having already performed many of the procedural and contact flight tasks in the UH60FS, the experimental group subjects possibly required less verbal instruction and demonstration in the aircraft and, therefore, were able to complete more practice iterations.

The results of this study indicate that few aviators met or exceeded the criterion for proficiency (two consecutive trials satisfying all ATM standards) on as many as half of the tasks. Furthermore, the only task for which the criterion was met was the experimental group's performance of emergency procedures in the flight simulator. In other words, through the last day of training, most of the subjects from both the experimental and control groups could not perform the required tasks in accordance with ATM standards. As stated in the Flight Training Supplement for the UH-60 AQC (Department of the Army, 1983, p. 1-1), student performance should be considered unsatisfactory when a task is not performed within the limits established by TC 1-138; however, all subjects participating in this research subsequently passed their UH-60 AQC end-of-course checkrides within two days of the last day of training.

Six additional hours of flight simulator training devoted to contact skills provided the opportunity for students to complete more practice iterations on most tasks in both the aircraft and simulator; however, there were no systematic differences in the level of proficiency related to this additional training. Furthermore, most of the subjects performed below ATM standards through the last day of training. The increased number of practice iterations completed by the experimental group is seen as a beneficial effect of extended training in the UH60FS. It is important to note that the data from this research produced no indication that additional simulator training impaired the students' progress in any way.

Project Status

All data have been collected and analyzed, and a final report, entitled "Effects of Expanding the UH60FS Portion of the UH-60 Aircrew Qualification Course," was submitted to the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) in October 1984. Submission of the final report completes all requirements for this project.

References

Department of the Army. (1981). Utility helicopter Aircrew Training Manual (TC 1-138). Washington, DC: Department of the Army.

Department of the Army. (1983). Flight training supplement: In support of TC 1-138. Fort Rucker, AL: U.S. Army Aviation Center.

Department of the Army. (1984). Flight fax, 12, (29). Fort Rucker, AL: U.S. Army Safety Center.

Wick, D. T., Keenan, J. B., Millard, S. L., Ruffner, J. W., Cross, K. D., Everhart, C. D., & Bickley, W. R. (1984, September). Revision/evaluation of the Individual Ready Reserve (IRR) aviator training program: First training year (ASI479-021-84). Fort Rucker, AL: Anacapa Sciences, Inc.

A PLAN OF RESEARCH TO ASSESS THE APPLICATIONS AND BENEFITS OF THE AH-1 FLIGHT SIMULATOR FOR TRAINING FIELD UNIT AVIATORS

Dr. Kenneth D. Cross, Project Director,
Dr. Dennis H. Jones, and Dr. George L. Kaempf

Background

The Army's Synthetic Flight Training System (SFTS) has been audited by the Army Audit Agency (AAA) on two occasions: first in 1981 and again in 1984. The results of the first audit are described in AAA Audit Report SO 82-6, (U.S. Army Audit Agency, 1982); the results of the second audit are summarized in a letter from the Southern Region U.S. AAA to the Assistant Secretary of the Army for Research, Development, and Acquisition (27 August 1984).

The overriding issue in both audit reports was the number of flight simulators that are required to support the training of field unit aviators. Specifically, the AAA concluded that the unit training requirement can be met with fewer flight simulators than are specified in the Army's Basis of Issue Plans (BOIPs). In their audit reports, the AAA has strongly emphasized that both the BOIP and the AAA analyses of flight simulator requirements are based on only the most vague information about the roles that flight simulators are to play in unit training. As a consequence, the AAA has strongly urged the Army to undertake the research needed to quantify the return on the Army's investment in flight simulators that are to be used solely to train field unit aviators.[2]

It is generally recognized that five factors must be considered in assessing the return on the investment in flight simulators:

- the cost of acquiring, housing, operating, and maintaining the flight simulators;
- the cost of transporting unit aviators to the flight simulator;
- the number of aviators to be trained in the flight simulator;
- the amount of flight simulator training each aviator will receive; and
- the benefits of the flight simulator training.

Information on the first three factors is available or can easily be obtained. However, little information is available on the last two factors: the amount of flight simulator training unit aviators should receive, and the benefits of the flight simulator training. It is these two factors that are the primary concern of this research. Specifically, the research has been designed to generate data with which to

[2]The return on investment in flight simulators used for institutional training was not questioned by AAA and, therefore, is not among the issues addressed in this research plan.

specify the type and amount of training that unit aviators should receive in flight simulators, and, to the extent possible, quantify the benefits of this training.

Early in the research planning process, it was concluded that initial research efforts should focus on a single flight simulator, and that the AH1FS is more suitable for this research than any other flight simulator now fielded (UH1FS and CH47FS) or soon to be fielded (UH60FS). The reasons for focusing on a single flight simulator are twofold. First, conducting research on two or more simulators concurrently would require more research personnel than can easily be mustered. Second, conducting research on two or more flight simulators concurrently would result in unnecessary duplication of effort. That is, it is believed that much of what is learned from the initial research on the AH1FS can be generalized to any other rotary-wing flight simulator that is to be used for unit training.

Factors considered in selecting the single most suitable flight simulator include: the number of unit aviators available to participate in the research, the number of simulators available at field unit locations, and the range of tasks that are potentially trainable in the flight simulator. On all three counts, the AH1FS was judged more suitable than the UH1FS, the CH47FS, or the UH60FS.

Research Plan

This section describes the plan of research that has been designed to provide data with which to assess the benefits and limitations of employing flight simulators to train field unit aviators. Although this research was designed specifically to evaluate the AH1FS, the general approach is considered suitable for assessing the unit training benefits and limitations of any Army flight simulator.

The task flow diagram in Figure 1 shows the research tasks to be accomplished and shows the interrelationship among the tasks. Each of the tasks shown in Figure 1 is discussed below in the order in which they are to be accomplished.

Conduct Analytical Studies

This project will commence with two analytical studies. The product of the first study will be a training-task taxonomy; the product of the second study will be a listing of target training tasks and conditions.

Develop Training-Task Taxonomy. An essential first step in this research is the development of a comprehensive training-task taxonomy. An acceptable taxonomy must list the full set of flying tasks that AH-1 aviators must be capable of performing, and the full range of conditions

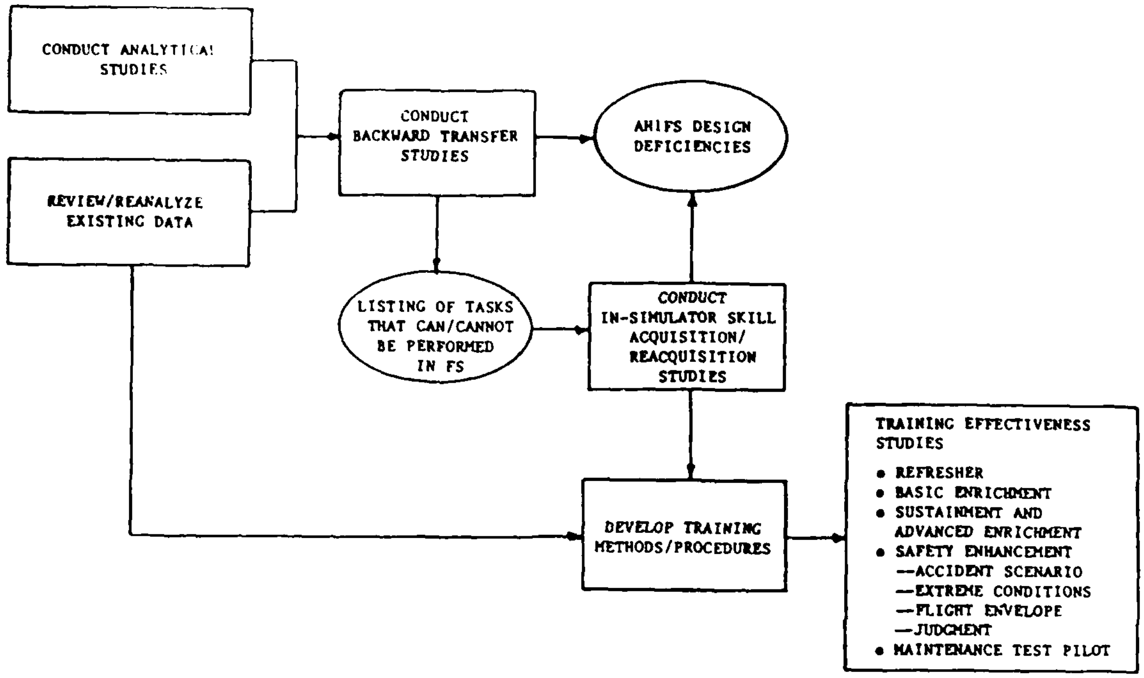

Figure 1. Task flow diagram for simulator research plan.

in which aviators must be capable of performing each task. The Aircrew Training Manual (ATM) task list represents a good point of departure, but cannot be used in its present form for two reasons. First, the ATM tasks differ greatly in their level of specificity; some tasks, such as Hovering Turn, are very specific; other tasks, such as Navigation by Dead Reckoning, are very general. Second, the ATM tasks are not mutually exclusive; that is, some ATM tasks are composites of several other ATM tasks.

The final product will be a task-by-condition matrix that shows, for each task, the conditions under which an AH-1 aviator may be required to perform that task. The training task taxonomy will be developed and evaluated by knowledgeable aviators and training experts. The training task taxonomy will be continuously refined until it is possible to define any training scenario by linking together task/condition combinations represented by cells in the matrix.

Identify Target Training Tasks/Conditions. The purpose of this analytical effort is to examine each cell in the task/condition matrix, and to identify the tasks/conditions for which flight simulator training is possible and probably beneficial. A thorough study of the design characteristics of the AH-1 flight simulator will be required to determine whether or not it is possible to simulate a given task/condition. When it is clear that a task/condition combination cannot be simulated, an attempt will be made to determine whether or not a low-cost design modification would make it possible to simulate the task/condition in question. If so, the simulator design modification will be recommended. If not, the task/condition will be eliminated from further consideration.

Each of the task/condition combinations that remain in the matrix will then be examined and a judgment made as to whether or not benefits would result from training that task in the AH-1 flight simulator. This analytic judgment will be made with respect to three target groups: aviators who require refresher training, low-time unit aviators, and medium- and high-time unit aviators.

The most critical and most difficult part of this effort will be to judge whether or not an adequate level of skill on a given task/condition can be acquired and sustained during routine mission support flying. Obviously, simulator training makes no sense if aviators can easily acquire and sustain skill on a task during routine mission support flying. In order to make such judgments, it will be necessary to conduct structured interviews with selected field unit aviators and, possibly, selected Directorate of Evaluation and Standardization (DES) personnel as well.

The tasks/conditions remaining in the matrix constitute the target tasks/conditions that are to be investigated during the empirical research.

Before proceeding, it should be stated that judgments about whether simulator training is possible and beneficial will be conservative. That is, no task/condition will be eliminated from the matrix if there is any chance that simulator training on that task/condition would be possible and beneficial.

Review/Reanalyze Existing Data

The objectives of this analytical effort are (a) to review and, when necessary, reanalyze existing data bearing on the use and benefits of flight simulator training, and (b) use the composite data to draw inferences about the design of the empirical research to be conducted subsequently.

Conduct Backward Transfer Studies

Research Requirement. A "backward transfer study" is one that is designed to measure the degree to which actual flying skills transfer to a flight simulator. Only highly experienced aviators are used as subjects in a backward transfer study. The procedure is simple: An experienced aviator is placed in the flight simulator and instructed to perform the task of interest without the benefit of practice. If the aviator is able to perform the task to criterion, backward transfer is said to have occurred. The presence of backward transfer indicates that transfer from the flight simulator to the aircraft will be positive, but provides no information with which to estimate the magnitude of the positive transfer.

More important for purposes of this research is the lack of a high degree of backward transfer. The inability of experienced aviators to perform a task to criterion in the flight simulator must be taken as evidence of a problem with either the design or the functioning of the flight simulator. Hence, the absence of a high degree of backward transfer signals the need for further study of the flight simulator's characteristics to determine the reasons for the low backward transfer. It is essential that such problems be resolved before proceeding to the more costly training effectiveness studies.

A variation of the backward transfer study is to train the experienced aviators in the simulator until their performance reaches an asymptotic level. This variation, of course, is appropriate only when there is a low degree of backward transfer. The nature of the learning curve in such cases provides useful diagnostic information. For instance, if the learning curve asymptotes below the criterion level of performance, it must be concluded that the flight simulator is either not providing the necessary cues or is incapable of processing control inputs correctly. Conversely, if the learning curve asymptotes at the criterion level after only a few practice trials, it can be concluded that the lack of high backward transfer is probably the result of small differences between the handling qualities of the simulator and the aircraft.

A second variation of the backward transfer study is to interview the subjects a second time after their first aircraft flight following simulator training. These interviews, like the earlier ones, would be aimed at identifying (a) differences between the handling qualities of the simulator and the aircraft and (b) differences between the cues available in the simulator and the aircraft.

Research Objectives. The backward transfer-of-training studies have the following objectives:

- validate the results of the analytic study (can task be performed in the flight simulator?),
- validate simulator functioning,
- identify low-cost simulator design modifications that would increase the degree of backward transfer,
- establish upper limit of performance in the flight simulator, and
- determine the amount of flight simulator-unique learning that is required to perform to criterion level in the simulator.

Conduct In-Simulator Skill Acquisition/Reacquisition Studies

Research Requirement. The training effectiveness of any training device is largely determined by the manner in which it is used. This is particularly true for flight simulators. And yet, there is little empirical data that can be used to identify near-optimal training methods and procedures. Hence, before research is conducted to assess the training effectiveness of the AH-1 flight simulator, it is essential that research be conducted to assess the relative effectiveness of alternative training methods and procedures. This research must address the following training program design issues and perhaps others as well:

- the order in which tasks are trained;
- the amount of training on each task/condition (fixed number of practice iterations vs. training to criterion);
- type of practice (repeated iterations on individual tasks vs. a training scenario);
- training schedule, including duration of flight simulator training sessions and the interval between sustainment/ enrichment training sessions;
- the type of feedback provided to the trainee; and
- the use of the instructional support features available on the AH-1 flight simulator.

Research Objectives. The objectives of this research are to develop and evaluate the relative effectiveness of alternative training methods for each type of flight simulator training application, including:

- refresher training,
- basic enrichment training,
- advanced sustainment/enrichment training,
- safety enhancement training,
  --accident scenario training,
  --extreme conditions training,
  --flight envelope training,
  --judgment training, and
- maintenance test pilot training.

Develop Training Methods/Procedures

The composite results of the analytical studies, the backward transfer studies, and the in-simulator skill acquisition/reacquisition studies will be used to develop training methods/procedures for each of the following types of flight simulator training:

- refresher training,
- basic enrichment training,
- advanced sustainment/enrichment training,

- safety enhancement training,
  - --accident scenario training,
  - --extreme conditions training,
  - --flight envelope training,
  - --judgment training, and
- maintenance test pilot training.

The training methods and procedures will be developed by a team composed of experienced AH-1 aviators, psychologists, training technologists, and experts in simulator design.

Evaluate Refresher Training Program

Research Requirement. Some portion of a unit commander's annual flight hour program involves using AH-1 aircraft time for refresher training. The Commander's Guide to the Aircrew Training Manual (FC-1-210) defines refresher training as training for aviators "prohibited or excused from flying duties for more than 180 days" (p. 2-34). Anecdotal evidence suggests that between 5 and 15 AH-1 aircraft hours are required to "refresh" the skills of ARL3 aviators. It is possible that a significant portion of the refresher training currently being conducted in the AH-1 aircraft could be trained in the AH1FS. Thus, a requirement exists to determine in what way, and to what extent, the AH1FS can be used to fulfill these refresher training requirements.

Research Objective. The objective of this research is to obtain data with which to evaluate the effectiveness of the AH1FS for accomplishing refresher training for ARL3 aviators.

Basic Enrichment Training

Research Requirement. As emphasized earlier in this report, increased operational effectiveness is the ultimate criterion for evaluating the utility of the AH1FS for unit training. The assumption has been made that if the AH1FS can be used to increase the proficiency of the AH-1 aviators assigned to the unit, the AH1FS will have made a major contribution toward increasing operational effectiveness. A second assumption made here is that the training requirements for increasing the proficiency of low-time aviators are markedly different from the training requirements for increasing the proficiency of medium- and high-time aviators. Thus, two different training programs--basic enrichment training and sustainment and advanced enrichment training--have been recommended as viable training programs for utilizing the AH1FS at the operational units.

Basic enrichment training focuses on skill enhancement for low-time aviators who have recently completed the AH-1 Aviator Qualification Course (AQC). The primary goal of basic enrichment training is to decrease the amount of time required to develop the level of skill and confidence needed to assume the responsibilities of pilot in command (PIC). Unit commanders realize that the operational effectiveness of their unit depends, to some extent, on how quickly new aviators can develop and solidify their basic flight skills and assume mission responsibilities once held by vacating aviators. Thus, a research requirement exists to evaluate the extent to which basic enrichment training in the AH1FS increases the proficiency and confidence of low-time AH-1 aviators.

Research Objective. The objective of this research is to obtain data with which to assess the effectiveness of the AH1FS for increasing the level of flying skills and confidence of low-time AH-1 aviators.

Sustainment and Advanced Enrichment Training

Experienced aviators require training to ensure that skills to perform relevant flight tasks are maintained and that these skills are not seriously degraded by environmental or situational constraints. In attempting to delineate the types of AH1FS training that would increase the operational readiness of experienced aviators, requirements for two types of training emerged. Each is discussed in detail below.

Sustainment Training: Research Requirement. First, experienced aviators could benefit from training in the AH1FS on those tasks for which skills are not maintained during routine mission support flying. Currently, AH-1 aviators are utilizing aircraft time to practice some tasks. Should it be demonstrated that the AH1FS could be used for skill sustainment, valuable aircraft hours could be devoted to other types of training (e.g., Army Training and Evaluation Program [ARTEP]). It should be noted that there are four categories of tasks for which skills are not maintained during routine mission support flying:

- tasks that can be trained in the aircraft but are not ordinarily performed during routine mission-support flying,
- tasks that cannot be trained easily in the aircraft (e.g., IMC flight),
- tasks that are not currently being trained in the aircraft (e.g., touchdown emergency maneuvers), and
- tasks that are more effectively trained in the AH1FS (e.g., gunnery tasks).

Taken together, these represent a formidable array of tasks for which skills could decay without sustainment training in the aircraft or the AH1FS.

Advanced Skill Enrichment Training: Research Requirement. The second type of AH1FS training that could be beneficial for experienced aviators involves skill enrichment. In the basic enrichment training program discussed earlier, low-time aviators are provided with AH1FS training on all ATM tasks under daytime and nighttime conditions; basic enrichment training focuses on skill solidification, increased competency, and increased confidence for low-time aviators. For experienced aviators, it is possible to concentrate on a very similar task list, but increase the complexity of the tasks by requiring the aviators to perform the tasks under adverse conditions, including the following:

- wearing night vision goggles (NVGs),
- wearing mission oriented protective posture (MOPP) gear,
- visual obscurants (rain, snow, fog, smoke), and
- wind (gusts, wind sheer).

Anecdotal evidence suggests that concern for safety prevents or severely limits the extent to which aviators are permitted to practice under these conditions. And yet, military doctrine suggests that, should a military engagement occur, it is highly probable that there would be a requirement to conduct military operations under low illumination levels, adverse weather, and/or in nuclear, biological, or chemical (NBC) conditions. Therefore, this type of enrichment training in flight simulators will clearly have a positive impact on the operational readiness of the units.

For the most part, rotary-wing training programs assume that by demonstrating skill proficiency on ATM tasks, the aviator will be effective when required to perform combinations of those tasks under wartime conditions. Although ARTEP training provides the aviator with valuable insight into the battlefield experience, ARTEP training focuses largely on coordination and cooperation among various battle elements. Because of safety constraints, it is difficult, if not impossible, to "load the aviator up" with multiple tasks requiring rapid decision-making and effective time-sharing techniques. However, this type of training is feasible using the AH1FS. For this reason, it appears highly desirable to include in advanced enrichment training a set of mission scenarios that are designed to increase aviators' ability to perform effectively during periods of heavy cognitive and perceptual-motor workload.

In addition to the above, advanced enrichment training should include training in air-to-air combat and training in evasive actions for other threat weapons, including air defense weapons and small arms fire.

Taken together, these types of training for experienced aviators, subsumed under sustainment and advanced enrichment training, represent an attempt to formulate an effective training strategy for increasing proficiency and thereby improving the operational effectiveness of the units. Thus, a requirement exists to determine the effectiveness of the AH1FS in accomplishing such training.

Research Objectives. The specific objectives of the research on sustainment and advanced enrichment training are to obtain data with which to assess the effectiveness of the AH1FS for each of the following:

- facilitating skill sustainment on those tasks not performed during routine mission flying,
- facilitating skill acquisition and sustainment for a variety of ATM tasks under a variety of adverse conditions (NVG, MOPP gear, visual obscurants, wind),
- increasing proficiency under high workload conditions,
- increasing air-to-air combat proficiency,
- increasing proficiency in performing the full range of evasive actions, and
- increasing aviator judgment ability under a wide range of conditions.

Safety Enhancement Training

This subsection describes research to evaluate the effectiveness of the AHIFS in conducting four different types of safety enhancement training.

Accident Scenario Training: Research Requirement. Although some aircraft training is aimed specifically at countering accidents, aircraft training in potential accident-producing situations necessarily involves some risk of causing the very type of accident the training is designed to counter. This risk would be eliminated if Army aviators could acquire the necessary accident avoidance skills in a flight simulator rather than in an aircraft. In addition to risk reduction during training, it is altogether possible that aviators could acquire a higher level of accident avoidance skills in the flight simulator than in an aircraft. In a flight simulator, it is possible to expose the trainee to all events up to and including the crash itself. Such exposure, of course, is not possible in the aircraft.

Accident scenario training is one type of training that promises to reduce the incidence of frequently occurring accident types. As was stated earlier, accident scenario training involves the use of a flight simulator to re-enact, as faithfully as possible, all the conditions and actions that have been shown to contribute (directly or indirectly) to a frequently occurring type of accident.

The accident types to be investigated during this research will be selected with the assistance of personnel from the U. S. Army Safety Center. However, it appears likely that the following accident types will be among the ones selected for study:

- brown-out by blowing dust,
- dynamic roll-over,
- loss of tail rotor effectiveness, and
- settling with power.

Descriptions of the above accident types can be found in TM 55-1520-210-10 and FM 1-51.

Accident Scenario Training: Research Objective. The objective of this research is to assess the effectiveness of the AH-1 flight simulator for training aviators to avoid and/or recover from known accident-producing situations.

Extreme Conditions Training: Research Requirement. Because of a unit commander's concern for safety, most aircraft training is conducted when environmental conditions are optimal or near optimal. Although aircraft training during adverse environmental conditions would increase aviators' combat capabilities, such training is certain to increase the incidence of accidents during training. It seems reasonable to hypothesize that flight simulator training under adverse conditions would decrease accident likelihood, especially under combat conditions where frequent exposure to adverse conditions is to be expected; there is a requirement to submit this hypothesis to empirical test.

Extreme Conditions Training: Research Objective. The objective of this research is to assess the effectiveness of the AH-1 flight simulator for training aviators to operate the aircraft in extreme environments.

Flight Envelope Training: Research Requirement. Safety considerations prevent IPs from exposing trainees to the handling qualities of the helicopter when flying near the extremes of the flight envelope. Consequently, aviators may be unprepared to control the aircraft when the situation requires them to fly at or near the extremes of the helicopter's flight envelope. If true, accident likelihood could be reduced by using the AH1FS to train aviators to operate at or near the limits of the AH-1 aircraft. The reduction in accident likelihood could be of critical importance in combat, where extreme maneuvers may be essential for survival. The intent is to search the accident files of the U.S. Army Safety Center for accidents that have resulted from aviator inability to control the aircraft at the extremes of the flight envelope. This type of accident prevention training would focus on these accidents.

Flight Envelope Training: Research Objective. The objective of this research is to obtain data with which to evaluate the effectiveness of the AH1FS for training aviators to fly at or near the extremes of the AH-1 flight envelope.

Judgment Training: Research Requirement. There is clear evidence that poor judgment is a frequent contributor to both civil and military aircraft accidents (Lindsey, Ricketson, Reeder, & Smith, 1983; Jensen & Benel, 1977), and there is growing evidence that judgment training has the potential for reducing the incidence of such accidents (Berlin et al., 1982; Brecke, 1982; Saleh, Leal, Lucaccini, Gardiner, & Hopf-Weichel, 1978; Jensen & Benel, 1977). Preliminary study indicates that judgment training on some judgment related accidents could best be conducted in a flight simulator. Hence, there is a requirement to evaluate the potential for conducting such training in the AH1FS.

Judgment Training: Research Objective. The objective of this research is to obtain data with which to evaluate the effectiveness of the AH1FS for providing training that reduces potentially accident producing judgment errors.

Maintenance Test Pilot Training

Research Requirement. Maintenance Test Pilots (MTPs) ordinarily become qualified by completing a course of instruction at the United States Army Aviation Logistics School (USAALS). Aviators may also receive MTP qualification by successfully completing an MTP equivalency administered by a USAALS Maintenance Test Flight Evaluator (MTFE). In either case, MTPs must learn to perform a variety of inflight maneuvers to assess the functioning of the aircraft and to correctly diagnose malfunctions when they are present. Like other unit aviators, MTPs have continuation training requirements they must fulfill (see FM 55-44). Many of the maneuvers that MTPs must perform during training and during maintenance check flights are violent and potentially hazardous.

Initial training and continuation training of MTPs is a potentially beneficial application of the AH1FS. However, the benefit of such training will depend upon the extent to which aircraft malfunctions can be programmed and the fidelity of the simulator's response to the programmed malfunctions. Research to assess the benefits of MTP training in the AH1FS will be conducted if the preliminary research shows that a sufficient number of malfunctions can be programmed and the simulator's response to the malfunctions is acceptable.

Research Objective. The objective of this research is to assess the effectiveness of the AH1FS for training MTPs.

Project Status

The draft research plan. entitled "A Plan of Research to Assess the Applications and Benefits of the AH-1 Flight Simulator for Training Field Unit Aviators," was submitted to the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) in October 1984. The research conducted in response to the plan is described in the project report entitled "Research on the Use and Benefits of Flight Simulators for Training Field Unit Aviators."

References

Berlin, J. I., Gruber, E. V., Holmes, C. W., Jensen, P. K., Lau, J. R., Mills, J. W., & O'Kane, J. M. (1982). Pilot judgment training and evaluation - Volume I (Report No. DOT/FAA/CT-82/56-I). Daytona Beach, FL: Embry-Riddle Aeronautical University, Aviation Research Center.

Brecke, F. H. (1982). Instructional design for aircrew judgment training. Aviation, Space, and Environmental Medicine, 53, 951-957.

Jensen, R. S., & Benel, R. A. (1977). Judgment evaluation and instruction in civil pilot training (Report No. FAA-RD-78-24). Savoy, IL: Aviation Research Laboratory, University of Illinois.

Lindsey, G. D., Ricketson, D. S., Jr., Reeder, M. J., & Smith, C. (1983). Lessons learned from FY82 U.S. Army aviation mishaps (USASC Technical Report TR 83-7). Fort Rucker, AL: U.S. Army Safety Center.

Saleh, J., Leal, A., Lucaccini, L., Gardiner, P., & Hopf-Weichel, R. (1978). Analysis of requirements and methodology for decision training in operational systems (Technical Report NAVTRAEQUIPCEN 77-C-0005-1). Orlando, FL: Naval Training Equipment Center.

U.S. Army Audit Agency. (1982, 1 March). Report of audit. Synthetic flight training system (Audit Report SO 82-6). Washington, DC: U.S. Army Audit Agency.

U.S. Army Audit Agency, Southern Region. (1984, 27 August). Letter to Assistant Secretary of the Army (Research, Development, and Acquisition) outlining the "Proposed Acquisition of Flight Simulators."

DEVELOPMENT OF A SEPARATION FORM FOR
ARMY AVIATION WARRANT OFFICERS

Dr. Sandra M. Szabo, Project Director

Background

In October 1979, the Warrant Officer Division, U. S. Army Military Personnel Center (MILPERCEN), requested that the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) provide research support to investigate an apparent trend toward decreased retention of aviation warrant officers (AWOs). The request stemmed from retention data obtained by MILPERCEN that indicated a significant decrease in retention of first-term AWOs. These AWOs were leaving the Army at the end of the three-year obligation incurred by attending the Army's Initial Entry Rotary Wing (IERW) flight training program. This career point is the first opportunity for AWOs to separate from the Army following completion of flight training.[3]

Specifically, the retention data indicated that, for the AWOs who completed training during the period fiscal year (FY) 1973 through FY75, retention beyond initial obligation remained relatively stable at approximately 65%. For the AWOs who completed flight training during FY76 and FY77T[4], however, the retention rate at the same career point had declined to approximately 45% (Bills, 1979).

MILPERCEN was concerned that the increased rate of AWO attrition might signal the onset of an aviator retention problem that already was troubling the other military services. MILPERCEN also was concerned that a continued high rate of AWO separation might seriously reduce the Army's aviation readiness and combat effectiveness. The problem was exacerbated by the following additional considerations (Everhart & Sanders, 1981):

- the increasing costs of aviator training and replacement,
- the increasing aviator force structure needs,
- the limitations in aviator training rates, and
- a decreasing manpower pool for recruitment of aviators.

In response to MILPERCEN's request for research assistance, ARIARDA conducted a worldwide survey of Army aviators. The survey used a questionnaire, constructed by ARIARDA, to identify factors that contribute to attrition of AWOs. The questionnaire items were organized

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[3]The initial obligation was extended from three to four years effective 1 October 1978.

[4]Beginning with FY77, the fiscal year was changed from 1 July through 30 June to 1 October through 30 September. FY77T represents the period 1 July 1976 through 30 September 1976 during which the transition to the new fiscal year concept occurred.

into two sections: a personal data section and a career factors section. Items in the personal data section were designed to provide information about the demographic characteristics, assignments, and career intentions of the respondents. Items in the career factors section were designed to determine the amount of influence that each of 46 factors have on AWOs' decisions to leave the Army.

During the four-month period from September to December 1980, approximately 900 AWOs and 300 commissioned officer aviators were surveyed. The AWOs were subsequently defined as retainees or attritees. The distinction was based on the AWOs' stated intentions to remain in or to leave the Army. Data provided by the survey identified demographic characteristics, such as age, rank, and Military Occupational Specialty (MOS), that are related to AWO attrition (Sundy, Ruffner, & Wick, 1981). In addition, the survey provided three different sources of information about the career factors that influence AWOs' decisions to leave the Army--AWO attritees (self-reports), AWO retainees (peer perceptions), and commissioned officer aviators (supervisor perceptions) (Rogers and King, 1981).

The ten most influential factors identified by the AWO attritees reflect three major areas of concern: (a) pay and benefits, (b) leadership and supervision, and (c) career and assignment factors (Rogers & King, 1981). These areas subsequently became the focus of a series of initiatives that were developed by MILPERCEN to enhance retention of AWOs. Included in the initiatives was an overall increase in flight pay, as well as equalization of flight pay between warrant officer and commissioned officer aviators (Morgan & Johnson, 1981).

Need

Since the MILPERCEN initiatives were enacted, retention of AWOs has steadily increased. Feedback from individuals in the field suggests that the increase in retention is due to both the retention initiatives and a decline in the economy. A third factor that contributed to a high rate of retention in FY83 and FY84 was the limited number of first-term AWOs who were eligible to leave the Army during this period (due to the transition from a 3-year to a 4-year initial commitment, effective for AWOs who began training after 1 October 1978). Historical data indicate, however, that AWO retention rates are likely to decline again as the economy continues to improve. These considerations, together with increasing aviator requirements and training costs, make AWO retention a continuing concern to the Army.

As part of its ongoing effort to maintain the upward trend in the retention of AWOs, MILPERCEN tasked ARIARDA to develop a separation questionnaire that will be administered to all AWOs who leave the Army. The questionnaire will provide a mechanism for the continuous assessment of AWO retention in the future. Specifically, information provided by the questionnaire will be used to implement and maintain a continuous, closed-loop feedback system that will provide MILPERCEN with current information about (a) the number and types of AWOs who separate from the Army, and (b) the type and importance of factors that influence AWOs' decisions to leave the Army. This information, in turn, can be used by the Department of the Army as an aid in activities such as:

- determining the number of aviators, by MOS, that must be trained for replacement,
- planning and projecting the AWO personnel strength, and
- developing and assessing Army policies that impact on retention of AWOs.

Major users of the information include MILPERCEN, the Deputy Chief of Staff for Personnel (DCSPER), and the U. S. Army Aviation Center (USAAVNC).

Project Objectives

The project has four specific research objectives. The objectives are as follow:

- identify the factors that historically have been related to military aviator retention,
- develop a preliminary version of the separation questionnaire,
- conduct pretests of the preliminary questionnaire and use the resulting information to develop the final version of the separation questionnaire, and
- develop and implement a data analysis plan for analyzing data yielded by the separation questionnaire.

Research Approach

The initial step in developing the questionnaire was to conduct an extensive review of contemporary retention research. Since the separation questionnaire was designed specifically for AWOs, the literature review focused on investigations of military aviator retention.

The primary purpose of the literature review was to determine the factors that historically have been related to retention of military aviators. These factors defined the types of items the questionnaire must contain to yield the necessary data about AWO attrition. Two additional sources used to define the information requirements were (a) interviews of AWO attritees and subject matter experts (SMEs) and (b) reviews of existing Air Force and Navy separation questionnaires.

Once the information requirements had been defined, specific items representative of each of the major types of information were designed. The items were then compiled to form two preliminary versions of a four-part questionnaire. Form A was designed to be administered to AWO attritees to identify factors that influence AWOs' decisions to leave the Army. A parallel form, Form R, was designed to identify factors that influence AWOs' decisions to remain in the Army. Part 1 of each questionnaire contains items designed to determine the demographic characteristics of AWOs who remain in or separate from the Army. Parts 2 and 3 consist of career factors that are rated by respondents on a 7-point numerical scale. In Part 2, the respondents rate each career factor to indicate their opinion about the extent to which the factor affects their job satisfaction. In Part 3, the respondents rate the same career factors to indicate the influence that each factor had on their decision to remain in or to leave the Army. Part 4 contains items designed to yield feedback about the suitability of the questionnaire's content and format.

A field test of the preliminary questionnaires was conducted during FY84. During the field test, Form A was administered to AWO attritees and Form R was administered to AWO retainees. Attritees were defined as:

- first-term attritees--AWOs who leave the Army at the end of their initial obligation,
- REFRADs--AWOs with more than four years but less than 20 years of active military service who request release from active duty (REFRAD), and
- voluntary retirees--AWOs who have Regular Army (RA) career status and who voluntarily retire prior to mandatory retirement at 30 years of active military service.

Retainees were defined as:

- first-term retainees--first-term AWOs who remain in the Army beyond their initial obligation, and
- mandatory retirees--AWOs who remain in the Army until mandatory retirement at 20 years (Reserve Component) or 30 years (Regular Army Component) of active military service.

Potential respondents in each of the criterion groups were identified by MILPERCEN. The questionnaire was administered to all the AWO attritees and to a selected sample of AWO retainees at each of 17 major Army aviation installations. Local points of contact (POCs) at the field test installations administered the questionnaires and returned the completed forms to ARIARDA.

Following completion of the field test, the data were analyzed and the results were used to produce the final versions of the retention/separation questionnaires. Particular emphasis was given to the inclusion of items that (a) were shown in statistical analyses to discriminate between AWO attritees and AWO retainees and/or (b) were identified as having particular relevance for Army personnel and policy decisions.

Once the final versions of the questionnaires had been developed, the questionnaires were submitted to the Professional Development Division, Office of the Director of Military Personnel Management (DMPM). The Professional Development Division was identified as the agency in the office of the DCSPER that is primarily responsible for managing the retention of all Army personnel (i.e., enlisted personnel, noncommissioned officers, warrant officers, and commissioned officers). Data provided by the administration of the questionnaires will assist DCSPER in monitoring the retention of AWOs and the factors that influence AWOs' decisions to remain in or to leave the Army.

Project Status

The activities performed during the development of the AWO separation questionnaire yielded a number of research products. The products include the following:

- a technical report entitled "Aviation Warrant Officer Retention: A Summary of Past, Present, and Projected Research by the Army Research Institute" that presents a comprehensive summary of ARIARDA's AWO retention research program;
- an article entitled "Aviation Warrant Officer Retention: A Continuing Effort" published in the U.S. Army Aviation Digest;
- a paper entitled "The Role of Retention in Managing the AWO Force" presented at the Ninth Psychology in DOD Symposium;
- a research report entitled "Development of a Separation Questionnaire for Aviation Warrant Officers" submitted to ARIARDA as a contractual requirement;
- an executive summary entitled "Development of a Separation Questionnaire for Aviation Warrant Officers" submitted to DMPM for implementing the questionnaire;
- a questionnaire entitled "Form A Separation Questionnaire for AWO Attritees" to be administered to all AWOs who separate from the Army; and
- a questionnaire entitled "Form R Questionnaire for AWO Retainees" to be administered to AWOs at various career points prior to their separation from the Army.

The submission of the research reports and the questionnaires to ARIARDA and DMPM completed all contractual requirements for this project.

References

Bills, A. D. (October 1979). Briefing presented to ARI.

Everhart, C. D., & Sanders, M. G. (1981). Aviation warrant officer retention: A matter of concern. U. S. Army Aviation Digest, 27(8).

Martin, S. S. (1982). Aviation warrant officer retention: A summary of past, present, and projected research by the Army Research Institute (Contract No. MDA903-81-C-0504). Fort Rucker, Alabama: U. S. Army Research Institute.

Martin, S. S., & Washer, L. (1983). Aviation warrant officer retention: A continuing effort. U. S. Army Aviation Digest, 29(4).

Morgan, G. A., & Johnson, K. M. (1981). Aviation warrant officer retention: A matter of action. U. S. Army Aviation Digest, 27(12).

Rogers, G. L., & King, O. T. (1981). Aviation warrant officer retention: the factors which influence the decision to leave. U. S. Army Aviation Digest, 27(9).

Sundy, B. T., Ruffner, J. W., & Wick, D. T. (1981). Aviation warrant officer retention: an evaluation of demographic items. U. S. Army Aviation Digest, 27(11).

DEVELOPMENT OF A DETAILED PLAN FOR CH-47 FLIGHT SIMULATOR TRAINING DEVELOPMENT STUDY

Dr. Robert E. Lockwood, Project Director

Background

Although many improvements have been made in Army helicopter flight training, the most important part of the student's instruction is still performed in an aircraft under the direct supervision of an instructor pilot (IP). This method is extremely costly in terms of time expended by students and instructors and in terms of flying-hour costs in today's sophisticated aircraft.

The costs increased dramatically during the late 1960s when the Army experienced a rapid expansion of its aviation capability. The increase in the cost of aviation training during this period of expansion clearly indicated the need for synthetic flight training systems (SFTS) that reduce the requirement to use operational helicopters.

To fulfill this need, the Army approved a Qualitative Materiel Requirement for development of SFTSs in July 1967. Concept formulation was initiated by awarding feasibility study contracts in December 1967. The results of the feasibility studies were positive, so it was recommended that development be initiated. Technical characteristics were presented at the In-Progress Review (IPR) in September 1968 and approved in November 1968.

A contract was awarded in June 1973 for the construction of an operational CH-47 flight simulator (CH47FS) equipped with a camera-modelboard visual system. A preliminary acceptance test was performed at the factory during September 1976 and the final acceptance test was conducted at the U.S. Army Aviation Center (USAAVNC), Fort Rucker, Alabama, in January 1977. An operational test of the CH47FS was begun in January 1977 and completed in August 1977 (U.S. Army Aviation Test Board, 1978).

The results of the operational test indicated that the CH47FS was an effective training device for both institutional and unit training environments. However, the test revealed the need for improvements in (a) the quality of the night visual displays, (b) the maneuver demonstration system, and (c) the yaw motion cues associated with emergency conditions.

A Cost and Training Effectiveness Analysis (CTEA) of the prototype CH47FS was conducted by the Directorate of Combat Developments (DCD), USAAVNC, during the period between January 1977 and February 1980 (DCD, 1980a). A review of the CTEA was conducted by the Analysis Branch, Directorate of Training and Doctrine (DOTD), USAAVNC, during August 1980 (DCD, 1980b). Based upon the review findings, it was concluded that the CTEA report did not provide adequate data to address the following questions:

- What is the cost and training effectiveness of the CH47FS given significant design changes in the production model CH47FS, including the addition of a side window, a larger computer, and an advanced system technology motion system?
- What is the mix of simulator time and aircraft flight time that will maximize training benefits and minimize training costs?
- How should the Aircrew Training Manuals (ATMs) be refined to reflect this mix?
- What should be the basis-of-issue-plan (BOIP)[5] that will maximize training effectiveness and minimize training costs?

Need/Problem

With the introduction of the production model of the CH47FS, there is a need to reevaluate the cost and training effectiveness of the simulator. This reevaluation is needed because of the design changes that occurred after the CTEA (DCD, 1980b) was conducted for the prototype simulator. In addition, the data available from the original CTEA were not sufficient to address the issue of usage of the CH47FS in a unit training context--specifically, unit continuation training. Thus, there is a need to reevaluate the cost and training effectiveness of the production model CH47FS for use in conducting unit continuation training. This research project was designed to determine the actual cost and training effectiveness of the CH47FS and to optimize its use for unit continuation training.

One of the critical issues associated with any study of the effectiveness of flight simulators in a continuation training program is the measurement of training effectiveness. Classical transfer-of-training designs use varying levels of aircraft time and varying levels of simulator time to train aviators to proficiency in a particular task or maneuver. The transfer effectiveness ratio is defined in terms of aircraft time saved by using the simulator, assuming all subjects are trained to proficiency (Roscoe, 1980). Within a continuation training program, the emphasis is on maintaining skills rather than on acquiring initial skills. Thus, training data from an institutional setting, where the simulator is used for initial skill acquisition, cannot be generalized to a unit training context. Because of the lack of generalizability of institutional training data, it was essential that a study be conducted that focuses directly on the unit training situation.

Within a unit training program, three possible training options exist:

[5]The BOIP is the plan that specifies the number of simulators to be purchased and the installations to which the simulators are to be sent.

- train all tasks/maneuvers in the aircraft,
- train some subset of tasks/maneuvers in the simulator and the remainder in the aircraft, or
- train all tasks/maneuvers in the simulator.

The third option may be possible in theory, but it is not a practical option for unit continuation training because of the necessary flying conducted in support of other Army units. The first two options, therefore, represent the only practical training alternatives. An implicit assumption underlying the development of advanced flight simulators is that simulator training can be substituted for some aircraft training and, thereby, reduce training costs without degradation of proficiency. Thus, the usefulness of the CH47FS in a unit training situation must be established by demonstrating that there is some mix of simulator and aircraft training that is more cost effective than aircraft training alone.

Project Objectives

The general objectives of this project were to determine the cost and training effectiveness of the CH47FS (production model) for unit continuation training, and to define the mix of simulator training and aircraft training that is most cost effective for maintaining the flying skills of unit aviators. The specific technical objectives of this project were:

- determine the cost of each training alternative (all training conducted in the aircraft versus aircraft and simulator training in varying mixes),
- establish the relative training effectiveness of each training alternative,
- recommend an optimal cost and training effective alternative for CH-47 aviator unit continuation training,
- based upon cost and training effectiveness, develop a valid list of ATM training tasks for (a) the CH-47C helicopter as the desired training medium and (b) the CH47FS as the desired training medium, and
- determine the adequacy of the CH47FS BOIP and revise it as necessary.

Research Approach

The research approach developed for this project was designed to (a) define the ATM tasks that require some amount of continuation training, (b) derive an initial estimate of the mix of aircraft and simulator time that would maximize training effectiveness while minimizing cost, and (c) use sequential analyses to monitor unit training procedures and refine the initial estimate of the optimal mix of aircraft and simulator time. The proposed research consists of three phases. Each phase is described below.

Phase 1: Training Survey. The first phase required that a survey be undertaken to determine the amount of aircraft and simulator training being received by operational CH-47 pilots. The survey must address both training time and number of practice iterations for training flights and mission support flights. The data from the survey should be used to define the initial mixes of aircraft and simulator training to be investigated in the transfer-of-training study.

Phase 2: Transfer-of-Training Study. The second phase required that a transfer-of-training study be designed to determine the ATM tasks that require training and to derive, for each ATM task requiring training, an initial estimate of the type and amount of training that would be most cost effective. During the transfer-of-training study, the amount of aircraft training and simulator training should be controlled for each participating aviator. As stated above, decisions about the specific mixes of aircraft and simulator training to be investigated should be based on the data obtained during the survey of operational units.

A basic assumption underlying the transfer-of-training study was that certain flight skills deteriorate in the absence of practice. Given this assumption, it was then necessary to specify the skills that deteriorate and to determine the most effective method of maintaining those flight skills in operational units. Consequently, the proposed experimental design for the transfer-of-training study required that four groups of aviators engage in the flight activity specified below:

- one group should fly their normal aircraft missions during the period of the study, but be required to refrain from any practice in the CH47FS,
- a second group should be restricted from all flight activity for six months,
- a third group should receive all their training in the CH47FS, and
- a fourth group should be required to practice ATM tasks in both the aircraft and the simulator in accordance with a rigidly controlled practice schedule.

The training alternative that maximizes training effectiveness while minimizing training costs could then be determined by assessing changes in proficiency for all participating aviators at the end of the six-month study period. By investigating varying mixes of aircraft and simulator time, it would be possible to specify, for each task/maneuver, the mix that produces optimal training effectiveness. Once these mixes are established, cost data for the simulator and the aircraft could be used to estimate the total cost for each training alternative.

Phase 3: Sequential Analysis. The transfer-of-training study was designed to provide the data needed to (a) identify the ATM tasks that can and should be trained using some mix of aircraft and simulator training and (b) derive an initial estimate of the mix of aircraft and simulator training that would be most cost effective for maintaining an acceptable level of proficiency on each ATM task. The third phase called for further study for two reasons. First, since the optimal training-mix curves would be based on a relatively small sample of aviators, the initial estimate of the optimal training mix derived from the transfer-of-training data could be imprecise and, therefore, could result in some amount of undertraining or overtraining of aviators. Second, because all the data in the transfer-of-training study would be based on a six-month study period, additional research would be required to determine whether the optimal mix data are valid for longer periods. It is altogether possible that a training mix that maintains proficiency for periods as long as 6 months could result in proficiency deterioration if continued for periods of 12 months, 18 months, or longer. It was for these reasons that the sequential analysis was considered essential.

The objectives of the sequential analysis were to monitor the unit continuation training program and to modify the mixes of aircraft and simulator time, should the initial training mixes fail to result in optimal training effectiveness. The data required to conduct the sequential analysis were to be collected from operational pilots in six-month increments after the completion of the transfer-of-training study. These data were to include:

- number of iterations for each ATM task completed during mission flights,
- number of iterations for each ATM task completed during CH47FS training, and
- measurements of task performance from checkrides given at the end of the six-month period.

When the data indicate that the training mixes of aircraft and simulator time fail to result in optimal training effectiveness, the data gathered to that point in the study should be used to adjust (refit) the training-mix curves, and data collection should continue for another six-month period (Wald, 1947).

In order to collect data consistent with the requirements specified in the transfer-of-training study, each CH-47 aviator should be requested to restrict aircraft flight time to mission-essential flying. Any additional training should be conducted in the CH47FS, except for the tasks that cannot be practiced in a simulator. The additional training should be specified by the initial function generated during the transfer-of-training study for each task. Performance data from the aviators' checkrides should be used to determine if the mix of aircraft and simulator training is optimal. The sequential analysis should continue until there is a statistically sound basis for concluding that the training mix for each task is optimal.

Project Status

A Training Development Study (TDS) plan was developed and reviewed by U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) personnel, revised as necessary, and delivered to DOTD. The submission of the final TDS plan on 14 December 1982 completed the original tasking on this project; no additional tasking was received during the contract period.

References

Roscoe, S. N. (1980). Aviation psychology. Ames, IA: The Iowa State University Press.

U.S. Army Aviation Test Board. (1978). Independent Evaluation Report (IER) for OT II of CH-47 flight simulator (CH47FS). Fort Rucker, AL: USAATB.

U.S. Army Aviation Center, Directorate of Combat Developments. (1980a). Cost and Training Effectiveness Analysis (CTEA) of the CH-47 flight simulator (CH47FS) (ACN 23879). Fort Rucker, AL: USAAVNC.

U.S. Army Aviation Center, Directorate of Training Developments. (1980b). Review of the CH-47 flight simulator (CH47FS) Cost and Training Effectiveness Analysis (CTEA). Fort Rucker, AL: USAAVNC.

Wald, A. (1947). Sequential analysis. New York: Wiley & Sons.

ASSESSMENT OF THE NEED/FEASIBILITY OF A SCOUT HELICOPTER TEAM TRAINING SIMULATOR

Mr. Steven L. Millard, Project Director

Background

This project was initiated by the Directorate of Training and Doctrine (DOTD) at the U.S. Army Aviation Center (USAAVNC). The purpose of the project is to define the need for a scout team[6] mission training device and to assess the feasibility of developing such a device.

The three major factors that prompted DOTD to initiate this research are (a) the importance and complexity of the scout helicopter missions, (b) the criticality of team coordination to mission success, and (c) the difficulties associated with the conduct of realistic, team training (DOTD Fund Cite, 1981). Each of these factors is discussed in the following paragraphs.

Scout helicopter crews are organic to three combat units: attack helicopter (AH) companies, air cavalry troops, and division artillery (DIVARTY) flight support sections. The basic mission of the Attack Helicopter Company (AHC) is to destroy armored vehicles. Scout helicopters support this mission by establishing and maintaining communication with the ground commander and with the crews of the attack aircraft to ensure proper integration of fires within the larger scheme of battle. The attack team leader, operating from a scout helicopter, manages the aviation assets during the mission. The remaining scout helicopters acquire targets and other combat information for the attack helicopters and reconnoiter avenues of approach to the engagement area and to firing positions. During the actual engagement, the scout teams (a) locate and maintain contact with the enemy, (b) designate targets for attack helicopters, close air support (CAS) aircraft, and field artillery batteries, and (c) provide local security for the attack helicopters by searching for enemy activity in the immediate vicinity.

The basic mission of the air cavalry troop is to perform reconnaissance and provide security for ground forces. The air cavalry scout helicopter's primary function is to provide combat information to the supported unit commander. A scout helicopter is normally deployed as a member of a team, with other scouts or with attack helicopters, depending upon the nature of the enemy situation. The attack helicopters of the air cavalry unit provide overwatch protection for the scout. With such protection, the scout helicopters of the air cavalry unit can make

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[6]The term "team task" is used to refer to any interaction between the crew members of two or more aircraft, or between members of an aircrew and the crew of a ground-based unit. The term "crew task" is used to refer to interaction between crew members of the same aircraft.

first contact with the threat, forcing the enemy to reveal their position and strength and to commit resources for battle before they are fully prepared. When augmented with both attack helicopters and artillery support, the scouts provide a credible anti-armor capability and are capable, when necessary, of defeating a sizable tank force.

Scout helicopters provide an aerial platform that greatly augments the mission of the DIVARTY flight support section. Each division has ten scout helicopters that provide the Field Artillery Aerial Observers (FAAO) of DIVARTY with the capability of rapid maneuver to critical areas on the battlefield for observation and adjustment of artillery fire.

The variety of scout aircraft, scout personnel, and scout missions in these three combat units largely defined the scope of this investigation. Consequently, the research encompasses (a) the missions performed by the scout helicopter crew, alone, and (b) the missions performed by various types of scout helicopter teams. The specific teams that were investigated are listed below along with the abbreviations that will be used hereafter to refer to them:

- OH-58/AH-1 - The crew of an OH-58 scout aircraft and the crew of one or more AH-1 attack aircraft.
- OH-58/AH-64 - The crew of an OH-58 scout aircraft and the crew of one or more AH-64 attack aircraft.
- OH-58/DIVARTY - The crew of an OH-58 scout aircraft and DIVARTY personnel.
- OH-58/CAS - The crew of an OH-58 scout aircraft and a forward air controller (FAC) or the crew of one or more CAS aircraft.
- AHIP/AH-1 - The crew of an Army Helicopter Improvement Program (AHIP) scout aircraft and the crew of one or more AH-1 attack aircraft.
- AHIP/AH-64 - The crew of an AHIP scout aircraft and the crew of one or more AH-64 attack aircraft.
- AHIP/DIVARTY - The crew of an AHIP scout aircraft and DIVARTY personnel.
- AHIP/CAS - The crew of an AHIP scout aircraft and a FAC or the crew of one or more CAS aircraft.

Analyses of the air cavalry, aerial observer (artillery), and attack helicopter missions revealed that these helicopter crews are not capable of performing the full range of their combat mission tasks independently. Scout helicopter crews serve as the eyes and ears for ground commanders, artillery units, and attack helicopter crews. In this capacity, the scout crew is required to process large amounts of information quickly and accurately and to interact smoothly and efficiently with other battlefield elements. Mission success, in most instances, is directly contingent upon such spatially and temporally coordinated action.

It has been proposed that the battlefield on which these crews must be capable of fighting will be characterized by highly sophisticated weapons systems and a numerically superior threat force. The AH-64 attack helicopter and the AHIP scout helicopter were developed in response to this situation. Furthermore, it is expected that the advanced technologies incorporated into the mission equipment of these aircraft will increase rather than decrease the requirements for team interaction. For example, the AHIP scout helicopter has a laser range finder/designation system to designate targets for the laser-guided Helicopter Launched Fire and Forget (HELLFIRE) missile fired from the AH-64 and for laser-guided artillery munitions. The target designation capability of the AHIP scout helicopter may impose a new and critically important requirement for team coordination by the AHIP scout crew.

As the importance of team coordination to mission success increases, the difficulty of conducting realistic team training also increases. However, realistic team training under the multiple task loadings of the modern battlefield is not easily achieved. In fact, the requirement to assess the need for and feasibility of developing a scout team mission training device that will simulate battlefield conditions and team coordination exists, in large part, because of such constraints on live training exercises. The resources required to support such training effort are extensive, including ammunition (missiles and "smart" artillery rounds), fuel, ranges large enough for the conduct of realistic navigation exercises, ranges that are safe for ordnance and laser firing, realistic threat vehicles and aircraft, as well as friendly combat and combat support elements. In addition, the AHIP scout is a two-seat aircraft, thus precluding the direct evaluation or training, by an IP, of two aviators performing as a scout crew.

Project Objectives

The specific technical objectives of this project, as stated in the DOTD Fund Cite, (1981) are listed below:

- identify all scout-attack or scout field artillery mission tasks and skills for which team training is required to achieve or maintain proficient performance,
- determine the advantages and feasibility of training team tasks using actual equipment and simulation devices,
- determine the simulation device capabilities that are necessary to achieve proficiency in performance of individual and coordinated team mission tasks, and
- determine the feasibility (costs and benefits) of adopting a device with the requisite capabilities identified by the analyses.

Research Approach

A two-phase approach was developed to accomplish the project objectives. The Phase 1 tasks were designed to (a) compile a comprehensive inventory of the team tasks that must be performed by each of the crews under investigation, and (b) determine the extent to which a team training device is needed to train each task. The tasks performed during Phase 2 were designed to (a) define the costs and benefits of one or more candidate training systems and (b) use these data to assess the feasibility of developing a cost-effective team training device.

The following tasks were performed during compilation of an inventory of team tasks for each of the eight teams defined above:

- define the basic missions of each team,
- subdivide each mission into mission segments,
- identify the mission segments in which some team coordination was required and prepare a detailed description of each team function, and
- develop a detailed description of the tasks that must be performed by each team member to accomplish the function.

The resulting inventory of team tasks was the subject of a training requirements analysis. The purpose of the analysis was to answer the following sequence of questions about each team task: Is the task presently being trained effectively? If not, can the task be trained effectively with conventional ground-based training techniques? If the task cannot be trained with ground-based techniques, can it be trained effectively in the aircraft? Tasks receiving a negative answer on all three questions were candidates for training in a team training device. The completion of this task required the collection of detailed information on the training conducted at both training institutions and in operational field units. The data gathered on the training of OH-58 and AH-1 aviators were used as a base from which to extrapolate, when necessary, and predict training for the AHIP scout and AH-64 aircraft.

At this point, the information gathered was presented to a panel of experts in both training technology and the operating characteristics, mission equipment, and battlefield tactics of the aircraft previously identified. The panel's job was to identify the tasks that can and should be trained in a training device rather than in an aircraft or classroom.

Phase 2 was to be initiated only if the results of Phase 1 showed that there were a significant number of important team tasks that could be trained effectively only in a team training device. It was proposed that the first task in Phase 2 was to develop a comprehensive list of training objectives based on the tasks that could be trained effectively in a training device. The general equipment characteristics necessary to achieve the training objectives were to be specified at that time.

Project Status

Work on Phase 1 activities was completed in 1983. The basic missions for each team were identified and each mission was subdivided into mission segments. The mission segments were analyzed to determine the functions performed during each mission segment by each member of the team. Based upon guidance from the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA), a detailed task analysis, performed by Applied Psychological Services (APS) in September 1981, was used as the basic reference document for the OH-58D mission segment analysis. No such task list was available for OH-58A/C; therefore, the mission segment analysis for that aircraft was also based upon the APS detailed task analysis for the OH-58D and then modified by an experienced aeroscout SIP to produce the OH-58A/C function list. A detailed task analysis was conducted on each of the functions identified above, and the completed task analysis was submitted to ARIARDA in June 1983.

A draft report, "Scout Helicopter Team Mission Simulator: A Needs and Feasibility Study," was completed and submitted to ARIARDA in October 1983. ARIARDA chose not to complete Phase 2 of the project; therefore, submission of the draft report satisfied all requirements for completion of this project.

Reference

Directorate of Training and Doctrine. (9 June 1981). Fund cite for scout helicopter team mission simulator feasibility study. Fort Rucker, AL: DOTD.

THE USE OF LIGHT ATTENUATION FILTERS FOR NIGHT-FLIGHT TRAINING DURING THE DAY: FIELD VALIDATION

Dr. Kathleen A. O'Donnell, Project Director

Background

Terrain flight is both an offensive and defensive tactic employed by pilots during combat. The aircraft is flown at or below treetop level so that terrain, vegetation, and man-made objects serve to mask and camouflage the aircraft. An enemy's ability to detect an aircraft visually, optically, or electronically is greatly reduced under these conditions. At night, terrain flight is an even more effective tactic for enhancing survivability. However, terrain flight at low luminance levels creates special demands on the pilot's visual, attentional, and response capabilities. Substantial training is required to develop and maintain night terrain flight skills.

Four problems complicate night terrain flight training at aviation field units. The first problem is accident risk; night terrain flight is one of the most hazardous modes of flight. The second problem is a shortage of night qualified instructor pilots (IPs) capable of training aviators to perform terrain flight maneuvers at night. The third problem is that the conduct of night training disrupts typical duty schedules. The fourth, and most significant, problem is the existence of local, civil restrictions on night terrain flight at many of the field units where night training is needed. For example, flight after 10:00 PM local time is not permitted on the Island of Oahu, and is restricted in the Federal Republic of Germany as well. Such restrictions make it extremely difficult to train and maintain night terrain flight skills.

One approach to the range of problems associated with training night terrain flight is to develop a methodology for training night flight procedures during daylight hours. A device developed for use in training night operations during daylight (TNOD) has been tested by the Army (Farrell, 1975; Bleda & Farrell, 1979; Peters, Bleda, & Fineberg, 1979; Bauer & Bleda, 1979; Bleda, 1979; Ciley & Allnutt, 1979; Ruffner, Ciley, & Wick, 1981). This device, the Light Attenuation Filter (LAF), consists of two neutral density filters (of molded polycarbonate), fitted into modified Army Sun, Wind, and Dust Goggle frames. Light reaching the eye through the LAF is reduced by a factor of 1,000,000. Therefore, the daylight image perceived through the LAF closely resembles a night visual scene. A bright, sunny day appears to the aviator as a fairly bright, three-quarter moon night; a dark, overcast day appears as a dark, moonless night (Ciley, Ruffner, Carr, & Allnutt, 1980).

Initial field tests of the LAF were conducted using UH-1 rotary-wing aircraft at Fort Rucker, Alabama. The tests included flight and navigation tasks performed at both terrain flight levels and higher altitudes. Pilot performance on flight tasks with the LAF was found to be approximately the same as performance previously observed at night (Farrell, 1975). However, the LAF was found to degrade performance on navigation tasks (Farrell, 1975). The degradation of performance on navigation tasks was attributed to the fact that the aviator's visual access to maps and instruments was dependent upon the aircraft's orientation with respect to the sun. That is, when flying away from the sun, the ambient illumination in the cockpit was very high. Under these conditions, aviators reported that the instruments and larger features on the maps were visible with the LAF and that thorough preflight planning would have made it possible to perform navigation tasks while wearing the LAF. When the aircraft was flying into the sun, however, the instruments were in the shadow of the instrument panel and could not be seen with the LAF. Moreover, aviators reported that maps could not be read when the aircraft was flying toward the sun.

Need/Problem

The inability to perform navigation tasks under certain training conditions led to an alteration of the filters. An area 1.5 cm^2 was cut out of both nasal portions of one of the filters, which created two small areas where more light was transmitted to the eye. Through these areas, the pilot has visual access to the maps and instruments.

There is a need to assess the utility of the new LAF and accompanying LAF training module as a means of training and maintaining night flying skills at aviation field units. Information from this type of assessment is essential for the development of a fully exportable, modularized Course of Instruction (COI) for implementing the TNOD technique in aviation field units.

Project Objectives

The specific objectives of this research are as follow:

- obtain performance and user acceptability data on the use of the LAF for the training of night flight skills,
- identify appropriate methods and materials for implementing the LAF for TNOD in aviation field units,
- assess the utility of the LAF as a means of meeting the needs of aviation field units for training and maintaining night flight skills, and
- develop a fully exportable and modularized COI for implementing the TNOD program in aviation field units.

Research Approach

Resource constraints and the need to conduct this research under conditions that naturally occur in operational units dictate the adoption of a non-experimental, survey approach to the validation effort. A detailed research plan was developed that specified the tasks required to meet the research objectives. The tasks set forth in the research plan are summarized in the following paragraphs.

Research Site. The research plan requires that all aviation field units that are currently under local civil restrictions on night flight be identified. From these installations, two company-sized units, with approximately equal numbers of rotary-wing aviators, will be selected for the validation effort. A point of contact (POC) will be identified at each unit at the earliest possible date. Each POC will be requested to retain all non-current copies of gradeslips for later analyses.

Data Collection. The research plan specifies that checkride grades, questionnaires, and structured interviews by project personnel will be used to obtain the training effectiveness and user acceptability information required to validate the LAF training. Grades from regularly scheduled night qualification flights, refresher flights, and continuation evaluation flights will provide information relevant to the training effectiveness of the LAF.

User acceptability of LAF training will be evaluated in two ways. First, unit utilization of the LAF will provide one measure of user acceptability. The proportion of night training flights during which the LAF was used will be derived from the gradeslip (DA Form 4507-R), currently used in the units as a training record. Second, all LAF-trained aviators will complete a pre-training questionnaire, a post-training questionnaire, and a structured interview--all designed to obtain the trainees' evaluations of the utility of the LAF and their recommendations concerning the integration of LAF training with other unit training.

Three visits to each field unit will be made by the project director during a six-month period. The purpose of the first visit is to distribute the LAF and accompanying training module and to administer the pretraining questionnaire to all rated aviators in the units. Unit standardization instructor pilots (SIPs), unit IPs, unit trainers (UTs), unit commanders, and unit training officers will be briefed on the purpose of the research, the schedule of the validation effort, the care and use of the LAF, and special LAF training implications. They also will be given a brief (15 to 20 minute) in-flight LAF orientation. All available current and non-current night training and evaluation gradeslips will be examined and relevant information will be recorded.

The second visit will be scheduled approximately one month after the initial visit. The objective of this visit is to review the units' implementation of the LAF training technique and ensure that the appropriate records are being maintained. A review of the tasks trained with the LAF will be conducted. If necessary, unit personnel will be encouraged to expand the use of the LAF to additional tasks. Informal interviews with unit pilots, IPs, and unit training officers will be conducted to obtain information concerning any factors judged to be limiting the use of the LAF training technique. Where possible, solutions to such problems will be recommended.

The final visit to the units will be scheduled approximately six months after the initial distribution of the LAF. The objective of this visit is to obtain information relevant to the performance and user acceptability of the LAF training technique. Each aviator in the unit will be required to complete the post-training questionnaire in a structured interview format. All unit SIPs, IPs, and UTs who have conducted LAF training will be interviewed. All LAF and night training evaluation gradeslips completed in the previous six months will be examined and the data required for this project will be recorded.

Data Analyses and Recommendations. Actual unit utilization of the LAF is the best available measure of user acceptability. A high ratio of LAF training to actual night training will be interpreted as an indication of high user acceptability. Questionnaire and structured interview data will be used to identify specific factors that might have limited the acceptability of the LAF training technique.

Overall flight and specific maneuver grades given during evaluation flights before and during LAF training will be compared for information relevant to training effectiveness. Marked differences between these data sets may be a function of LAF training; therefore, unit SIPs, IPs, and UTs will be questioned regarding such a possibility.

Finally, the LAF training module, which accompanies the LAF, will be revised in accordance with the results and the recommendations obtained.

Project Status

Work Completed. The research plan was approved by the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) in December 1982. The LAF training module, pre- and post-training questionnaires, and a brief outline of instructions for use of the LAF were completed by January 1983. All the documents were reviewed by three IPs. Their recommendations were received and incorporated by June 1983.

Acquisition of the equipment necessary for fabrication of the LAFs proved to be more difficult than project personnel anticipated. Assembly of the LAFs was initiated in February 1983 and nearly completed by June 1983, when project personnel were informed that the LAF lenses designed to fit the Sun, Wind, and Dust Goggle frames were too large for the frames. Five pairs of LAF lenses were subsequently ground to fit the goggle frames. These fully assembled LAFs were mailed to the Army Research Institute Field Unit, U.S. Army Europe (USAREUR) in July 1983, at the request of General Otis, Commander in Chief (CINC). A copy of the LAF training module and the outline of instructions for LAF use accompanied the five sets of goggles.

In June 1983, the LAFs were used by two Individual Ready Reserve (IRR) students in order to evaluate the pre- and post-training questionnaires. The questionnaires were found to be acceptable (i.e., no ambiguities or misunderstanding occurred).

At the end of the contract period, no further progress had been made on this research project. The lack of progress is due to the unwillingness of Forces Command (FORSCOM) units to support the field testing.

Work Projected. Successful completion of the project, as outlined in the research plan entitled "Field Validation of the Light Attenuation Filters and the Night Terrain Flight Training Module," requires that the project be supported by key FORSCOM units.

References

Bauer, R. W., & Bleda, P. R. (1979). Night armor training in simulated darkness (Research Report 1212). Fort Knox, KY: U.S. Army Research Institute for the Behavioral and Social Sciences.

Bleda, P. R. (1979). Application of light attenuating devices (LADs) to night rifle marksmanship training (Research Memorandum 79-2). Washington, D.C.: U.S. Army Research Institute for the Behavioral and Social Sciences.

Bleda, P. R., & Farrell, J. P. (1979). Development of light attenuating devices (LADs) to simulate night visibility during daylight (Technical Paper 375). Washington, D.C.: U.S. Army Research Institute for the Behavioral and Social Sciences.

Ciley, C. D., Jr., & Allnutt, M. F. (1979). An experiment to evaluate the training potential of the pilots' night training device (Technical Report 14-79). Fort Rucker, AL: U.S. Army Research Institute for the Behavioral and Social Sciences.

Ciley, C. D., Jr., Ruffner, J. W., Carr, J. W., & Allnutt, M. F. (1980). Night terrain flight training module. Fort Rucker, AL: Canyon Research Group.

Farrell, J. P. (1975). Night training by simulating the night visual environment during the day (Memorandum 75-4). Washington, D.C.: U.S. Army Research Institute for the Behavioral and Social Sciences.

Peters, J. I., Bleda, P. R., & Fineberg, M. L. (1979). Effects of illumination level and sense of direction on land navigation performance (Technical Paper 362). Washington, D.C.: U.S. Army Research Institute for the Behavioral and Social Sciences.

Ruffner, J. W., Ciley, C. D., Jr., & Wick, D. T. (1981). Application of the pilots' night training device to daytime training in night terrain flight emergency procedures maneuvers (Working Paper FR/FU 80-8). Fort Rucker, AL: U.S. Army Research Institute for the Behavioral and Social Sciences.

DEVELOPMENT OF A COMPREHENSIVE RESEARCH PLAN FOR ARMY FLIGHT SIMULATOR DESIGN AND USE

Dr. Kenneth D. Cross, Project Director

Background

In June 1982, the Assistant Secretary of the Army for Research, Development, and Acquisition, Dr. J. R. Sculley, requested that Commander, Development and Readiness Command (DARCOM), form a Flight Simulator Steering Group that was to map out the paths future Army flight simulator research and development should take. Gravely concerned about the escalating complexity and cost of simulators, the Assistant Secretary established as a primary objective "...the development and acquisition of only such simulator training capabilities as are absolutely essential."

At the outset, members of the Steering Group were directed to outline a program of research that addresses three broad questions:

- How much simulator fidelity is needed for effective training transfer?
- What paths should research and development follow to optimize future flight simulator development?
- What Army policies are needed to manage more effectively the simulator program?

The Group's membership was drawn from DARCOM, Training and Doctrine Command (TRADOC), and the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA). The group has represented in it researchers, developers, and managers from both the training and materiel communities.

Primary responsibility for developing a comprehensive long-term research plan was assumed by Mr. Charles A. Gainer, the Steering Group representative from ARIARDA. Mr. Gainer organized a local team to undertake the development of the plan and supervised the team's efforts from inception to completion. Both ARIARDA and Anacapa Sciences, Inc. (ASI) personnel served on this team.

The research plan included four sections: an introduction, two proposed integrated research plans, and a discussion of research support issues. A detailed, but not exhaustive, literature review and a bibliography were appended as background material for the introduction and the overall research plan.

After an overview, the introduction defined key terms as they were used in the research plan and then detailed basic assumptions and concepts that had a major impact on the formulation of the research plan. The introduction also identified and discussed present constraints on flight simulator research and development. The introduction concluded with a statement of the rationale underlying the proposed research approach.

The next two sections of the plan mapped out two paths of research: a long-term path and a short-term path. An overview of the two paths of research is presented below.

Research Objectives

The broad objective of the program of research was to compile data needed to specify, for individual flight tasks, the fidelity of each simulator design parameter and training feature that would yield the most cost-effective training. To accomplish this objective, it was proposed that research be conducted to quantify the relationship between fidelity and training effectiveness, and that training cost data be collected or extrapolated to determine relative cost effectiveness of training alternatives. Thus, the specific objectives of this proposed program were as follow:

- design and conduct research to obtain the data needed to quantify the relationship between training fidelity and training effectiveness,
- design and conduct research to obtain the data needed to define the relationship between flight simulator life-cycle costs and training fidelity, and
- design and conduct research to define the type, cost, and training effectiveness of training methods and media that represent alternatives to simulator training.

Overview of Proposed Research

A substantial amount of time and effort was required to complete the research needed to quantify fully the relationship between training fidelity and training effectiveness. However, the aviator training problems that existed during proposal development could not be ignored. One solution to this dilemma was to initiate long-term and short-term paths of research. This solution was adopted and had a major influence on the proposed research plan.

The long-term path, which was to commence simultaneously with the short-term path, was proposed as a program of basic and exploratory research concentrating on training fidelity requirements and on the development of various training techniques. Training effectiveness and cost effectiveness of various training fidelity profiles were to be evaluated to ensure that emerging/future training hardware capabilities could be exploited. Most importantly, the research program associated with the long-term path was designed to remain flexible and responsive to both advances in technology and changes in operational requirements.

The long-term path was aimed at providing comprehensive data for future requirements and at utilizing future technology. Five research areas were identified as the primary domain of the long-term path: fidelity requirements for visual systems, fidelity requirements for motion systems, fidelity requirements for simulator displays and controls, fidelity requirements for simulator aerodynamic models, and requirements for support features. Secondary areas of required long-term supporting research were also identified.

The short-term path was based upon the premise that, with only a moderate amount of analytic study and research, it is possible to develop a high-technology, low-complexity, generic flight simulator that would prove far more cost effective than the high-fidelity flight simulators presently being procured by the Army. The short-term path had as its immediate goal the development and evaluation of a prototype high-technology, low-complexity, generic flight simulator. This generic simulator would consist of a set of standardized modules that could be easily and inexpensively tailored to accomplish training for any rotary-wing aircraft in the Army inventory. Using present or very-near-term hardware and training technology, the prototype simulator would be designed to accomplish individual and crew training. If the prototype device proved cost effective for individual and crew training, research would be conducted to identify the additional hardware and the training methods required to accomplish team and combined-arms training in the device. Evidence that the device is cost effective would lead to the recommendation that the Army procure and field generic simulators for use until the optimal design and use of flight simulators is defined empirically through the long-term path research.

Project Status

A draft of the first three sections of the research plan (a 184-page document) was completed, reviewed by ARIARDA and ASI personnel, and distributed for review by members of the Simulator Steering Group.

The revised draft of the research plan, entitled "A Plan of Research for Army Flight Simulators" was delivered to ARIARDA in August, 1983. The delivery of this draft fulfilled the tasking for this project.

ASSESSMENT OF FLIGHT APTITUDE SELECTION TEST SCORES AS PREDICTORS OF ACCIDENT INVOLVEMENT

Dr. Robert E. Lockwood, Project Director

Background

Historically, human error has been found to be a contributing factor in approximately one-half to two-thirds of all aviation accidents. A major portion of the accident producing errors have been committed by the aircraft pilot (Zeller, 1978). In a review of Air Force accidents occurring in 1949, Thorndike (1951) reported that pilot error was a major contributing factor in 24.0% of the accidents listed; materiel failure was a contributing factor in only 26.2% of the accidents. A review of U.S. Army aircraft accidents by Ricketson, Johnson, Branham, and Dean (1973) revealed that pilot error was a factor in 80% of all accidents that occurred during the years between 1958 and 1972.

Sanders, Hofmann, Hunt, and Snow (1974) conducted an exploratory study to determine whether or not personality factors and/or decision-making skills are related to the likelihood of becoming involved in a human error accident. Although it was found that three of Cattell's Sixteen Personality Factor Questionnaire factors discriminated between members of the accident group (human error accidents only), and members of the no-accident group, this finding was not supported by a subsequent study that employed a larger sample size (Sanders, Hofmann, & Neese, 1975). The authors concluded: "These data indicate that individual differences in personality characteristics of aviators prevent identification of personality traits associated with pilot error accident-involved and pilot error accident-free groups" (Sanders et al., 1975, p. 7). This study exemplifies the negative finding of numerous studies that have investigated the relationship between accident likelihood and scores on personality tests. Although it seems probable that personality factors influence flight performance, personality factors do not operate independently. Rather, they interact with environmental factors, equipment design, training, and situational factors. Thus, research conducted on the attributes of aviators involved in pilot error accidents must, ultimately, deal with the interaction of many factors that contribute to an accident.

Research Objective

The objective of this research was to determine whether or not Flight Aptitude Selection Test (FAST) scores can be used to predict accident involvement. The FAST measures a number of abilities and personality factors that have been shown to predict success in the flight training program (Kaplan, 1965; Eastman & McMullen, 1978a). Two subtests from the FAST--Self-Description and Biographical Information--both have numerous items that assess personality factors; however, the present research was designed to investigate all subtests.

Research Approach

The original tasking for this project was to investigate the relationship between accident involvement and performance on the Revised Flight Aptitude Selection Test (RFAST). The RFAST, the test currently used to select applicants for flight school, is composed of seven of the 11 subtests from the original FAST, with each subtest containing approximately one-half of the items that appeared on the FAST. This shortened version was implemented in 1980. Since no accident data exist on pilots who were admitted to flight school with an RFAST score, it was necessary to use the older FAST scores. However, since the RFAST is essentially a shortened version of the FAST, analyses using FAST scores should provide a reasonable estimate of the relationship between RFAST subtest scores and accident involvement.

The approach used in this research required the accomplishment of two analytic tasks:

- assess the relationship between test performance and accident involvement, and
- assess the relationship between test scores and accident type.

Total score, subtest scores, and individual item scores on the FAST were correlated with accident involvement in which pilot error was a known or suspected contributor. Accidents included in this study range from major accidents (Level A) to precautionary landings (Level E).

Study Sample

The analyses were computed using a sample of 2,451 Army aviators: 1,026 who had been involved in pilot error accidents and 1,425 who had not. The accident group was composed of 275 Commissioned Officers and 751 Warrant Officers; the non-accident group was composed of 460 Commissioned Officers and 965 Warrant Officers. The accident group includes about 25% of all aviators who were involved in pilot error accidents between 1975 and 1982. The non-accident group was selected from the population of pilots who had graduated from Initial Entry Rotary Wing (IERW) training between 1975 and 1982 and who had not had an accident.

To assess the representativeness of the control group, an analysis was performed to compare the control group's scores on five FAST subtests with the corresponding scores of the sample of 7,007 aviators used to revalidate the FAST in 1978 (Eastman & McMullen, 1978b). Although significant differences between means were found for two of the five subtests, the differences were small: 82.9 vs 79.7 for the Self-Description subtest; 36.8 vs 35.0 for the Biographical Information subtest. The statistical significance of such small differences is the result of the very large size of the samples. It was concluded that using the current sample as representative of all IERW graduates would not result in biased estimates of the relationship between test scores and accident involvement.

Data Analyses

Data on FAST performance were obtained for all subjects from archival records. Accident data, including the type of accident, for the 1,026 aviators in the accident group were obtained from accident data files maintained by the U.S. Army Safety Center. These data were submitted to two types of analyses. First, Pearson Product-Moment correlation coefficients were computed to assess the magnitude of the relationship between accident involvement and (a) total FAST score, (b) score on each of the 14 FAST subtests, and (c) score (correct/incorrect) on each of the 547 FAST items. The item level analysis was undertaken to investigate the possibility of recombining items, across subtests, into a meaningful predictor of accident involvement.

The second analysis consisted of a one-way analysis of variance to assess the relationship between FAST subtest scores and type of accident. This analysis included only the subtests that were found to have a correlation of .10 or greater with accident involvement.

Results and Conclusions

Statistically significant correlation coefficients ($p < .05$) were found for the total test score and for 10 of the 14 subtest scores. Although statistically different from zero, all 11 correlation coefficients were very small--varying from .054 to .110. As stated earlier, samples as large as the ones used in this analysis often yield statistically significant results that have little practical significance. For example, the strongest relationship between accident involvement and a subtest score ($r = .110$) accounts for only 1.2% of the variance associated with accident involvement.

An analysis limited to the FAST subtests that were retained on the RFAST showed that the highest correlation between accident involvement and any RFAST subtest is .082--the correlation coefficient obtained for the Mechanical Functions subtest. Correlation coefficients for the remaining RFAST subtests vary from .08 to near zero. These findings show that the subtests retained on the RFAST account for even less variance in accident involvement than the FAST subtests. Thus, it is clear that the relationship between the subtest scores and accident involvement is not practically useful for identifying Initial Entry Rotary Wing (IERW) applicants who are highly likely to become involved in an accident.

The results of the item level analyses show a pattern similar to the one revealed by the subtest level analyses. Although there are many statistically significant correlations between item scores and accident involvement, the magnitudes of the correlations are too small to be practically useful. The majority (342) of items from the FAST had correlations with accident involvement between zero and ±.03. The four highest correlations among the 547 items range from ±.10 to ±.12. These four items still have very little variance shared with accident involvement. A review of the items showed that most of the statistically significant items were from subtests that had not been retained in the RFAST. This finding, coupled with the small correlation coefficients found, suggests that a recombination of items to form a predictor is not a promising approach.

Following the correlational analysis, a series of one-way analyses of variance were computed using only the subtests with a correlation coefficient equal to or larger than .10. In addition, since Biographical Information and Self-Description subtests were of particular interest in this study, these subtests were included in the analysis of variance even though their correlations with accident involvement were less than .10.

There were no statistically significant differences among accident category means for either the Warrant Officer Candidate (WOC) Self-Description subtest or the Commissioned Officer (CO) Biographical Information subtest. Differences among category means for the remaining five subtests--all FAST subtests--were statistically significant. However, the absolute magnitudes of the differences are so small that they have little value for discriminating among categories of accidents. For example, using the Total Score, the largest mean, 219.1, is for the Level A accident group; the smallest mean, 208.4, is for the no-accident group. The standard deviations for these groups are 28.7 and 29.8, respectively. The 10.61 point difference between the two means is about one-third of the standard deviation for each group. Therefore, the expected distribution of scores for the Level A accident group will contain many of the scores expected for the no-accident group. Specifically, it can be shown that approximately 68% of the no-accident group will have scores between 178.64 and 238.24, and approximately 68% of the Level A accident group will have scores between 190.35 and 247.75.

In summary, the analyses resulted in some statistically significant relationships between test scores and accident involvement. However, the statistical significance was mainly attributed to the large sample size used in the analyses. It was concluded that the relationships between FAST subtest scores and accident involvement are so weak that FAST scores cannot be considered a practically useful predictor of accident involvement. Also, since none of the subtests retained in the RFAST are correlated above .10 with accident involvement, the RFAST is an even less powerful predictor of accident involvement than the FAST.

Project Status

Five copies of the Working Paper, entitled "FAST Scores as Predictors of Accident Involvement," were submitted to the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) on 29 March 1983, thus completing ASI's tasking on this project.

References

Eastman, R. F., & McMullen, R. L. (1978a). The current predictive validity of the Flight Aptitude Selection Test (ARI Field Unit Research Memorandum 78-2). Fort Rucker, AL: U.S. Army Research Institute for the Behavioral and Social Sciences.

Eastman, R. F., & McMullen, R. L. (1978b). Item analysis and revision of the Flight Aptitude Selection Tests (ARI Field Unit Research Memorandum 78-4). Fort Rucker, AL: U.S. Army Research Institute for the Behavioral and Social Sciences.

Kaplan, H. (1965). Prediction of success in Army aviation training (Technical Research Report 1142). Washington, DC: U.S. Army Personnel Research Office.

Ricketson, D. S., Johnson, S. A., Branham, L. B., & Dean, R. K. (September 1973). Incidence cost and factor analysis of pilot-error accidents in U.S. Army aviation. Paper presented at the 30th Aerospace Medical Panel Meeting AGARD/NATO, Soesterberg, Netherlands.

Sanders, M. G., Hofmann, M. A., Hunt, P. D., & Snow, A. C. (1974). Personality aspects of pilot-error accident involvement (USAARL Report 75-1). Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory.

Sanders, M. G., Hofmann, M. A., & Neese, T. A. (1975). A cross-validation study of the personality aspects of involvement in pilot-error accidents (USAARL Report 75-15). Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory.

Shaw, L., & Sichel, H. S. (1971). Accident proneness. Oxford: Pergamon Press.

Thorndike, R. L. (1951). The human factors in accidents with special references to aircraft accidents (Project 21-30-001, Report 1). Randolph Field, TX: U.S. Air Force School of Aviation Medicine.

Zeller, A. F. (November 1978). Three decades of USAF efforts to reduce human error accidents: 1947 - 1977. Paper presented at the 35th Aerospace Medical Panel Meeting AGARD/NATO, Paris, France.

INVESTIGATION OF THE FEASIBILITY OF USING VISUAL FLIGHT SIMULATORS FOR NIGHT VISION GOGGLE TRAINING

Dennis H. Jones, Project Director

Background

During the past two decades, there has been a major re-evaluation of traditional military strategies involving Army aviation. Specifically, recent military experience indicates that technological advances in aircraft detection and ground-to-air weaponry require Army aviators to (a) employ low-altitude tactics, including nap-of-the-earth (NOE) flight, as an integral part of their offensive and defensive strategies, and (b) expand their operational capabilities to include nighttime and adverse weather conditions. The combination of these two requirements--the performance of low altitude tactics under low levels of illumination--represents a major challenge to Army aviation.

The ability of Army aviators to perform terrain flight maneuvers and, simultaneously, to navigate in unfamiliar environments at night, using unaided scotopic vision, is limited by the availability of ambient light. Without sufficient ambient light, the aviator simply cannot see the terrain clearly enough to fly safely or to navigate effectively. For more than a decade, the Department of the Army has sponsored research and development (R&D) aimed at producing a night vision device that facilitates the performance of terrain flight tactics under low levels of illumination.

The R&D effort began during the latter part of the Vietnam war when it became obvious that Army aviators must be capable of performing terrain flight tactics during the day and at night in order to survive mid-intensity warfare. Based on a recommendation from a Modern Army System Test and Evaluation Review (MASSTER), an In-Progress Review (IPR) committee directed that a low-cost night vision goggle (NVG) device, originally developed for use by ground personnel (Johnson, Tipton, Newman, Wood, & Intano, 1972), be adopted as an interim solution to terrain flight under low levels of illumination. Thus, the Army Navy/Pilot Visual System (AN/PVS-5) NVG was procured and a Required Operational Capability (ROC) was issued without formal developmental testing or operational testing.

The standard AN/PVS-5 NVG is a binocular device with unity magnification. It is approximately 6½ inches square, weighs 28 ounces, and provides a 40° field-of-view with a visual acuity of approximately 20/50. The device contains two electro-optical systems designed to perform optimally under low levels of illumination. Each electro-optical system contains an image intensifier tube that increases the number of ambient light particles and utilizes fiber optics to project a visual image onto a green phosphorous plate.

The IPR committee accepted the AN/PVS-5 NVG as an "interim solution" to the requirement for a night vision device to facilitate performance of Army aviators. The committee members knew from the outset that the AN/PVS-5 NVG was not ideally designed for use in an aircraft cockpit. Therefore, it was not surprising that subsequent research and experience demonstrated that the standard AN/PVS-5 NVG was only a marginally acceptable night vision device (Gunning, 1983). However, the problems revealed by the research and experience have guided the modifications of the standard AN/PVS-5 (McLean, 1982), as well as the design of the newest night vision device, the Aviator Night Vision Image System (ANVIS) (Richardson & Crew, 1981).

Need/Problem

Pursuant to the instructions of the IPR Committee ROC, NVG training requirements were established and detailed in the Aircrew Training Manual (ATM) for each Army aircraft. Each ATM specifies the prerequisites for NVG training, as well as the academic and flight training requirements for NVG qualification training, NVG continuation training, and NVG refresher training. For example, to become NVG qualified, an aviator must:

- receive 10.5 hours of academic instruction in night (unaided) flight and NVG flight procedures,
- demonstrate proficiency in the performance of all ATM tasks (except for the 5,000 series tasks) during night (unaided) flight,
- receive 1.5 hours of cockpit blackout training prior to beginning NVG flight training, and
- receive between 8.5 and 13.5 hours of NVG flight training prior to demonstrating proficiency to an NVG qualified IP.

The ATM requirements for NVG qualification training were representative of the training requirements for NVG continuation training and NVG refresher training. That is, except for 1.5 hours of cockpit blackout training, all flight training was conducted in the aircraft.

Given the safety problems associated with using night vision devices during rotary-wing flight, it was probable that accident risks could be reduced by accomplishing some portion of NVG training in visual flight simulators, prior to NVG training in the aircraft. Furthermore, if the NVG flight training currently being conducted in the aircraft could be augmented by training in visual flight simulators, there was a potential for enormous savings in manpower, aircraft time, and other resource requirements.

On 29 June 1983, the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) was tasked by the Directorate of Training and Doctrine (DOTD) to "...conduct formal systematic testing, collect and evaluate empirical data, and determine the feasibility of night vision goggle (aided) training in visual flight simulators."

Project Objectives

The specific objectives of this research project were dictated by the research approach selected by the representatives from DOTD. The general objectives are as follow:

- identify the NVG tasks that could be trained in a visual flight simulator,
- develop a POI to be used in training NVG tasks in a visual flight simulator, and
- determine the feasibility of NVG training in visual flight simulators.

Research Approaches

On 22 July 1983, a meeting was held with representatives from various staff agencies to discuss issues surrounding the choice of an appropriate research design. Comments from the representatives were divided. Some representatives suggested that the feasibility question could be answered by obtaining judgments from several UH-60 NVG-qualified instructor pilots (IPs) after they had performed relevant flight tasks with NVGs in the UH60FS. Other representatives argued that a feasibility study alone was not adequate and that nothing short of a full transfer-of-training study would provide the data needed to evaluate fully the cost effectiveness of NVG training in simulators.

In view of the lack of consensus among agency representatives, members of the ARIARDA and Anacapa Sciences, Inc. (ASI) staff decided to develop three alternative research designs that varied in terms of (a) the type and magnitude of the resource requirements, (b) the amount of time (elapsed) required to complete the research, (c) the amount of support required from other agencies, and (d) the quantity and quality of data yielded by the research. The three research alternatives are discussed below.

The first research alternative was a skill acquisition study that addressed the feasibility question in a short period of time and with a relatively small number of resources. This research design provided information about the NVG skill acquisition of 10 UH-60 Aviator Qualification Course (AQC) graduates during NVG training in the UH60FS. Each subject would be trained on relevant NVG tasks during five three-hour simulator sessions. By comparing each subject's performance on each ATM task during the fifth simulator session with his/her performance on the same ATM task during the first simulator session, it would be possible to assess the extent to which performance of NVG tasks in the simulator improved with simulator training. However, since this research design did not assess subsequent performance of NVG tasks in the aircraft, there was no way to assess the extent to which simulator training on NVG tasks transfers to the aircraft.

The second alternative was a transfer-of-training study that addressed the most important questions associated with NVG training in visual flight simulators. This study was designed to allow detailed comparisons of performance and skill acquisition of (a) a group of subjects trained to NVG qualification in the UH-60 aircraft (control group) and (b) a group of subjects who received NVG training in the UH60FS prior to NVG qualification training in the UH-60 aircraft (experimental group). The results of this research design could be used to (a) assess the rate of skill acquisition during training in a visual flight simulator, (b) identify the transfer of training from the simulator to the aircraft by task, and (c) estimate the total savings in aircraft time, IP time, and other resources that could be realized from training in visual flight simulators. However, this design was resource intensive and required extensive support by various agencies of the U.S. Army Aviation Center (USAAVNC) located at Fort Rucker, Alabama.

The third alternative was a transfer-of-training study designed to incorporate the experimental design into the normal NVG training conducted at USAAVNC. Initial Entry Rotary Wing (IERW) students were receiving NVG qualification training in the UH-1 aircraft during the Combat Skills phase of their training. The proposed study would evaluate the effectiveness of using the UH60FS and the UH-1 Cockpit Procedural Trainer (CPT) to train UH-1 IERW students for NVG flight in the UH-1 aircraft. Although the resource and support requirements for this alternative were less than those for the second alternative (UH-60 transfer-of-training study), the dissimilarity of the UH-60 and UH-1 cockpits, combined with marked differences in their flight handling characteristics, would possibly confound the results of this research approach.

Project Status

The research alternatives were developed and a report describing them was submitted first to ARIARDA and then to DOTD for review and evaluation; the report is entitled "UH-60 AQC Research Design Phase I and Phase II." Support was not approved for any of the research alternatives; consequently no research was conducted to investigate the effectiveness of NVG training in visual flight simulators. Submission of the report describing the three proposed research alternatives fulfilled the contractual requirements for completion of this project.

References

Gunning, J. A. (1983). Modified faceplate goggles. U.S. Army Aviation Digest, 29-5, p. 2-6.

Johnson, J., Tipton, E., Newman, D., Wood, J. & Intano, G. (1972). Visionics night vision goggle study (ECOM Report 7026). Fort Monmouth, NJ: U.S. Army Electronics Command.

McLean, W. E. (1982). Modified faceplate for AN/PVS-5 night vision goggles (USAARL Report No. 83-1). Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory.

Richardson, P., & Crew, D. (1981). Development test II (PQT-G) of aviator night vision imaging system (ANVIS) Test Report, TECOM Project No. 4-EE-AVS-006-001). Fort Rucker, AL: U.S. Army Aviation Development Test Activity.

APPENDIX

PROJECTS/PRODUCTS LOG

AUTHOR(S)	PROJECT	TITLE	STARTED	UNBOUND IN FILE	SUBMITTED TO ARI	SUMMARY SHEET	CONTRACT LETTER	ASI #
Martin	WOR	Aviation warrant officer retention: A summary of past, present, and projected research by the Army Research Institute			10/82			001-82(B)
Cross	Annual	81-82 Annual summary report			11/5/82		11/5/82 ARI RN 85-103 5/8/86* (AD-A167-740)	002-82
Wick	IRR	Revision/validation of the individual ready reserve aviator training program (research plan)		X	2/16/82			003-82(B)
Ruffner	ATM	Validation of aircrew training manual practice iteration requirements		X	11/2/83		11/2/83	004-83
Ruffner	ATM	ATM requirements validation (research plan)		X	3/3/82		3/3/82	005-82
Aldrich	AH-64	Prerequisites and selection criteria for assignment to the AH-64 advanced attack helicopter (research plan)		X	3/29/82	3/29/82		006-82(B)
Craddock	Misc.	Weighted kappa: A measure of interrater reliability		X	4/15/82			007-82(B)
Siering	THIESIS	Training helicopter initial entry students in simulators (research plan)		X	5/28/82			008-82(B)

*Dates cited after 31 December 1985 refer to work performed under Contract Number MDA903-86-C-0055 dated 17 February 1986.

AUTHOR(S)	PROJECT	TITLE	STARTED	UNBOUND IN FILE	SUBMITTED TO ARI	SUMMARY SHEET	CONTRACT LETTER	ASI #
Millard	IRR Cobra	Training syllabus for IRR Cobra aviators: Phase I/II		X	6/30/82	6/30/82		009-82(B)
Lockwood,Cohen	RFAST	Development of a 1984-85 version of the Army flight aptitude selection test (research plan)		X	12/11/81 2/15/82		12/11/81	010-82(B) 010-82
Aldrich,Keenan	GRSLP	A methodology for developing a flight grading system (resource estimate)		X	9/7/82			011-82(B)
Lockwood,Craddock	CH-47	CH-47C flight simulator (CH47FS) training development study (study plan)		X	3/22/82 10/82 12/14/82	3/22/82	12/14/82	012-82(B) 012-82
Martin	WOR	Development of a separation form for aviation warrant officers (research plan)		X	12/11/81			013-81-(B)
O'Donnell,Keenan	LAF	Field validation of the light attenuation filters and the night terrain flight training module (research plan)		X	11/82			014-82(B)
Aldrich	AH-64	*AH-64 Crew Function Survey*		X	7/26/82	7/26/82		015-82(B)
Lockwood	ACC PRED	FAST scores as predictors of accident involvement (Working Paper FR/FU-83-1)		X	3/29/83			016-83

AUTHOR(S)	PROJECT	TITLE	STARTED	UNBOUND IN FILE	SUBMITTED TO ARI	SUMMARY SHEET	CONTRACT SUBMISSION	ASI #
Keenan,Millard	ATT	Scout helicopter team mission simulator: a needs and feasibility study.		X	10/83			017-83(B)
Keenan,Millard, Cross	ATT	Scout helicopter team mission simulator: A needs and feasibility study (research plan)		X	2/23/83 8/83	2/23/83 8/83		018-83(B)
Cross	Annual	82-83 annual summary report			10/83		ARI RN 85-104 5/8/86* (AD-167-950)	019-83
Lockwood, Shipley Revised by McAnulty	RFAST	Evaluation of the revised flight aptitude selection test			10/82 10/83 1/84			020-84(B)
Wick,Keenan, Millard,Ruffner Cross,Everhart Bickley	IRR	Evaluation of a revised individual ready reserve (IRR) aviator training program: Interim report on first training year		X	9/10/84 12/14/84	9/10/84	12/14/84	021-84(B) 021-84
Cunningham, Kelley	Adv MITAC	Advanced MITAC corridor orientation. Self-instruction manual						022-84(B)
O'Donnell, Brown	Short People	Inflight performance of Army student aviators in relationship to new anthropometric selection standards			6/13/84	6/13/84		023-84-(B)

AUTHOR(S)	PROJECT	TITLE	STARTED	UNBOUND IN FILE	SUBMITTED TO ARI	SUMMARY SHEET	CONTRACT LETTER	ASI #
McCracken, Aldrich	LHX	Analyses of selected LHX mission functions. Implications for operator workload and system automation goals (Technical Note)		X	8/29/83 7/10/84	7/10/84		024-84-(B)
Martin	WOR	Aviation warrant officer retention: A continuing effort	Aviation Digest article.					025-84
Cross	SSG	A plan of research for Army flight simulators		X	9/83			026-83(B)
Aldrich	AH-64	A composite list of crew functions for the AH-64		X	11/83			027-82(A)
Jones	NVG	UH-60 AQC research design Phase I and Phase II		X	DF 8/11/83		DF 8/11/83	028-83
Millard, Dohme	THIESIS	Programmed texts: Autorotations and simulated engine failure; Climbs, turns descents, hovering, and taxiing; Communication procedures and radio phraseology; Helicopter engine instruments; Takeoffs, traffic patterns, and approaches			10/83			029-83(B)
Millard, Dohme	THIESIS	Programmed text: Emergency procedures		X	11/83			030-83(B)
Millard, Dohme	THIESIS	Examinations: 5/9/10/11 EA 3H-2; EA 3J-2; EA 2M-2; EA 2N-2		X	11/83			031-83(B)
Millard, Dohme	THIESIS	Primary flight training guide		X	11/83			032-83(B)

AUTHOR(S)	PROJECT	TITLE	STARTED	UNBOUND IN FILE	SUBMITTED TO ARI	SUMMARY SHEET	CONTRACT LETTER	ASI #
Ruffner	PAPER	Factors affecting flight skill retention of active duty Army helicopter pilots. Paper presented at the Human Factors Society Annual Meeting, Norfolk, VA, October 1983						033-83
Martin, Ruffner	NGB	Army National Guard aviator questionnaire		X	10/7/83			034-83
Martin, Ruffner	NGB	Army National Guard Training Log						035-83
Wick	IRR	Individual ready reserve aviator training program. Volume I: Study guide; Volume II: Reference material						036-83
Aldrich, Shipley	GRSLP	Design and evaluation of a prototype combat skills gradeslip	12/83					037-83(A)
Aldrich	AH-64	Prerequisites and selection criteria for assignment to the AH-64 advanced attack aircraft	1/17/84					038-85(A)
Wick, Ruffner	PAPER	Conserving instructional training resources through use of the personalized system of instruction. Paper presented at the 1984 Human Factors Society Meeting, San Antonio, TX.						039-84

AUTHOR(S)	PROJECT	TITLE	STARTED	UNBOUND IN FILE	SUBMITTED TO ARI	SUMMARY SHEET	CONTRACT LETTER	ASI #
McAnulty, Jones	PAPER	An evaluation of aviator training ability requirements scale ratings. Paper presented at the 1984 Human Factors Society Meeting, San Antonio, TX.						040-84
Jones, McAnulty	PAPER	An examination of ability requirements for various rotary wing missions. Paper presented at the 1984 Human Factors Society Meeting, San Antonio, TX.						041-84
Ruffner, Wick,	PAPER	Retention of helicopter flight skills, Is there a "critical period" for proficiency loss? Paper presented at the 1984 Human Factors Society Meeting, San Antonio, TX.						042-84
Martin, Sanders	PAPER	The role of retention in managing the AWO force. Paper presented at the Ninth Psychology in DoD Symposium, April 1984.						043-84
Martin	WOR	Questionnaire for AWO Retainees/Attritees		X				044-84
Martin, Ruffner Sanders	NGB	Army national guard aviation training requirements research (research plan)			5/84			045-84(B)

AUTHOR(S)	PROJECT	TITLE	STARTED	UNBOUND IN FILE	SUBMITTED TO ARI	SUMMARY SHEET	CONTRACT LETTER	ASI #
Cohen, Lockwood Keenan	RFAST	An identification of basic abilities required for successful completion of initial entry rotary wing training			1/83			
NAME CHANGED TO:		The development of test specifications for a revised flight aptitude selection test			12/82			
NAME & AUTHORS CHANGED TO:								
McAnulty, Jones, Cohen, Lockwood		Identification of the abilities required for effective helicopter training performance			5/17/84	5/17/84		046-84-(B)
McAnulty	FLTSUR	Flight surgeon flight training survey		X				047-84
McAnulty	RFAST	Development of a paper-and-pencil measure of complex cognitive-perceptual aptitude (research prospectus). Appendix A: Flight Planning Test			3/84			048-84(B)
Millard	THESIS	Training helicopter initial entry students in simulators			3/84			049-84(B)
Kaempf	BH	Expansion of the Black Hawk simulator training (draft research plan)			5/11/84			050-84(B)

AUTHOR(S)	PROJECT	TITLE	STARTED	UNBOUND IN FILE	SUBMITTED TO ARI	SUMMARY SHEET	CONTRACT LETTER	ASI #
Miles, Cunningham	Basic MITAC	Basic MITAC self-instruction manual			1/84			051-84(B)
McAnulty	FLTSUR	Incentive factors survey		X				052-84(B)
Jones, McAnulty Shipley, Sanders	MTAB	An evaluation of the mission track assignment battery as a classification system for Army aviators. Phase I report: An examination of the ability requirements for various rotary wing missions		X	10/4/84		10/4/84	053-84(B)
Aldrich, Craddock McCracken	LHX	A computer analysis to predict crew workload during LHX scout-attack missions		X	6/13/84 7/84 10/22/84	10/22/84		054-84(B)
Kaempf	BH	Interim analysis of effects of expanded use of Black Hawk simulator (Executive Summary and Summary)		X	7/20/84	7/20/84	DF 7/20/84	055-84
Martin	WOR	Development of a separation questionnaire for Army aviation warrant officers (Summary Report, Research Report, Form A, and Form R)			9/28/84		9/28/84	056-84
Ryan-Jones, Bickley, McCracken McMullen, Wright Cross, Keenan, Millard	SSG	Aviator training requirements and simulation fidelity (Research Note)		X	9/7/84	9/7/84		057-84(B)

AUTHOR(S)	PROJECT	TITLE	STARTED	UNBOUND IN FILE	SUBMITTED TO ARI	SUMMARY SHEET	CONTRACT LETTER	ASI #
Wick	IRR	Evaluation of a revised Individual Ready Reserve (IRR) aviator training program: Final Report	3/14/84	X	12/14/84 revised and 7-3-85	12/14/84 resubmitted 7-3-85	7-3-85	058-84(B)
Cross, Jones	NRSIM	A plan of research to assess the applications and benefits of the AH-1 flight simulator for training field-unit aviators		X	10/1/84	10/1/84		059-84(B)
Kaempf	BH	Effects of expanding the UH60FS portion of the UH-60 aircrew qualification course		X	10/5/84		10/5/84	060-84(B)
Cross	Annual	83-84 Annual summary report		X	11/15/84		11/15/84	061-84
Jones, Kaempf	NRSIM	AH-1 backward transfer research design		X	10/26/84		DF 10/26/84	062-84
Aldrich	LHX	A computer analysis of LHX automation options and their effect on predicted crew workload	10/84		9/11/85 revised and 8/86*	resubmitted	8/86*	063-84(A)
Martin, Ruffner Cross, Sanders	NGB	An evaluation of the training requirements of Army National Guard aviators	11/14/84	X	7-25-85 revised and 5-23-86*	resubmitted	7-25-85	064-85(A)
McAnulty	FLTSUR	Evaluation of a flight surgeon course syllabus change	12/18/84	X	1/9/85	1/9/85		065-85(B)

AUTHOR(S)	PROJECT	TITLE	STARTED	UNBOUND IN FILE	SUBMITTED TO ARI	SUMMARY SHEET	CONTRACT LETTER	ASI #
Cross, Gainer	SSG	An enumeration of research to determine the optimal design and use of Army flight training simulators		X	2/14/85			066-85(B)
McAnulty	FLTSUR	Internal ARI/ASI Memorandum "Flight Surgeon Recruitment Incentive Project" (includes Incentive Factors Survey)		X	2/7/84	2/7/84		067-84
McAnulty	FLTSUR	Internal ARI/ASI Memorandum "Flight Surgeon Appraisal Project" (includes Flight Surgeon Flight Training Survey		X	5/84			068-84
Krausz, Everhart, Wick, Ruffner	IRR	User's Guide--OH-58A Training Program for Individual Ready Reserve (IRR) Aviators Phase I and Phase II			Print Shop 5/85 *ARI rec'd 50 copies f/Print Shop 6-13-85		6-25-85	069-85
Krausz, Everhart, Wick, Ruffner	IRR	User's Guide--OH-58C Training Program for Individual Ready Reserve (IRR) Aviators Phase I and Phase II			Print Shop 5/85 *Same Note		6-25-85	070-85
Everhart, Krausz, Wick, Ruffner	IRR	User's Guide--OH-UH-1H Training Program for Individual Ready Reserve (IRR) Aviators Phase I and Phase II			Print Shop 5/85 *Same note		6-25-85	071-85
Krausz, Wick Ruffner	IRR	Study Guide--OH-58A Training Program for Individual Ready Reserve (IRR) Aviators Phase I and Phase II			Print Shop 5/85 *Same note		6-25-85	072-85

AUTHOR(S)	PROJECT	TITLE	STARTED	UNBOUND IN FILE	SUBMITTED TO ARI	SUMMARY SHEET	CONTRACT LETTER	ASI #
Krausz, Wick Ruffner	IRR	Study Guide--OH-58C Training Program for Individual Ready Reserve (IRR) Aviators Phase I and Phase II			Print Shop 5/85 ARI rec'd 50 copies from Print Shop 6-13-85*		6-25-85	073-85
Everhart, Wick Ruffner	IRR	Study Guide--UH-1H Training Program for Individual Ready Reserve (IRR) Aviators Phase I and Phase II			Print Shop 5/85 *Same note		6-25-85	074-85
ARI, ASI	IRR	Reference Materials--OH-58A Training Program for Individual Ready Reserve (IRR) Aviators Phase I and Phase II			Print Shop 5/85 *Same note		6-25-85	075-85
ARI, ASI	IRR	Reference Materials--OH-58C Training Program for Individual Ready Reserve (IRR) Aviators Phase I and Phase II			Print Shop 5/85 *Same note		6-25-85	076-85
ARI, ASI	IRR	Reference Materials--UH-1H Training Program for Individual Ready Reserve (IRR) Aviators Phase I and Phase II			Print Shop 5/85 *Same note			077-85
Cross	NRSIM	Motion Sickness Questionnaire			6/85			078-85
Kaempf	NRSIM	Motion Sickness Questionnaire			6/85			079-85
Cross	Final	Final Summary Report 1 Sep 81 - 31 Dec 85			8/86*			080-86

AUTHOR(S)	PROJECT	TITLE	STARTED	UNBOUND IN FILE	SUBMITTED TO ARI	SUMMARY SHEET	CONTRACT LETTER	ASI #
Aldrich, Szabo	PAPER	A methodology for predicting crew workload in new weapon systems Paper submitted for presentation at the 30th Annual Meeting of the Human Factors Society, 29 Sep - 3 Oct 86.						081-86
Szabo, Ruffner, Cross, & Sanders	PAPER	Obstacles to meeting Army National Guard aviator training requirements Paper submitted for presentation at the 30th Annual Meeting of the Human Factors Society, 29 Sep - 3 Oct 86.						082-86

AUTHOR(S)	PROJECT	TITLE	STARTED	UNBOUND IN FILE	SUBMITTED TO ARI	SUMMARY SHEET	CONTRACT LETTER	ASI #
Kaempf, Ruffner	AH-1	Development of In-Simulator Skill Acquisition Curves for Selected AH-1 Tasks		X	1 May 86			677-104-86(A)
Miles, LaPointe	AH-1 Preflight Walk-around	Development of an Interactive Videotape Training Package for AH-1 Preflight Walkaround Inspection		X	1 May 86			677-102-86(A)
Aldrich, Bierbaum Szabo	AH-64	Development of Training Requirements for Use as Inputs for the AH-64 Training System Model		X	1 May 86			677-101-86(A)
McAnulty, Bierbaum	AH-64	Evaluation of the AH-64 Target Acquisition Designation Sight Selected Task Trainer as a Potential Selection Instrument		X	1 May 86			677-103-86(A)

**Subcontract Agreement S-744-036-002. Submitted to Universal Energy Systems 1 May 86. Received copy of letter from ARIARDA COTR (Mr. Gainer) to UES (Mr. Seman) dated 14 May 86 in which Mr. Gainer stated in paragraph 5 that "I deem the deliverables as satisfactory in the completion of the statement of work provided you under Contract #F41689-84-D-0002 (Subcontract #S-744-036-002)."