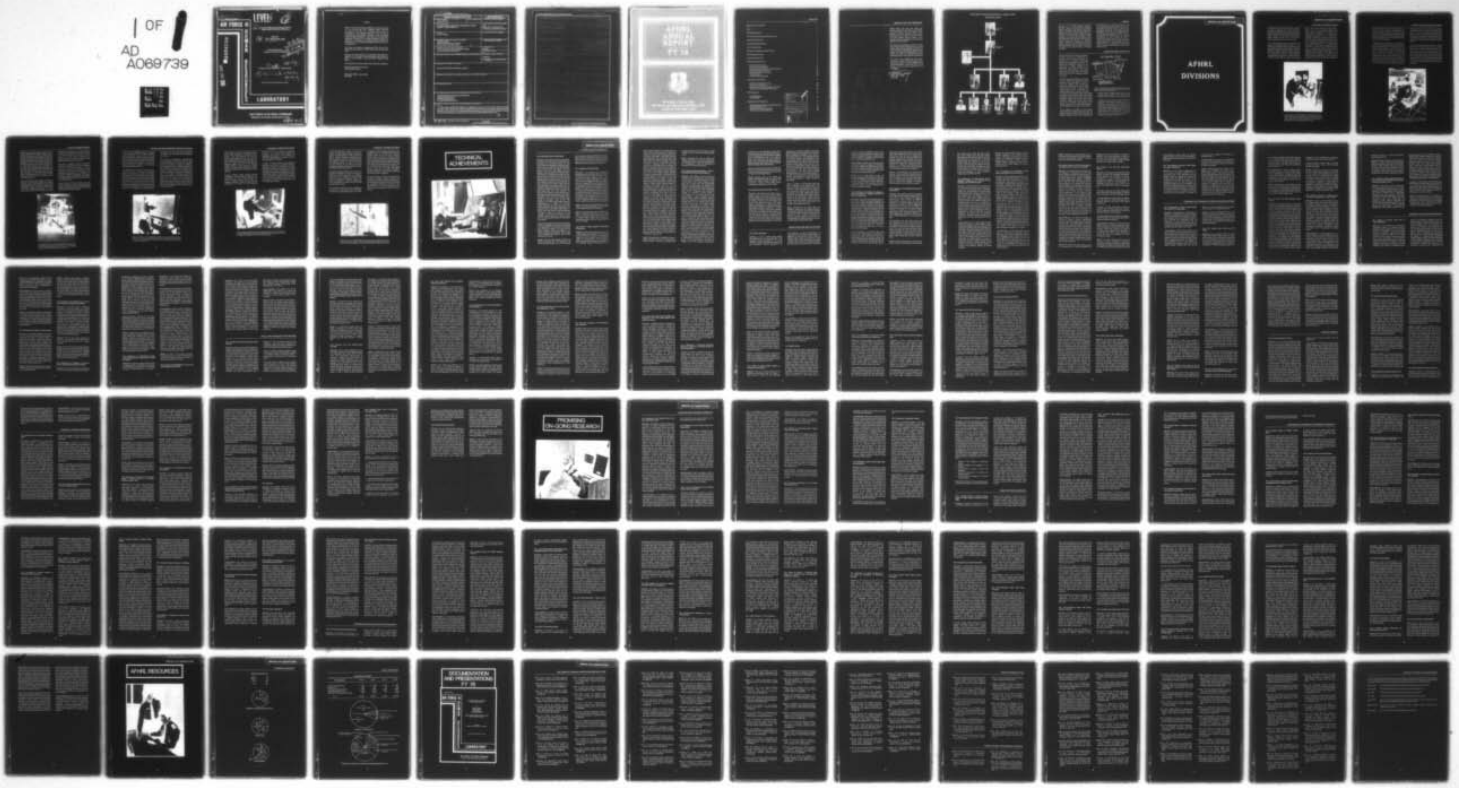
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This report was submitted by Applications Office, HQ Air Force Human Resources Laboratory (AFSC), Brooks Air Force Base, Texas 78235.

This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

RALPH S. HOGGATT, Colonel, USAF
Chief, Applications Office

RONALD W. TERRY, Colonel, USAF
Commander

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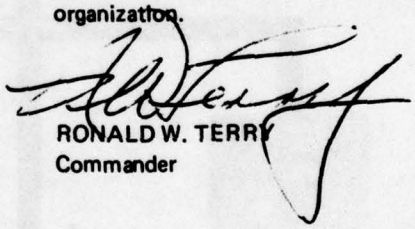
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MESSAGE FROM THE COMMANDER

Skilled workers, with good tools, produce the superior products that can dominate a market. Skilled Air Force personnel, with good weapon systems, produce the military superiority that can ensure success against any adversary. The success or failure of human endeavors, whether military or not, depends on both the capabilities of the tools and the skill with which they are used.

The research and development program of the Air Force Human Resources Laboratory aims to provide the technology base and applications used by the Air Force to match its technologically advanced weapon systems with appropriately skilled personnel, both military and civilian. The contributions to military supremacy and Air Force success can be substantial.

This annual report highlights—for our sponsors, customers, and others—some of the features of our organization, programs, on-going research projects, and accomplishments of fiscal year 1978. You are invited to visit and become acquainted with our organization.



RONALD W. TERRY
Commander

AIR FORCE HUMAN RESOURCES LABORATORY
ORGANIZATION



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Commander



Colonel Kenneth E. Stout
Vice Commander



Dr Earl A. Alluisi
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Occupation & Manpower
Research Division



Colonel Tyree H. Newton
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Personnel Research Division



Colonel Richard L. Shelton
Chief,
Technical Training Division

MISSION

The Air Force Human Resources Laboratory (AFHRL) is the Air Force Systems Command's organization charged with planning and executing the USAF exploratory and advanced development programs for personnel selection, classification, and retention; force structure and utilization; education, training, and instructional strategies; training technology for simulators and instructional devices; performance evaluation; and human resources data in system design and operation. The Laboratory provides technical and management assistance in support of studies, analyses, development planning activities, acquisition, test, evaluation, modification, and operation of aerospace systems and related equipment.

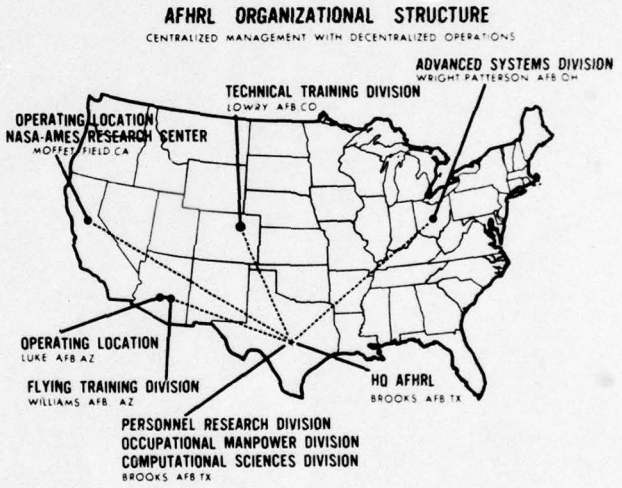
The AFHRL mission is broader than those of most other technology laboratories of AFSC. The hardware laboratories are almost entirely concerned with technological development; but hardware technology development is only one of the responsibilities of AFHRL. Of equal importance in AFHRL's mission is the development of information for uses in making management and policy decisions on selection, training, and personnel matters. This effort in human resources technology is most important because the largest single item in the Department of Defense budget is the cost of personnel and the associated costs of training and administratively supporting the personnel force.

ORGANIZATIONAL STRUCTURE

The Air Force Human Resources Laboratory (AFRHL) consists of a headquarters, six divisions, and two operating locations. The Laboratory is structured for centralized management with decentralized operations. The research and development program of the Laboratory is centrally managed by the headquarters staff located at Brooks AFB, Texas. The divisions perform the research activities and to a great extent are collocated with major users of the Laboratory products and services.

Collocation of research facilities with the users of the research and development (R&D) product has many advantages. It allows for maximum interaction and communication between the research scientist and the operational military manager. It permits better understanding of the environment and problems faced both by scientist conducting the research and the military manager implementing the results of the scientific study. Close working arrangements generate mutual support and produce technology transfer with minimum delay. Often, collocation produces real economic saving through mutual use of equipment and personnel by the research scientist and the operational organization. This is especially true in the area of flying training.

The six divisions of AFHRL are the Advanced Systems Division at Wright-Patterson AFB, Ohio; the Personnel Research Division, the Occupation and Manpower Research Division, and the Computational Sciences Division at Brooks AFB, Texas; the Flying Training Division at Williams AFB, Arizona; and the Technical Training Division at Lowry AFB, Colorado.



The Air Force Human Resources Laboratory consists of six divisions and two operating locations centrally managed by the headquarters located at Brooks Air Force Base, Texas.

In addition to the six major divisions, AFHRL has established two operating locations. One is at NASA-Ames Research Center, Moffett Field, California and was established to coordinate research in full-mission flight simulation and flight management systems. The other operating location is at Luke AFB, Arizona; one of its missions is to conduct research with the Tactical Air Command on simulation training for air-to-air combat.

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DIVISIONS

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ADVANCED SYSTEMS DIVISION

The Advanced Systems Division develops improved engineering techniques for training simulators, techniques for including manpower and other logistic support requirements in the development of weapon systems, methods for improving the maintenance of weapon systems once they are in the field, and improved methods for ground operator training.

In the training simulation area, the major efforts are devoted to developing improved techniques in the following areas: generating out-the-window visual and electro-optical scenes for flight simulators, with major emphasis on computer generated imagery; displaying such visual imagery in a simulator with emphasis on the requirements of tactical air combat readiness training providing motion cues in a flight simulator in a realistic yet cost-effective manner; and providing design criteria for simulator instructor/operator stations. In the area of including manpower and logistic support requirements in weapon system development, the emphasis is on providing an integrated methodology to aid in controlling the personnel and other support costs of weapons over the system life cycle, thus reducing the cost of ownership. In the field maintenance area, current emphasis is on developing criteria for a computer-based technical order system which can support technician performance in the full range of maintenance tasks and on a broad systems study of the Air Force maintenance system to identify factors bearing on the efficiency and effectiveness of the system. In the ground operator training area, the major effort is devoted to the improvement of team training for command, control, and communications operations.



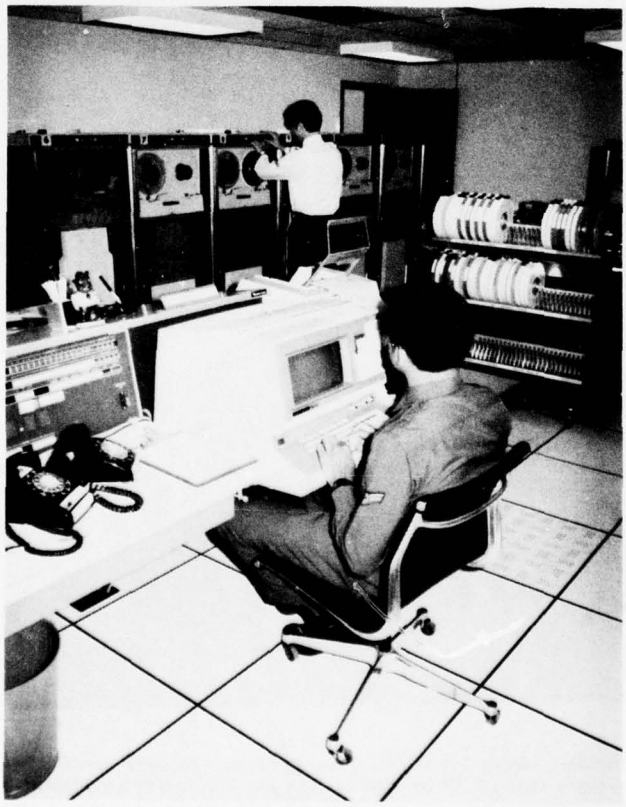
Engineer adjusts the shoulder harness of the Advanced Low Cost g-cueing system (ALCOGS) developed by the Advanced Systems Division under civilian contract. ALCOGS represents the second generation of g-cueing technology. The hydraulic servos provide a ten-fold increase in bandwidth over the original pneumatically driven g-seats.

COMPUTATIONAL SCIENCES DIVISION

The Computational Sciences Division operates the AFHRL scientific research, mathematical, and statistical computer data processing center in support of the other Laboratory divisions. It designs advanced rapid retrieval techniques for data bases and provides statistical analyses of personnel and training research data for a variety of agencies.

Computational Sciences Division has developed a series of data bases containing information on personnel and training systems. The data bases are stored on magnetic tape. Software to process, organize, and display selected information from a single data base and to consolidate information on a common subgroup from two or more data bases has been implemented. The data bases include records on all active duty Air Force enlisted and officer personnel at 6-month intervals; Air Force Reserve and National Guard personnel; records of graduates from basic military training, technical training, and flying training programs, and from the Officer Training School and Reserve Officer Training Corps commissioning programs; and records reflecting separations and losses from active duty. Special purpose longitudinal files have been derived from these data bases. These longitudinal files significantly reduce data processing requirements in many personnel and training research studies.

The Computational Sciences Division develops statistical and mathematical procedures to analyze data arising in research projects throughout the laboratory. Special techniques have been implemented to analyze the psychometric characteristics of aptitude, interest, and attitude tests and questionnaires. Other techniques have been developed and programmed to combine background information optimally; analyses using these methods are used to improve Air Force personnel selection and assignment procedures.



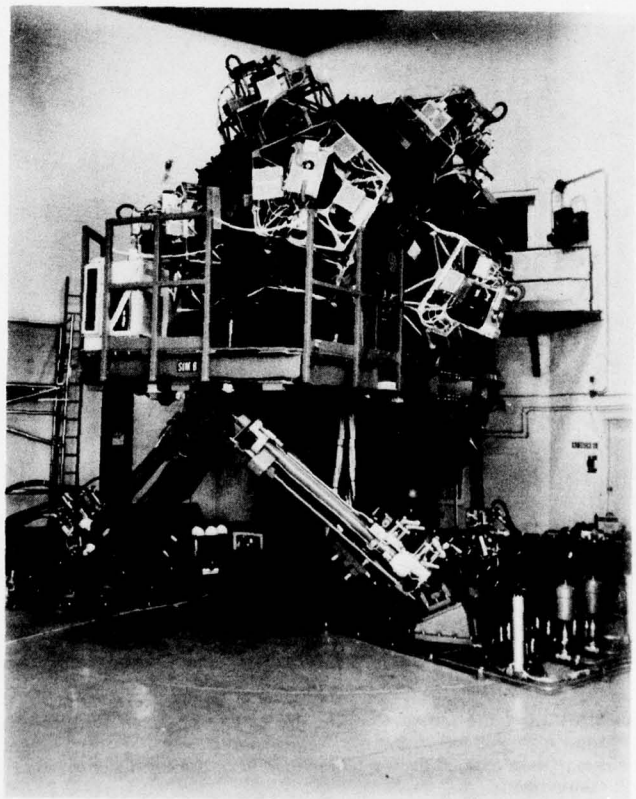
The modern scientific data processing center of the Computational Science Division provides statistical analysis and computational support to AFHRL divisions and various other agencies.

Responsibility for research and development in flying training technology for AFHRL resides with the Flying Training Division. This division develops, tests, and evaluates existing and newly-developed hardware, programs, procedures, and techniques for improving all phases of flying training programs. The Division is collocated with the Air Training Command at Williams AFB, Arizona, and has an operating location at Luke AFB, Arizona, with the Tactical Air Command. The division facilities are accessible to the Air Force flying commands (ATC, TAC, MAC, and SAC) and serves the Navy and Army as well. The close proximity to the Gila Bend Gunnery Range, Tactical Fighter Weapons Center, and the Air Force Flight Test Center enhances its interface with the operational community.

The Flying Training Division operates the Advanced Simulator for Pilot Training (ASPT) and conducts studies to exploit simulator capabilities for improving flying. ASPT is the Air Force's most advanced and sophisticated simulator developed for aircrew training and research. Originally configured as a T-37B aircraft, the simulator system has been modified to simulate the A-10 aircraft and is now being modified to simulate advanced aircraft, such as the F-16. Using the advanced simulator, the Division conducts research to define simulation equipment and techniques which may lead to improved training transfer and better operational simulators.

The Division is conducting research in flying skills maintenance and reacquisition, low level navigation, air-to-air refueling requirements, air combat maneuvering, air-to-ground continuation training, simulator visual and force cue requirements, crew coordination, operational test and evaluation, and A-10 and F-16 syllabus effectiveness. The division is also helping accident boards simulate the conditions of aircraft accidents to improve the data on which their findings are based.

In the future, the Division intends to assist the operating commands in tactics research. Simulation research is planned to determine the requirements for simulating the NATO scenario and wartime missions to increase the USAF force readiness.



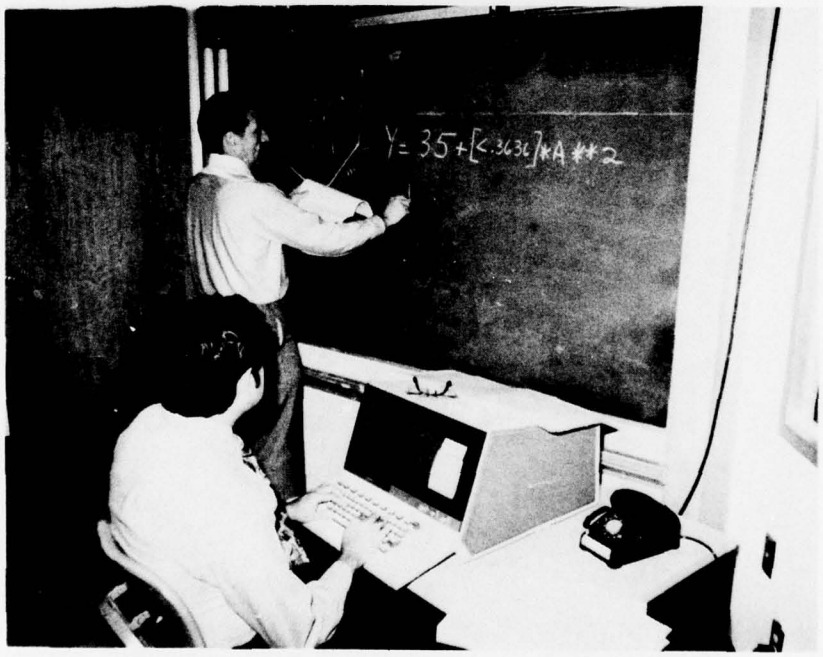
The Advanced Simulator for Pilot Training at Williams AFB is a marvel of technology and has been effectively used both in research and training. Originally configured as a T-37B aircraft, the system has been modified to train pilots transitioning to the A-10 aircraft.

OCCUPATION AND MANPOWER RESEARCH DIVISION

The Air Force has 566,000 members and thousands of jobs ranging from cook to computer specialist, from auto mechanic to aerial gunner, and from personnel specialist to munition expert. Matching the right person with the right job requires job analysis and individual qualification assessment. The AFHRL division responsible for research to improve work force utilization and management is the Occupation and Manpower Research Division.

The Occupation and Manpower Research Division conducts studies on methods for collecting, analyzing, and modeling occupational information; structuring work into jobs, specialties, career ladders, and broader management categories; and establishing grade, pay, training, education, experience, and other job requirements. The division does research which focuses on determining characteristics of jobs, developing methodologies to apply occupational data to training and instructional systems, evaluating the impact of transferability on performance and classification structures, and developing the capability to identify skill deficiencies and organizational problem areas.

This division has developed a computer-based Person-Job-Match (PJM) System that has been operationally integrated in the Air Force Recruiting Service Procurement Management Information System (PROMIS). PJM is a sophisticated algorithm that computes an applicant's best job options for as much as 7 months in advance by comparing his interest and abilities with those of his contemporaries and Air Force needs. The primary output of the system is an ordered list of job opportunities from which a person will choose. The list is ordered and limited so as to maximize Air Force personnel effectiveness. Recruiters indicate that the system, in matching the applicant's abilities, interests, and Air Force needs, virtually guarantees placing "the right person in the right job."



Research scientists from the Occupation and Manpower Research Division modify the algorithm for the Person-Job-Match System (PJM). PJM is an operational, computer-based, job assignment system developed by the Laboratory to optimally match new recruits with Air Force job requirements.

A major portion of the Air Force budget is personnel cost. A major contributor to personnel costs is attrition of first-term personnel. Of every 100 non-prior service accessions, 15 are lost in training, with an additional 10 to 12 lost during their tour. Over half of those completing the first tour and eligible to reenlist fail to do so. The Personnel Research Division is doing research to develop methods and devices which will reduce untimely attrition and increase career motivation of Air Force personnel.

Personnel Research Division develops improved methodologies for the selection, classification, and assignment of Air Force military personnel. The Division conducts research into the nature of individual differences, methods of measuring those differences, and means for their systematic application in Air Force selection and assignment programs. The Division meets research and development requirements for the Armed Services Vocational Aptitude Battery to support Air Force single managership of this battery.

In order to improve selection and classification techniques, the Division is conducting studies of personnel utilization, job satisfaction, and career development. Among its research efforts are projects to determine the impact of assigned work on job satisfaction, retention, and the development of career intent. Efforts toward the development of measures of job performance to be used as criteria for selection and classification measures have led to the development of a performance appraisal system for Air Force civilian personnel.



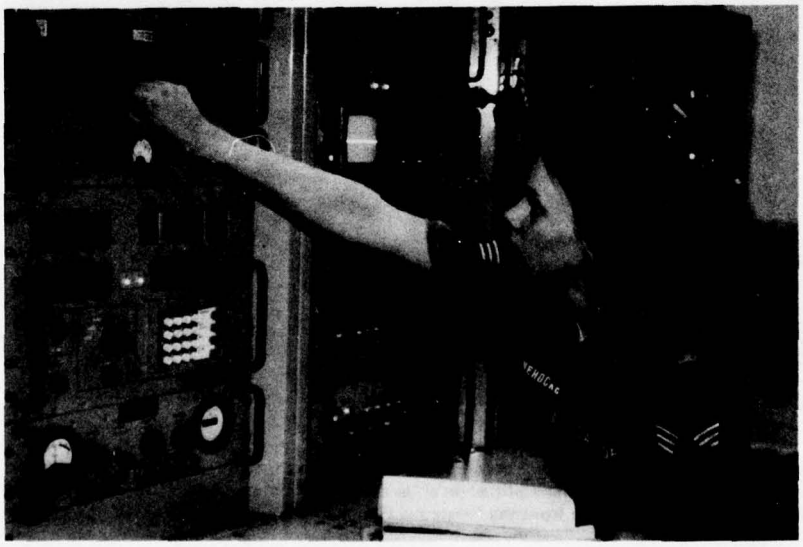
As part of **Research on the Air Force Female Pilot Program**, pilot applicant undergoes test on complex task coordinating abilities on an aircrew psychomotor testing device. The study was conducted by scientists from the Personnel Research Division.

The Air Force inventory includes a vast array of complex and highly technical weapons and delivery systems. The sophistication of these systems, the need to maintain a high level of readiness and the inherent personnel turnover of a voluntary military system demand a high level of technical training and skill upgrading activity. To meet the need for continual training, the Air Force has evolved complementary systems of resident technical schools and formal on-the-job training (OJT).

The Technical Training Division is the division of the Laboratory responsible for research in the areas of technical training, particularly for developing, demonstrating, and evaluating improved methods, media, and systems for technical training. The Division is doing research to determine what training is best accomplished in resident and what training should be done on the job.

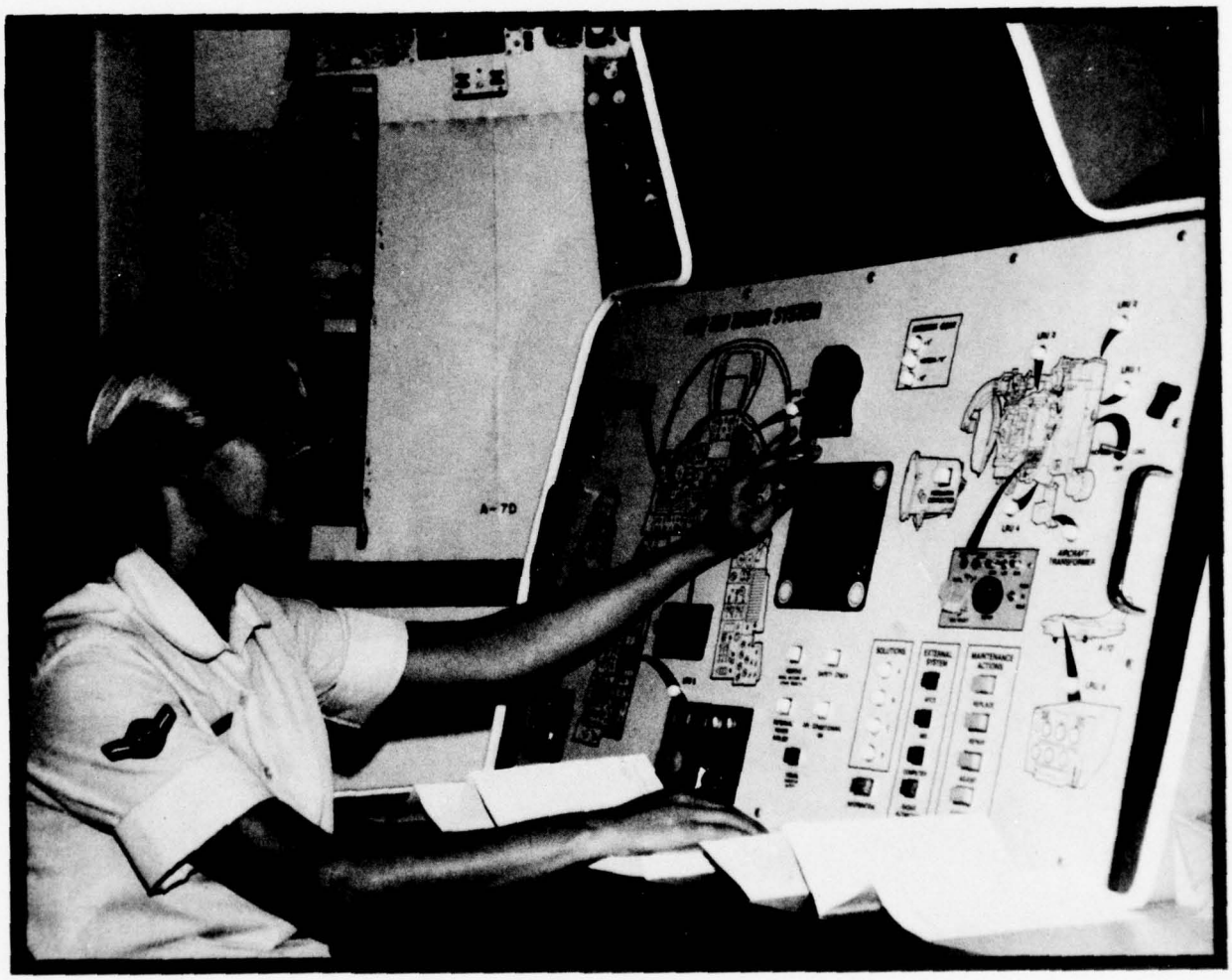
The Technical Training Division has developed an individualized, computer-based, multi-media, Advanced Instructional System (AIS). The system was designed to provide technical training and course management for up to 2,100 students per day in four selected courses at the ATC Lowry Technical Training Center (LTTC) and to provide a research facility for a continuing program on development and test of instructional technology. System development and integrated system test were completed in October 1977, and the instructional portions of AIS for the four technical training courses were transitioned to LTTC at that time. The system demonstrated significant student time saving when compared to conventional methods of training while maintaining and improving quality of graduates.

Continued research in the areas of computer assisted instruction, computer managed instruction, the development of simulators for maintenance training, and the development and evaluation of instructional and management techniques to improve the cost effectiveness of the Air Force OJT system are the major research and development (R&D) thrust of the Division.



Technician trains on the 6883 Maintenance Training System developed by Technical Training Division under civilian contract. The 6883 maintenance simulator provides a broad range of instructional capabilities not present in actual equipment trainers and at lower cost.

TECHNICAL ACHIEVEMENTS



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Title: AFHRL/NTEC Carrier Landing Study

Description: This study was to evaluate a wide versus a narrow field of view (FOV) for projected Navy simulators. The Advanced Simulator for Pilot Training (ASPT) was configured to provide an aircraft carrier in the visual scene; Naval Training Equipment Center (NTEC) data base was adopted. Twenty-one subjects were used. These subjects were first assignment instructor pilots in the T-38 with 500 to 1,200 flying hours. Subjects were divided into three groups: Group A received wide FOV with the circling approach; Group B received narrow FOV with the circling approach; and Group C received narrow FOV with straight-in approach. Each group was given 15 trials. After the first 15 trials, all groups flew the circling approaches and landings under wide FOV conditions. Group B subjects were provided audio or visual stimuli designed to cue them into when they should begin their turn to final approach. The number of trials required to reach a criterion level of performance was recorded and analyzed. Each subject was allotted a 3-hour time block. Simulator features developed by the study are (a) TACAN station located on centerline of deck, (b) two initial conditions, (c) the ASPT moving model feature was incorporated to the "meatball," (d) a simulated aircraft deceleration to a stop, (e) a basic carrier model consisting of 56 objects partitioned into five models and using a total number of 979 edges, (f) a moving model that provides immediate glideslope information critical to a pilot on final (the "meatball"), (g) ship wake, (h) software to control "meatball" position, pilot's view, and eye to hook, and (i) an area of interest indexer was implemented to the console.

Utilization: Psychologists from NTEC have taken the tapes for data analysis. The results will be beneficial in the specification of visual systems for projected Navy simulators. Findings of the study may also identify strategies which can be applied to Air Training Command's Undergraduate Pilot Training (UPT) Instrument Flight Simulator (IFS) for 360° overhead traffic training.

Benefits: This joint effort between AFHRL and NTEC demonstrates how DoD facilities can be utilized for mutual benefits; i.e., the results provided by this study may effect substantial dollar savings in future simulator procurement and may provide information of value to the Air Training Command to better utilize the IFS and increase training effectiveness thereby reducing actual flying time.

Title: Contribution of Motion Training

Description: Two preliminary experimental investigations were conducted to assess the potential training benefits to be derived from the use of a six-degrees-of-freedom platform motion cueing system in terms of pilot performance in the aircraft. The first study investigated the impact of platform motion on the acquisition of basic contact, takeoff, and landing skills by the novice Undergraduate Pilot Training (UPT) student pilot. No significant training benefits were observed in the simulator or aircraft. The second study investigated the training value of the motion pretraining on the acquisition of aerobatic maneuvers in the post-solo UPT student pilot. Again, no significant effect was observed. It was concluded that pretraining with platform motion cues did not produce a significant enhancement of skill learning over the range of contact (visual) tasks investigated.

Impact: The results of these studies and other related research efforts are being studied for potential impact on future design and procurement decisions.

Benefits: If procurement decisions were made on the basis of findings of these studies, several million dollars per installation could be saved. If further use of existing motion systems were discontinued, considerable savings in energy and maintenance costs could be achieved.

Title: Effects of Varying Simulator Visual Display Characteristics

Description: Popular opinion favors the use of color in flight simulator visual displays. It is felt that color improves performance. There are no psychophysical reasons why color should improve performance except for color stereoscopy. In the absence of depth cues, equidistant red and blue objects appear to be at different distances. This phenomenon may

improve depth perception by enhancing perceived texture. There is little research on this question but what there is does not show conclusively that color in a simulator visual display is associated with better flight performance than is black and white. Color may influence user acceptance, however; but popular opinion also favors use of collimation. Users say collimation increases realism and aids depth perception. Accommodation and convergence are effective when the objects viewed are at different distances. Collimation, however, puts all objects the same distance away. Stereopsis depends on binocular vision, but a visual display provides essentially monocular information since it is a single picture (not a different picture for each eye). There is little research available on this question. A study was conducted to compare the effect on student pilot learning and criterion performance of using colored imagery as opposed to black and white imagery in a simulator visual display. Thirty-two Air Force undergraduate student pilots were trained in approach and landing in a simulator. Instructor pilots (IPs) gave the students conventional instruction. The students' performances were rated by the IPs. Training was accomplished with either a black and white or a color display. A second study was conducted to compare display collimation with reduced collimation. Due to physical limitations of the simulator, a smaller CRT was used and only black and white imagery displayed. Thirty-eight IPs were subjects in this study. Each IP flew three practice approaches and landings in the simulator and then flew five approaches and landings on which the performance was rated by a research IP. Half the IPs used a display which was collimated; the other half used a display which had reduced collimation. Analysis of the ratings received by students in the color study reveal no significant difference in learning rates or final performance scores between groups using either black and white or color displays. In the second study, an analysis of ratings received by the IPs on their five criterion trials showed no significant difference between display conditions of collimation and reduced collimation. Power analysis shows that each of these experiments would have detected a practically significant difference, if one existed, with a probability of more than .75.

Impact: This research was not elaborate; however, it addressed problems which have not received much research attention. The results may stimulate more thorough studies and should be of interest to people involved in simulator visual system design, purchase, and use.

Benefit: Collimation and color are complex and expensive components of simulator visual systems. This research provides increased understanding about the contributions of color and collimation to improved use of simulator visual systems.

Title: Simulator Design Configurations – Study II: Motion/g-Seat/Visual Effects and Interactions

Description: The objective of this study was to empirically assess the performance of experienced T-37 pilots in the Advanced Simulator for Pilot Training (ASPT) under varying platform motion, g-seat, field of view (FOV) and ceiling/visibility conditions. A selected group of experienced T-37 instructor pilots flew several contact and instrument maneuvers in the ASPT under these systematically varied simulator configuration and environmental variables, in an attempt to monitor changes in performance due to these variables. The ceiling/visibility variable consistently produced significant effects in the two maneuvers where this variable was manipulated. In the ground controlled approach (GCA) and the overhead pattern, pilots performed poorer when the simulated weather conditions deteriorated. The platform motion variable produced significant effects in three of the five maneuvers: the loop, GCA, and overhead pattern. Generally, pilots performed the maneuvers better without platform motion, as compared in either three of six degrees of freedom (DOF) motion. The FOV variable demonstrated significant effects in the aileron roll, barrel roll, GCA, and overhead pattern maneuvers. Pilot performance tended to be superior under the two largest FOV settings, with the poorest performance accompanying the most restricted FOV condition. The g-seat produced no significant main effects in any of the maneuvers in the study. Subject effects were demonstrated in all of the maneuvers, indicating individual differences in the accomplishment of the maneuvers. Only one interaction demonstrated significance in any of the maneuvers, that being the first order platform motion by ceiling/visibility interaction in the GCA. The analysis of the effect strengths demonstrated a hierarchy in terms of the amount of performance

variability due to each independent variable. Generally, subject effects were the single largest contributor to the performance variability, followed in decreasing order by ceiling/visibility, field of view, platform motion, and finally g-seat. The study results are documented in AFHRL-TR-78-9, *Effects of Platform Motion, Visual and G-Seat Factors Upon Experienced Pilot Performances in the Flight Simulator*.

Impact: The results of this tudy when combined with data from other studies will provide data concerning motion and visual cueing systems which can be used to document simulator specifications.

Benefits: Indirectly, results of this research may enhance flight simulation usage by providing better knowledge of flight simulator requirements. The study also provides a unique tested research methodology for appreciation in future studies.

Title: Surface Attack Training Research – Study I

Description: The purposes of this research were to develop transition and surface attack simulator training programs for novice A-10 pilots and to determine simulator features and capabilities required for effective training in the air-to-surface (A/S) mission. These goals were refined to four specific objectives: development of a transition and surface attack syllabus; generation of objective performance measurement algorithms; determination of design requirements for instructor stations; and, assessment of the utility of advanced instructional features. The approach used four classes of "B" course students who had recently completed Undergraduate Pilot Training (UPT) and fighter lead-in school. Each class received two blocks of instruction on the Advanced Simulator for Pilot Training (ASPT). The first block consisted of 4 to 8 hours of transition training with primary emphasis on traffic pattern work. The second block of training was composed of 2 to 7 hours of A/S weapons delivery (i.e., dive bombing and strafe). The original syllabus was modified for each succeeding class until an "optimum" syllabus evolved. The final syllabus has 4 hours over two sorties in the transition training block and 6 hours over three sorties in the weapons delivery block. Concurrently, the A-10 instructor pilots were observed during the performance of their duties and administered questionnaires. The data collection methods identified deficiencies in the design and operation of the ASPT instructor station for A-10 training and obtained recommendations for additional controls and displays required to enhance instructional effectiveness.

Impact: In addition to increasing flight safety and ease of instruction on the weapons range, it was found the simulator training provided an excellent medium for training UPT graduates to transition to the A-10 aircraft; improved initial bomb delivery performance on the actual weapons range by nearly 50 percent; and provided nearly perfect transfer of training for the initial phases of weapons delivery training. In the early phases of A/S training, one simulator mission can effectively replace one aircraft mission. This allows actual flying time to be transferred to other phases of training.

Benefits: Applications of this research effort will significantly improve cost and training effectiveness of tactical A/S weapons delivery training in addition to extending methods for utilizing flight simulators beyond the UPT training environment. By substituting simulator training for aircraft training, it is estimated that this program will save the Air Force 2.6 million dollars through October 1978.

FORCE STRUCTURE AND UTILIZATION

Title: Criterion Development

Description: A series of related studies directed toward development of an economical system for the evaluation of job performance for use in the validation of selection and classification measures has been accomplished. Alternate approaches to the investigation included development of paper-and-pencil tests of job knowledge, evaluation of differences in rater accuracy, and the impact of differential factor content on the validity of ratings rendered. These studies demonstrated that paper-and-pencil tests can be used to differentiate between skill levels within a career field and that the content

of factors is much less important than the understanding of the rater of the desired outcomes of the ratings. Demonstrated differences in rating accuracy may be amenable to reduction through training; current efforts are addressing this point.

Impact/Utilization: Positive results from these studies suggest that a systematic evaluation of the efficiency of Air Force selection and classification devices may be possible. Immediate utilization of these findings lies in our current effort towards development of a comprehensive civilian appraisal system.

Benefits: If it is found feasible to apply the discovered techniques across the board, the Air Force will have the capability to demonstrate job relevance of selection and classification measures. Application of these techniques to civilian appraisal will insure an evaluation system at the state-of-the-art in compliance with current statutes.

Title: Development and Validation of Measures to Assess the Correlates of Successful Performance in the 81XXX Career Field

Description: The purposes of this research were to (a) select and/or develop screening methodologies to measure the personal, pshycological, attitudinal, and motivational correlates of successful performance in the 81XXX career field; (b) field test and evaluate methodologies on a representative sample of 81XXX accessions; and (c) assess the effectiveness of the screening techniques and furnish recommendations for improving the quality of the security police force. Results are reported in AFHRL-TR-77-38, *Preliminary Development and Validation of a Screening Technique for Entry into the Security Police Career Field*, and AFHRL-TR-77-79, *Screening for Entry into the Security Police Career Field*. This research effort was initiated as a result of a Request for Personnel Research (RPR 74-14) from the Air Force Security Police Directorate.

Impact/Utilization: The 81XXX career field comprises about 35,000 persons, approximately 6 percent of the total enlisted force, has had an unacceptable number of first-term airmen who become noneffective and who subsequently either are retrained or separated from the Air Force. This is a substantial loss of money and manpower resources which might be minimized through a more refined selection and classification system. The results of this research effort form the basis for selecting those personnel who have the maximum likelihood of becoming successful security policemen. Due to the decrease in attrition in recent months, this screening methodology is being held in abeyance at present. However, if an increase in attrition should occur, operational use of a selection composite developed from this research project would be considered.

Benefits: Costs associated with retraining and separation of personnel who are noneffective security policemen could be reduced by identifying those not likely to succeed in this career field. Additionally, there are intangible savings associated with having a security police force composed of maximally effective personnel to insure operational readiness.

Title: Development of an Organizational Assessment Package (OAP)

Description: This research involved the development of an Organizational Assessment Package (OAP) for use by the Air Force Leadership and Management Development Center (LMDC) in identifying organizational problem areas. The OAP was developed on a contingency model of organizational effectiveness which considered organizational effectiveness to be a function of the manager, the situational environment, and the criteria of success. Results are reported in AFHRL-TR-78-93, *Organizational Survey Assessment Package for Air Force Organizations*, and AFHRL-TR-79-10, *Situational Factors Identification in Air Force Organizations*.

Impact/Utilization: The OAP is used by LMDC travel team members as their prime instrument to guide their organizational intervention program. OAPs are administered to work groups at installations throughout the Air Force, work group effectiveness factor indices are generated for each work group, problem areas are identified, and action is taken to deal with problems identified by LMDC consultants. The OAP became LMDC's operational instrument in September 1978.

Benefits: LMDC has reported that at least three other surveys that were to be developed by other agencies

were cancelled and the OAP used instead. LMDC travel team members report that their problem identification function and overall efficiency has been vastly improved by using the OAP. A data base developed from data collected on the OAP has provided LMDC with normative data which provides a means of comparing different groups (for example, different bases or commands and different Air Force Specialty Codes) and a given group with an Air Force or command norm. The OAP provides a means of testing the effectiveness of various intervention strategies used by LMDC travel teams.

Title: Development of Communications Security (COMSEC) Questionnaire and Evaluation of the Effectiveness of the COMSEC Program

Description: This project called for the development of a questionnaire covering the major aspects of the program. The Communications Security (COMSEC) questionnaire was administered to a random sample of military personnel in 12 major air commands. The major objective of this questionnaire was to obtain data which would allow COMSEC officers to ascertain the current level of knowledge concerning the major aspects of the COMSEC program. Such information serves not only as an assessment of training effectiveness but as a tool to identify training areas that require increased emphasis. Distributional analyses of survey results were provided to the user to pinpoint areas of training deficiency and allow for comparisons by major air commands of training effectiveness. This research effort was initiated in response to a Request for Personnel Research (RPR 75-40) from Air Force Communications Security Center.

Impact/Utilization: On a periodic basis, all USAF personnel are required to receive COMSEC training. Twenty-eight COMSEC officers and major commands and separate operating agencies are designated as the focal points within their organizations to administer the program. Through various media, they try to keep both military and civilian personnel aware of the program objectives and the necessity of being alert in order to avoid possible security violations and the compromise of classified material. A survey to ascertain the degree of COMSEC awareness and the effectiveness of current training programs provide essential information for program managers in planning future COMSEC programs and training emphasis.

Benefits: The expected benefits are (a) to increase individual awareness of the COMSEC program, thereby preventing the occurrence of security violations and subsequently strengthening overall national security, and (b) to create a gauge of COMSEC program effectiveness which identifies specific areas of training weakness that require additional attention.

Title: Development of Occupational Attitude Inventory and Prediction of Career Decisions

Description: Recent management and research efforts to improve the quality of working life for enlisted personnel have been constrained by the lack of standardized measurement techniques. The effectiveness of specific programs and policy changes are difficult to assess without well-designed survey instrumentation. Results of different types of intervention cannot be compared directly without some common basis for evaluation. The ultimate impact of these changes on career decisions and tenure cannot be forecast without the use of a validated assessment battery. In response to this problem, AFHRL initiated efforts (a) to identify relevant aspects of the Air Force working environment, (b) to develop appropriate survey measurements, and (c) to provide baseline comparative data for various groups of interest (career/non-career, major commands, etc.). This work resulted in the Air Force Occupational Attitude Inventory (OAI), a multidimensional assessment device for operational use in the field. The instrument was developed on the basis of a comprehensive review of research and practice in the job satisfaction domain. Items and factors contained in the prototype inventory were refined by statistical and judgmental criteria to include the broadest possible representation of relevant job aspects. Follow-up validation of the inventory with regard to "hard" criteria (personnel attrition and retention) is in progress.

Impact/Utilization: The OAI item pool served as a basis for developing survey-directed feedback techniques now in use by the Leadership and Management Development Center (LMDC) and other Air Force organizations in their analysis of the 81XXX career field. The Army Research Institute has used the instrument with slight modifications since 1976 as part of a comprehensive job analysis program. Similar use by the U.S. Civil Service Commission has been documented.

Benefits: Improvement of job satisfaction levels in the enlisted force is expected to have positive benefits in terms of job performance, reduction of adverse actions, and enhanced career potential.

Title: Impact Analysis for the 1977 Reevaluation of the Weighted Airman Promotion System (WAPS)

Description: A policy-capturing study dealing with the reevaluation of the Weighted Airman Promotion System (WAPS) was carried out in the spring of 1977 and documented in AFHRL-TR-77-80, *Revalidation of Factors Comprising E-5 Through E-7 Weighted Airman Promotion System (WAPS)*. A subsequent study during Fiscal Year 1978 addressed the following objectives: (a) to compare the promotion outcomes of the current Weighted Airman Promotion System (WAPS) versus two selected experimental systems to determine the impact on women, minorities, time in service, and time in grade, (b) using representative Air Force Specialty Codes (AFSCs) which contain both flying and nonflying personnel, to compare the current WAPS using total decorations score versus the current WAPS using decorations-in-grade score with regard to promotion outcomes, and (c) using representative Air Force Specialty Codes (AFSCs) which require no Specialty Knowledge Test (SKT), to compare promotion outcomes of the current WAPS (minus the SKT factor) versus two other systems with regard to the impact on women, minorities, time in service, and time in grade. The results of this second study are described in a March 1978 AFHRL staff report.

Impact/Utilization: The WAPS was developed by AFHRL in 1968 to provide a computerized promotion system that was both equitable and visible to airmen. Since the implementation of WAPS in 1970, airmen in grades E-4 through E-7 have been selected for promotion based on their mathematically weighted composite promotion scores consisting of six promotion selection factors. The weights and factors have been periodically reevaluated by AFHRL and the research outcomes used to recommend any improvements to the existing WAPS. The results of the analysis will assure AF managers that no proposed modifications to WAPS will have an adverse effect upon women or minorities.

Benefits: The results of the impact analysis reported here contributes to the overall improvement and effectiveness of the current WAPS. The benefits of WAPS are in turn more objectivity in promotion selections, better understanding and acceptance of the system by airmen, higher morale, increased efficiency, and increased quality of selectees.

Title: Research on the Air Force Female Pilot Program

Description: At the outset of the female pilot training program, there were many unanswered questions and concerns regarding the applicability of selection procedures for women applicants, and the performance of women in training environment developed and refined for a male population in a traditionally male role in the Air Force. At the request of HQ USAF/DPPT, research was undertaken to:

1. Establish a data base from female Undergraduate Pilot Training (UPT) selectees composed of measures found to be predictive of UPT performance for men.

2. Compare these data with those previously obtained from male subjects for overall performance and for predictive efficiency with regard to UPT training outcome; and

3. Monitor the flying performance of women as judged by their instructors, supervisors, and themselves in comparison to both official Air Force flight standards and relative male performance.

The initial findings from this research are reported in AFHRL-TR-78-67, *Air Force Female Pilot Program: Initial Performance and Attitudes*.

Impact/Utilization: Results from this study have been briefed and used in making management and policy decisions regarding the female pilot program. Based, in part on these results, decisions were made to undertake a gradual expansion and normalization of the female pilot program, while continuing to monitor and assess the performance of women entering pilot training.

Benefits: The major benefits resulting from this research included establishing a comparative performance data base from females on flight-related characteristics, providing empirical information useful in the decision making process regarding the training

and utilization of female pilots, and providing objective support for the Air Force commitment to equal opportunity and treatment for its personnel of both sexes.

Title: Self-Instructional Laboratory R&D Management Course, 1978 Revision

Description: At the request of Headquarters, Air Force Systems Command (AFSC/DL) and in cooperation with many laboratories and staff agencies, AFHRL has updated and expanded the handbook previously developed for use by new/or inexperienced scientists and engineers in the management of 6.1, 6.2, and 6.3 research and development (R&D) contracts. The handbook covers planning and presolicitation activities, solicitation and award, and post-award management. A new chapter on advanced development management methods has been added, and the use of progress and self-test questions has been continued to maintain the self-instructional capability for mastering the handbook material.

Impact/Utilization: The course will be implemented by many of the AFSC laboratories, as the basis for a supplement to the training of personnel responsible for contract management.

Benefits: Potential savings are of two types: (a) the reduced cost of providing the training via the self-instructional course at the duty station rather than by a conventional course at one site and (b) the benefits which result from the improved training. The first cost avoidance has been estimated by HQ AFSC/DL at 200 thousand dollars per year. Benefits of the improved training will be impossible to validate, but it should be noted that, in the past, significant inefficiencies in the initiation and management of R&D contracts have been noticed. Considering that the course is applicable to R&D contracts worth over 230 million dollars per year, an improvement of even 1 percent would produce a savings of 2.3 million dollars per year.

PERSONNEL AND TRAINING FACTORS IN ADVANCED SYSTEMS

Title: Demonstration of Human Resources/Design Option Decision Tree Methodology

Description: A demonstration of a methodology for predicting the impact that various design alternatives have upon the manpower, training and cost requirements associated with modern weapon systems has been performed. This methodology allows the introduction of human resources data into the weapon system design process at the earliest stages via a process which structures the various design trade offs performed during weapon system design.

Impact/Utilization: These research results will be used to enhance and improve the methodology and to eventually promote the methodology into a tool that can be routinely used by weapon system designers to address human factors information during the earliest stages of weapon system design. The application of this methodology results in lower support and operational costs for weapon system. The Air Force Flight Dynamics Laboratory has used and will continue to use the methodology and the results thereof to support their cockpit design studies.

Benefits: It has been determined that the cost of ownership accounts for up to 80% of weapon system life cycle costs (C-130 data). It has been estimated that the human resources account for over half of the ownership costs. This methodology allows human resource factors to be included in the early design of systems and equipment.

Title: F-16 Technical Order Content and Cost Analysis

Description: At the request of the F-16 System Program Office (SPO), AFHRL performed a content and cost analysis of the technical order requirements for the F-16 production aircraft. The 4-month effort was completed in September 1978. The purpose of the effort was to provide "baseline" or "should cost" information to F-16 SPO procurement personnel for

use in contract negotiations. The products delivered to the F-16 SPO include: algorithms for predicting content and cost of technical orders for organizational, intermediate, and depot maintenance and estimated costs for these three types of technical orders for the F-16.

Impact/Utilization: The results are being used by procurement personnel in the F-16 SPO during contract negotiations for purchase of production aircraft technical orders. The algorithms also have applicability to other efforts to determine the content and cost of technical orders for new or modified aircraft systems.

Benefits: Dollar savings to the F-16 SPO will range between 10 and 20 million dollars. This savings will result because it is expected that the negotiated price for the production aircraft technical orders will be an amount between the original contractor's price and the much lower AFHRL "baseline" cost.

Title: **Life Cycle Cost Impact Modeling System (LCCIM)**

Description: A computerized system of three models and associated data banks for analyzing the impact of design on weapon system support requirements and life cycle cost (LCC) to aid design decisions and support planning throughout the system development/modification process. Its ability to use data available in the conceptual stage of the systems acquisition process and rapidly analyze interactions to provide quantitative impact estimates makes it a powerful tool to reduce system ownership cost. Developed in support of the Digital Avionics Information System (DAIS) Advanced Development Program, the LCCIM has been used to analyze the potential impact of the DAIS concept of avionics integration on weapon system support personnel requirements and LCC. The component models of the LCCIM may be operated either independently or interactively. Independently, they provide separate capabilities for reliability and maintainability analysis, training requirements analysis, and system ownership cost analysis. Interactively, they provide a capability to reduce the amount of user generated input required for its LCC analysis operation. That capability serves to distinguish the LCCIM from other models and to make it an effective means for a fuller consideration of the consequences of ownership as guidelines in system design and support planning.

Impact/Utilization: Applied within the Digital Avionics Information System (DAIS) Advanced Development Program.

Benefits: The LCCIM is a powerful tool for reducing the cost of weapon system ownership. Its use within Air Force systems acquisition/modification/retrofit programs can aid in anticipating and avoiding unnecessary system ownership cost by providing information concerning the system ownership consequences (impacts) of design/support alternatives. The LCCIM is particularly effective in estimating the implications of design and support planning on system operation and support (O&S) requirements: the aspect of system ownership which accounts for up to 80 percent of system LCC.

Title: Ostrofsky Procedure for Including Human Resources and Logistics Factors in System Design

Description: A structured, analytical decision process for including human resource and logistic factors in the design of systems, sub-systems, and equipment was developed by Professor Ostrofsky, University of Houston. This procedure was adapted to Air Force design requirements under sponsorship of AFHRL and the Air Force Office of Scientific Research (AFOSR). The major steps include determination of the functions to be performed by the equipment; identification of alternate, candidate designs which accomplish the functions; establishing evaluation parameters; evaluating the candidate designs; and ordinal ranking of the candidate designs for final selection of the optimum configuration. Precise mathematical formulations and computer programs are available to aid in the evaluation of candidate designs.

Impact/Utilization: A successful application of the method to design of the F-16 emergency power unit service stand was completed in September 78 in coordination with the contractor and the F-16 System Program Office. Further application of the methodology is continuing on development of the maintenance concept for the operational control center for the MX missile. Space and Missile Systems Organization (SAMSO), AFOSR, and AFHRL will

contribute jointly to funding and technical monitoring of this effort.

Benefits: The ability of weapon system planners and designers to consider human resources and logistics factors during system acquisition has been greatly enhanced. More complete design and planning decisions can now be made. The benefits are in terms of reduced system ownership costs, improved maintainability of equipment, improved safety during equipment use, and enhanced operational readiness.

Title: The Impact of Advanced Maintenance Data and Task Oriented Training Technologies on Maintenance, Personnel, and Training Systems

Description: At the request of DoD, a White Paper with the above title was written by Dr. John P. Foley, Jr., of the Advanced Systems Division. This paper considers the impact of advanced technical data and task-oriented training (TOT) on maintenance, personnel, and training systems. Technologies considered as advanced maintenance data concepts were those for which hard research data were available; namely, fully proceduralized job performance aids (FPJPAs), FORECAST aids, enriched logic tree troubleshooting aids (LTTAs), and the Air Force version of symbolic integrated maintenance system (SIMS). To maximize the effectiveness of these advance concepts, the training and personnel systems must be modified. A model is presented which describes reducing first enlistment training while improving first enlistment performance. This is based on the use of the advanced maintenance data concepts, TOT, and a modified personnel system. The model provides advanced system training after the technician has made the decision to re-enlist. Problems likely to be encountered in implementing the model are discussed, and recommendations are given. The White Paper is summarized in AFHRL-TR-78-24, *Executive Summary Concerning the Impact of Advanced Maintenance Data and Task Oriented Training Technologies on Maintenance, Personnel, and Training Systems.*

Utilization: The White Paper will influence technical data, personnel, and training decisions at DoD and all of the military services. Long-range planning and research will reflect various ideas expressed in the White Paper as the research community attempts to reduce training time while improving maintenance performance and personnel retention.

Benefits: Full implementation of the model would reduce training time and costs for first enlistment technicians, while improving their maintenance performance. Re-enlistees would receive advanced training, which, when combined with advanced maintenance data would reduce errors, resulting in less costly, more efficient maintenance.

PERSONNEL SELECTION AND RETENTION

Title: Addition of Vocational Interest Data To Enlisted Classification

Description: The Vocational Interest-Career Examination (VOICE) is an occupational activities preference inventory designed for use in the classification and assignment of Air Force enlisted personnel. It is intended to refine the job placement process through the addition of an interest component to the currently used aptitude variables. After initial development of the instrument, homogeneous factor-referenced scales as well as scales based on satisfaction outcomes in 20 DoD occupational clusters were developed. Preliminary validation of the VOICE was accomplished using a criterion of expressed job satisfaction with their assigned specialty. Validation studies continue using criteria of attrition, retention, long-term satisfaction with job assignment, and work productivity. To facilitate use of VOICE in an operational environment, the contract development of a computerized system for administration of the inventory is now in progress. VOICE is documented in the following technical reports: AFHRL-TR-73-28, *Development and Validity of a Vocational and Occupational Interest Inventory*; AFHRL-TR-76-88, *Development of Factor-Referenced Subscales for the Vocational Interest-Career Examination*; AFHRL-TR-76-89, *Relationships Between Performance on the Vocational Interest-Career Examination and*

Reported Job Satisfaction; AFHRL-TR-77-69, *Vocational Interest-Career Examination: Norming and Standardization on a Nationwide High School Sample*; and AFHRL-TR-78-62, *Vocational Interest-Career Examination: Use and Application in Counseling and Job Placement*.

Impact/Utilization: The primary utility of VOICE is in the refinement and improvement of job placement decisions with incoming enlisted accessions. VOICE has been demonstrated to enhance the prediction of satisfaction significantly in 87 percent of all Air Force assignments. Placing recruits in a job assignment that coincides with their expressed interest should aid also in reducing involuntary separations due to job dissatisfaction as well as enhancing career motivation, job productivity, and personnel retainability.

Benefits: If the relationship between job satisfaction and reduced turnover are realized, the use of VOICE in enlisted classification should reduce recruiting requirements in the years ahead as retention improves in all specialties. It is further believed that individuals who are satisfied with their occupational assignments are more likely to be effective on the job than those otherwise assigned.

Title: Demonstration of Adaptive Testing Technology

Description: The advantages of adapting or tailoring a test to the abilities of an applicant have been sought throughout the history of aptitude testing. A computer based adaptive testing sytem has been demonstrated at the San Antonio Armed Forces Entrance and Examining Station (AFEES). The system operated by estimating the applicant's ability, selecting the most appropriate item, administering and scoring it and then repeating the cycle, with easier or harder items as required, until a stable estimate of ability was reached. No two subjects necessarily received the same numbers of items or the same groups of items. The system automatically progressed to different subject areas. It was determined that stable ability estimates could usually be reached with half the items required with conventional paper-and-pencil testing.

Utilization: Adaptive testing systems will be used by USAF Recruiting and the Military Enlistment Processing Command (MEPCOM).

Benefits: Adaptive testing produces a systematic approach to measuring applicants' ability with greater accuracy and with greater security of testing materials than with conventional paper and pencil testing. It will eliminate scoring errors and errors due to improper administration of tests. Test compromise will be enliminated. No individual will be able to forecast the subset of items that will be administered to an applicant. The system will increase the accuracy of the selection-classification decision making process.

Title: Development and Validation of the Air Force Dental Laboratory Specialist Screening Battery

Description: The Air Force makes a considerable investment in selecting personnel for technical training. The primary goal of the operational testing program is to maximize the return on training expenses by selecting those who will be successful in a training program. The objective of this research was to develop a valid replacement for the costly and unreliable Chalk Carving Test that was used to select candidates for the Dental Laboratory Specialist technical field. Data analyzed from the administration of experimental perceptual and dexterity tests to a large sample of prospective dental laboratory students revealed that use of a composite of four of the perceptual tests, rather than the Chalk Carving Test, would substantially improve the ability to identify successful dental trainees.

Utilization: The Air Force Dental Aptitude Test (AFDAT) is fully operational and in use by the Air Force Recruiting Service and the Air Training Command.

Benefits: Use of the Air Force Dental Aptitude Test improves the ability to identify potentially successful candidates for the Dental Laboratory Specialist Course. Training Cost savings will be achieved through a lower course attrition rate with additional benefits of decreased test administration and scoring time and lower test material costs.

Title: Development and Validation of the Armed Services Vocational Aptitude Battery (ASVAB)

Description: This continuing program provides the Air Force with efficient and effective instruments for

the selection and assignment of airmen. In response to the need for a joint-services test, the Armed Services Vocational Aptitude Battery (ASVAB) has been extensively modified and expanded to provide a single battery which can be effectively utilized by all armed service. AFHRL continues to serve as the lead laboratory in this effort. Validation data on current ASVAB subtests and composites have been analysed for 43 Air Force technical training course clusters. Data on 35 of these, many of which included separate sex and race validities were sent to the Deputy Assistant Secretary of Defense (DASD MPP) on 21 October 1977 to assist the Secretary of Defense (OSD) General Counsel in reviewing legal defensibility of the tests. The data generally indicated useful validities across sex and race subgroups. Preliminary versions of new ASVAB forms (to be designated 8, 9, and 10) have been developed and normed. This work is summarized in AFHRL-TR-77-19, *Development of the Armed Services Vocational Aptitude Battery*.

Impact/Utilization: ASVAB will be revised periodically in accordance with Air Force Regulations 33–6 and 35–8. Emphasis continues to be directed toward making selection more effective. The ASVAB is used by the USAF Recruiting Service and all major commands. Also, the ASVAB is used in a joint service high school testing program and is the selection and classification instrument used by all armed services.

Benefits: Through the use of the ASVAB, the Air Force has been able to select and effectively utilize a quality enlisted force. Although there is no direct method to compute the total dollar impact of the ASVAB in terms of reduced training attrition and in increased operational effectiveness, if one assumes that the increased efficiency in the force management yields a modest increase in productivity of only 5 percent, the annual gain is the equivalent of about 5,000 man-years, which would change into a dollar value of approximately 30 million dollars.

Title: Development of a Methodology to Assess Psychological Stress and Its Impact in the Air Combat Environment

Description: As a result of a request from the Tactical Air Command (TAC), a joint effort evolved between (AFHRL/PEM) and the USAF School of Aerospace Medicine (USAFSAM/VNE) to develop a methodology to (a) identify which aspects of a combat fighter mission produce the psychological experience of stress, (b) assess the level of stress generated by various aspects of a fighter mission, and (c) evaluate the impact of stress on performance in air combat.

A methodology was developed and a trial administration was conducted using subjects having extensive Southeast Asia combat experience. Based on the results of the trial administration, it would appear that the methodology is valid and capable of identifying empirical relationships between psychological stress and performance in air combat. (AFHRL-TR-78-3, *Methodology to Assess Psychological Stress and Its Impact in the Air Combat Environment*.)

Impact/Utilization: Empirical evidence generated by this methodology should be of use to operational managers and strategists, within the training environment, and within the selection and classification system for rated personnel. Increased knowledge of the stress associated with fighter missions and of the stress management of fighter pilots will allow more precision in estimating personnel requirements and in maximizing the effective utilization of combat aircrew resources. Additionally, in combination with other on-going research efforts, it is possible that a stress management factor might be introduced into the pilot screening program, either at the point of initial selection, or at differentiation into cockpit assignments. Finally a spin-off benefit is the generation of a data base relevant to the maximum number of fighter missions that a single pilot could effectively fly against heavily defended targets in a 2-week period. This information is important with regards to "sortie surge" maximums. Efforts are underway to extend the application of this methodology to a data base with combat experienced personnel and to establish a complementary data base from the simulated combat environment.

Benefits: The focus of this project was towards enhancing the selection, training, and management of combat aircrew resources, thereby increasing the operational readiness of the Air Force.

Title: Revision and Standardization of the Air Force Officer Qualifying Test (AFOQT)

Description: Form N of the Air Force Officer Qualifying Test (AFOQT) has been developed, standardized, and validated for use in officer procurement and flight training selection programs. The reference group for score interpretation had not been updated since 1960 and full validation of the subtest scores used for flying training programs had not been accomplished since 1969. Further, admission of females to traditional male career areas, including pilot and navigator specialties, and the emphasis on equal treatment of females and males mandated the removal of sexist orientation in AFOQT subtests and composite scores. Several new scales were developed for the Navigator/Technical Composite and their development and validation is described in AFHRL-TR-77-36, *Navigator-Observer Selection Research: Development of New Air Force Officer Qualifying Test Navigator–Technical Composite*. Scale development and validation of the Pilot composite is documented in AFHRL-TR-78-33, *Pilot Selection System Development*. Development of the remaining portions of the AFOQT battery is documented in AFHRL-TR-78-43, *Air Force Officer Qualifying Test Form N: Development and Standardization*. Standardization of Form N changed the reference group for score interpretation from the Air Force Academy (AFA) class of 1964 to a representative sample from all major sources for Air Force commissioning programs; the sample was selected from airmen, Air Force Reserve Officer Training Corps (AFROTC), Officer Training School (OTS), AFA cadets, and junior officers.

Impact/Utilization: The AFOQT, Form N was implemented in April 1978, for use in selecting all candidates for AFROTC and OTS programs, and in all flying training programs except for AFA candidates.

Benefits: Validation data demonstrate that attrition, and hence cost per graduate, would increase in AFROTC, OTS, and flying training if candidates for these programs were selected without the use of aptitude scores in the areas measured by the AFOQT. The extensive modifications made in Form N should reduce attrition rates over those that could be expected by using previous versions of the AFOQT. Extensive turbulence in each of the training programs cited and the absence of base attrition rates if the AFOQT was not used at all prevent establishement of specific dollar savings. Removal of sexist orientation of the AFOQT and establishment of current validities of the composites should avoid workhours and dollar expenditures associated with test bias charges and litigation now being made against other selection instruments.

SIMULATION TECHNOLOGY FOR TRAINING

Title: Advanced CIG Techniques Evaluation System (ACTES)

Description: Among the most significant problems in computer image generation (CIG) is development of suitable technique/algorithms, together with suitable rendition of natural and cultural features in the data base to enable simulation fidelity for a wide range of applications. These applications include takeoff, landing, air-to-air refueling, low-level terrain avoidance, target identification, and bomb damage assessment. Real-time systems are complex, expensive, and cannot readily be configured with the flexibility necessary to perform the detailed investigations required in conjunction with the foregoing applications. The alternative is a strictly software simulation which, while representing the best in flexibility, is slow and generally limited to static presentation. This would not be acceptable for providing the validation of techniques which must be performed under dynamic real-time conditions.

Hence, the Laboratory initiated a program to develop a CIG system that would provide flexibility, together with sufficient rapidity of simulation update, to enable dynamic scene generation in a time effective manner.

The system design is based upon use of general purpose computation for slower, complex operations while relegating the simple, more repetitive computations to special purpose hardware. This resulted in a system with minimal compromise in flexibility, since the data base and most algorithms

are still under software control. This video disc was provided for recording up to 600 successive scenes; this can be transferred in total to tape, and the tape in turn can accumulate sufficient scense for up to 1 hour of real-time video. Playback results in a presentation that is real time and based upon aircraft dynamics as entered into the simulation. Results of the program are documented in AFHRL-TR-78-41, *Airborne Electro-Optical Sensor Simulation System*, which describes the general system configuration and capability.

Utilization: The research using the system will be performed to determine cues relevant to performing the wide image of tasks encompassing both visual and sensor simulation. This research impacts data base fidelity and algorithm development. It includes an assessment of the impact of improvements within the context of current systems, as well as the impact of new CIG concepts upon simulation fidelity. The research results will be germane to the development of future generation CIG systems designed for both visual and sensor simulation. It is expected that both Aeronautical Systems Division and industry will be able to utilize the research results.

Benefits: It is expected that research results will enable an assessment of potential training value resulting from improvements in current technology, as well as new concept development. It is expected that this should lead to an increased training effectiveness through incorporation of concepts/algorithms, and data bases optimized for training value.

Title: Advanced Low Cost g-Cueing System (ALCOGS)

Description: The first g-seat developed for an Air Force flight simulator was in the Advanced Simulator for Undergraduate Pilot Training (ASUPT), Project 1192. This pneumatically controlled seat was developed to enhance the motion simulation by providing a sustained acceleration cue to the simulator pilot. This seat and five more, which were developed in the early 1970s for the Air Force, demonstrated much promise in enhancing flying training. Recognizing the potential of the g-seat, as well as the g-suit and seat shaker, AFHRL awarded a contract in 1976 to develop an advanced g-cueing system. In order to match the high performance environment of the tactical aircraft simulators, a more responsive g-cueing system had to be developed. The ALCOGS represents the second generation of g-cueing technology. The hydraulic servos provide a ten-fold increase in bandwidth over the original pneumatically driven g-seats. This increased bandwidth makes the seat much more responsive to commands and, as a result, makes the ALCOGS the most advanced g-cueing system ever developed. Used in a program of motion simulation engineering research, the ALCOGS is the only viable research tool in the Air Force for investigating the role of g-cueing in tactical aircraft (A-10, F-15, F-16) simulators. This role includes utilization of the g-seat as an onset acceleration cueing device, as well as a sustained acceleration cueing device. The ALCOGS development is documented in AFHRL-TR-78-73, *Motion and Force Cueing Requirements and Techniques for Advanced Tactical Aircraft Simulation*. Algorithm development is currently in progress. The first phase of this research includes psychophysical studies which should be completed in early 1979. Algorithm selection and refinement will follow through 1979 and will be documented in 1980 in an AFHRL technical report.

Utilization: ALCOGS technology is already being utilized by several simulator manufacturers who have copied the ALCOGS approach in the design of their own g-cueing systems. The Air Force is also utilizing ALCOGS hardware technology. The g-suits and seat shakers for the 16 F-4E simulator retrofit packages will be ALCOGS suits and shakers. ALCOGS software results are expected to be implemented in other g-cueing systems by 1980. ALCOGS algorithm development results will be used in future Air Force procured seat g-cueing systems, as well as in the modification and improvement of seat g-cueing systems currently being procured or in operational simulators.

Benefits: ALCOGS offers the Air Force its only test bed for g-cueing motion simulation R&D for tactical aircraft simulation. Because of its wide bandwidth, the ALCOGS is the only viable research tool for investigating the role of g-cueing in advanced tactical aircraft simulators. The compact packaging of the g-seat makes it possible to install the seat pan and backrest modules into almost any fighter/attack or training seat. The principal benefit of ALCOGS technology will be increased training effectiveness which should enhance operational effectiveness and readiness.

Title: ASPT Aerial Refueling Visual Simulation-Engineering Development

Description: The objective of this project was to expand the Advanced Simulator for Pilot Training (ASPT) capability to include receiver aerial refueling simulation with associated performance measurement techniques. This capability was requested by the Simulator System Program Office (SIMSPO) at the AFSC Aeronautical Systems Division (ASD/SD24) who is responsible for providing MAJCOMs simulator equipment required to meet operational training requirements for forthcoming simulators including the receiver aerial refueling task. The inherent flexibility of the ASPT could best provide the numerous experimental conditions required for analysis of the behavioral impact on pilot performance of such variables as field of view (FOV), tanker image detail, and day/night systems. A list of the necessary additional ASPT system operational capabilities was constructed based on the receiver aerial refueling mission scenario, behavioral research, and SIMSPO requirements. SIMSPO requirements necessitated the generation of one-window configurations for replicating the A-10 and B-52 simulator FOVs and three-window configurations for the A-7/F-4 and F/FB-111 simulator FOVs. The existing variable/slewable FOV software provides for any size single-window FOV. To generate multi-window FOVs, this program had to be modified and special data base hoods generated in order to mask undesired portions of the wide angle FOV ASPT display. Since Tactical Air Command (TAC) and Strategic Air Command (SAC) pilots current in the aforementioned aircraft were to be used as subjects in the study, minor adjustments were made to the ASPT T-37 flight dynamics in an attempt to approximate the simulated aircraft handling qualities. This was accomplished by adjusting the thrust, drag, engine response time, and gross weight factors. A dynamic graphics display was programmed to facilitate the console operators. This project is documented in AFHRL-TR-78-51, *Advanced Simulator for Pilot Training (ASPT): Aerial Refueling Visual Simulation–Engineering Development*.

Utilization: The engineering modification of the ASPT resulting in the additional capability to perform receiver aerial refueling simulation will be utilized in a number of ways. One research study has been performed addressing FOV and tanker image detail requirements; a second phase of this study is scheduled. It is also anticipated that the capability will be utilized in the training/research programs for the A-10 and F-16 aircraft.

Benefits: Study conclusions may be effectively utilized in specifications to future flight simulators having the potential of resulting in considerable dollar savings, reduced training time, enhanced operational readiness, and increased capabilities and training effectiveness.

Title: Advanced Simulator for Pilot Training (ASPT) Computer Update

Description: The Advanced Simulator for Pilot Training (ASPT) system was delivered with a single SEL 86 Computer to perform flight and motion cueing simulation and performance measurement on two T-37B cockpits. The iteration rate of this system resulted in a lack of confidence in motion research results. Improvement of the simulation fidelity required additional computer power. The single SEL 86 was replaced by three SEL 32/55 central processing units. This required a complete restructuring of the Advanced Simulator for Pilot Training (ASPT) software to provide functionally separated 30 Hz aircraft simulation, doubling the basic iteration rate of the system. Each cockpit is independently controllable, permitting simultaneous simulation of two aircraft with completely different flight and performance characteristics. ASPT is currently being used to simulate both the T-37B and the A-10A aircraft. The faster iteration rate will permit simulation of high performance aircraft such as the F-16. Sufficient computer capability exists in the new system to permit on-line software development via text editor terminals while research and/or training is being performed by using the cockpits.

Utilization: The three-computer ASPT system is operational and in use by the Flying Training Division of AFHRL in all ongoing research.

Benefits: The increased capabilities provided through the high fidelity simulation and on-line software development vastly improves the research potential of the ASPT system. A 30 Hz rate is expected to allow simulation of all known aircraft. This includes

proposed control configured vehicles (CCV), which may have special motion cueing requirements for effective aircrew training. The current ASPT system will permit evaluation of g-seat, g-suit, visual, and motion cueing requirements in a variety of aircraft and/or environments; i.e., air-to-surface, air-to-air, hostile, tactical, and aerial refueling. Advanced training features to include extended operation and system performance measures can be used concurrently in the exploration of these parameters. Of critical importance is the fact that the research can effectively anticipate actual procurement windows.

Title: Advanced Simulator for Pilot Training (ASPT) g-seat Optimization – Phase I

Description: The Advanced Simulator for Pilot Training (ASPT) g-seat was delivered to be used in conjunction with a T-37 simulation. The original software was based on the geometry and characteristics of the T-37 aircraft; however, the seat was also designed as a research device with a high degree of flexibility. The objectives of this study (Phase I of III) were to establish the nature of the response lags in the g-seat system of the ASPT and to minimize those lags by optimizing the hardware configuration and the software execution. Another objective of the software optimization was to provide a more usable and understandable program which would facilitate determination of the most effective drive techniques (under Phase II) and use of auxiliary devices (under Phase III). A bench test mock-up of the ASPT g-seat system was constructed. The bench test consisted of an air compressor, pneumatic hoses, regulator valve, Conoflow valve, needle valve, booster valve, instrumented (potentiometer, accelerometer) bellow with lead weights, strip chart recorder, signal generator, and voltmeter. Each component of the test rig was adjusted, removed, or replaced and the effect on the g-seat bellow response was recorded. Software optimization was accomplished by analysis of each step of the existing program to identify areas in need of explanatory comments, areas of unnecessary branching and constants, excessive arrays, improvable techniques or in need of reogranization into a more logical form.

Utilization: The ASPT g-seat hardware of cockpit B has been reconfigured based on the Phase I recommendations. The software has been optimized with the addition of explanatory comment statements, reduction of arrays, maximization of linear flow, elimination of unnecessary constants, utilization of faster, more effective technqiues, and reorganization into a more logical form. The Phase I effort is described in AFHRL-TR-78-92, *Advanced Simulator for Pilot Training (ASPT): G-Seat Optimization*.

Benefits: The major value of this work is in a highly improved response time of the hardware and in software preparation for Phases II and III which will investigate drive philosophies and emulation of new g-cueing devices. Dollar savings will eventually be possible in evaluating new g-cueing designs in advance of production, but estimates are not available. Other benefits include better high-performance aircraft g-cues (A-10; F-16), better synchronization with visual systems, and applications to production of future pneumatic g-seat. It may be feasible to provide acceleration onset cues (the g-seat currently provides only sustained cues) through subsequent drive philosophy developments.

Title: Data Base Descriptors for Electro-Optical Sensor Simulation

Description: Most current and future computer image generation (CIG) systems will require large, detailed data bases in order to provide the high fidelity imagery required for training various tasks. The volume of data in these large data bases dictates that the data base generation process be automated, using source data which is available for large areas of the world. The Defense Mapping Agency Aerospace Center (DMAAC) digital data base has been used successfully in this manner for radar simulation, however, simulation of sensor imagery such as that typical of forward looking infrared (FLIR) or low light level television (LLLTV) places demands on the data base which the DMAAC source data cannot satisfy. This study investigated the descriptors or modifiers which may be used in conjunction with the DMAAC data base to provide for simulation of cultural features in sensor imagery. The approach involved modeling data bases from real-world scenes, generating imagery from these scenes, and determining what additional parameters are needed in addition to those in the DMAAC data base to generate representative imagery. The results are documented in AFHRL-TR-78-86, *Data Base Descriptors for Electro-Optical Sensor Simulation*.

Utilization: The results of this study will be utilized by the Aeronautical Systems Division Simulator Systems Program Office and CIG contractors in future sensor simulation work. Further study is required before the results are considered for implementation in the DMAAC data base, since it is probable that some suggested parameters may be constant or insignificant for certain applications.

Benefits: The results of this study include a sensor model which may be used to generate sensor imagery using a data base which contains the appropriate sensor parameters. Once the optimum set of parameters is established, it will be possible to append these parameters to the DMAAC data base to allow it to serve as general source data for sensor simulation applications.

Title: Design, Development, Test and Installation of a Simulator for the F-111D 6883 Converter Flight Controls Test Station

Description: The 6883 Maintenance Training System is the first maintenance simulator developed for training maintenance technicians to operate and maintain sophisticated automatic test equipment. Previously, training was conducted using very expensive and often unreliable actual test sets that permitted little, if any, "hands-on" experience with realistic malfunctions. The 6883 simulator not only parallels the actual equipment in appearance and required training functions, but also provides a broad range of instructional capabilities not present in actual equipment trainers. Such features include immediate feedback, error rate control, error branching, and self-paced guidance and practice. This project was designed (a) to demonstrate the feasibility of using simulation technology in the design of training devices for representing intermediate-level maintenance tasks and (b) to develop a research test bed for the systematic investigation of alternative simualtion techniques. Results of this effort are documented in AFHRL-TR-78-87, *Maintenance Training System: 6883 Converter/ Flight Control Test Station*.

Impact/Utilization: As part of the evaluation phase of this effort, the 6883 simulator is currently in classroom use at Lowry AFB, Colorado. The simulator is being used to train students in all of the course objectives previously trained, using an actual 6883 test station. Utilization of the additional capabilities of the simulator is planned for the post-evaluation phase. During the evaluation phase, the cost and training effectiveness of the simulator will be determined in order to improve specifications for future applications of this technology for the Air Force. The AFHRL developed in-house functional specification has been used as a model for procurement of recent training systems for the E-3A, EF-111A, and F-15. The successful demonstration of the 6883 simulator has also been a significant factor in convincing potential users that simulation is a workable and more effective alternative to conventional training equipment approaches.

Benefits: The 6883 simulator effort has successfully demonstrated that I-level maintenance training equipment acquisition costs can be lowered by at least 50 percent with a corresponding decrease of at least that amount in support costs. The digital, solid-state design and relative simplicity of the simulator have resulted in a highly acceptable MTBF and significantly improved maintainability. The incorporation of a wide range of instructional enhancements will dramatically improve trainee skill acquisition through provisions for standardized training and evaluation, increased exposure to troubleshooting problems, and controlled hands-on practice. Furthermore, the success of the 6883 simulator has demonstrated that devices specifically designed for training can be far more effective than actual equipment, which previously was thought to be the best medium for training.

Title: Development of Automated Performance Measurement System for the Advanced Simulator for Pilot Training (ASPT)

Description: The ASPT was designed to be used as a training research tool; however, when delivered and accepted, the device did not have an objective performance measurement system capability. Since the ASPT is a full-mission T-37B trainer, it was necessary that a measurement capability be developed for representative tasks for all phases of T-37 training. In keeping with the Instructional System Development approach to training, tasks to be learned are defined and evaluated according to their behavioral or criterion-referenced objectives. Since flying tasks are goal-directed, proficiency should be assessed in terms of the degree to which the specific behavioral

objectives are obtained. Consequently, the criterion-referenced approach was adopted for subsequent measurement development efforts for the ASPT. A unique capability of the ASPT, the preprogramming system, made possible the development of measurement scenarios which could be used in real-time and provide immediate knowledge of results. Automated measurement scenarios have been developed and implemented for selected tasks in all phases of T-37 training. These include basic instruments, basic contact, takeoff/approach landings, advanced instrument, aerobatics, and formation flight skills. A data storage and retrieval system, the Student Data System (SDS), was developed in conjunction with the automated performance measurement system. The SDS enables the storage of all information generated by each measurement scenario as well as identification data. A provision was made for entering instructor evaluations as well as commentary upon completion of the maneuver. Retrieval programs were developed to enable the editing and processing of data directly from the student file thereby eliminating manual data handling. Since their original development, both the measurement system and SDS have undergone continuing changes and refinements in order to increase their validity and efficiency.

Impact: The automated performance measurement system has been used in the studies addressing the effectiveness of platform motion, visual system cueing, and advanced training features. Aside from its support role for these and other R&D efforts, these measurement development efforts have demonstrated the validity of the criterion-referenced approach and the feasibility of real-time measurement within the training environment. It has also enabled the study of basic research issues within the area of objective performance assessment.

Benefits: The automated performance measurement system has enhanced the scientific objectivity of almost all of the behavioral studies performed on the ASPT. Thus, it has played a key role in virtually every research study accomplished on the ASPT.

Title: Effects of Delayed Platform Motion on Training for Roll-Axis Control

Description: As one of the initial efforts of the Motion-Cue Requirements Study, the effects of delayed motion in training for and performing roll-axis stabilization were examined. With the assistance of the 6570th Aerospace Medical Research Laboratory, data were collected from 23 young adults inexperienced in such tasks. In approximately equal numbers, they trained until proficient with either no delay between motion and the cathode ray tube (CRT)—stimulus or with 80, 200, and 300 milliseconds delay or with no motion whatever. The rate of learning and level of performance achieved was found inversely related to delay; as delay increased performance became worse. Performance with the 200 and 300 millisecond delay was like that without motion. In subsequent test performance with undelayed motion, even though all subjects showed some skill, initially the performances differed among each other in the same way as at the end of training. The static and 200 to 300 milliseconds subjects required as many as 12 sessions to match the skill of other subjects.

Impact/Utilization: The primary value of this study is as a basis for further analysis of the motion problem. However, it may be reasonably concluded from it that if platform motion is purchased, it should not involve motion/visual mismatches greater than about 100 milliseconds to provide useful training in roll control of fighter type aircraft. This finding may significantly affect flight simulator procurement planning.

Benefits: The potential for dollar savings and increased training effectiveness is dependent upon the application given to the information.

Title: Elliptical Features

Description: Real-time computer image generation (CIG) systems have used edges or straight lines as the basic building blocks for constructing an image. This program has developed algorithms that provide the capability to compute images of ellipsoids and ellipses. The algorithm produces an elliptical image whose boundary appears as a smooth curve. Previously, ellipsoidal and elliptical objects were modeled with edges, and the resulting image had a faceted appearance. The elliptical feature capability can also be used in conjunction with planar surfaces to model a variety of solids. Examples of the application of this technique are aircraft fuselages, wings, fuel storage tanks, clouds, and trees. A complete description of the elliptical feature

algorithm is contained in AFHRL-TR-77-66, *Computer Image Generation Imagery Improvement: Circles, Contours, and Texture.*

Utilization: The elliptical feature capability has provided the CIG data base modeler with an additional modeling medium. This capability permits the creation of models which are more realistic, as well as allowing more efficient and effective use of the image generator's capability. For example, a cylinder would involve two elliptical features and four edges to define it in the data base. If only edges were used, approximately 48 edges would be required. The latter approach would require approximately 10 times the number of edges to be processed than the former. The edges saved by modeling with the elliptical features can be used to add further detail to the data base. This technology is being applied to several simulators currently under development.

Benefits: The elliptical feature capability provides the data base modeler with greater flexibility, thereby permitting creation of more complex environments than if the modeler were restricted to edges alone. This in turn will result in greater image detail and training effectiveness.

Title: FY 78 Simulator for Air-to-Air Combat (SAAC) System Refinement and Enhancements

Description: Through management of a maintenance contract by the AFHRL Flying Training Division, a number of significant system refinements and enhancements were made to the Simulator for Air-to-Air Combat (SAAC) which significantly affected its reliability and utility for both operational training and training research. Among those improvements were (a) replacement of the random access disk (RAD) with a dual, moving-head disk drive, (b) addition of a high speed cardreader, (c) installation of a safety net, (d) rearrangement of the instructors operator station (IOS), (e) replacement of the systems wiring bundle rack (CATRAC), and (f) improvement of missile trajectory performance.

Impact/Utilization: System enhancements and refinements have impacted the utility of the SAAC in the following areas: (a) replacement of the RAD, which had a relatively high failure rate, with a dual, moving-head disk drive reduced the mean time between failures (MTBF) for the entire system, and improved the flexibility in program loading procedures, (b) a high speed cardreader was added to reduce time required to build an operational load, (c) a safety net was added to minimize the hazards of maintenance personnel falling from the motion platform while working on the visual system, a distance from 6 to 15 feet, (d) enhanced training utility of the system was achieved by rearranging the IOS to provide an improved position for instructor pilot (IP) or operator management of flying training or research using the SAAC, (e) to preclude distortion of the CATRAC containing the wire bundle furnishing power to the cockpits and the imminent threat of chaffing and ultimate failure of wiring in the bundle, replaced the CATRAC and improved distribution of the wiring fall, and (f) AIM-7 and AIM-9 missile trajectory algorithms were refined to portray more realistic firing envelopes for each missile.

Benefits: The benefits accrued from incorporating these changes have resulted in improved maintainability of the system, enhanced its availability for training, reduced inefficiencies and inaccuracies in simulating aircraft aerodynamics and weapons trajectories, and enhanced the utility of the device in performing flying training research.

Title: Human Motion and Force Sensory Mechanism Model

Description: In order to provide adequate and accurate simulation of aircraft motion, a better understanding of how a pilot senses and utilizes motion and force information in flight is necessary. This effort was initiated in early 1976 to investigate and develop and/or refine models of the more prominent motion and force sensory mechanisms. Performed under a contract, this work has resulted in the integration of four sensory modalities (vestibular, non-vestibular proprioceptive, tactile, and visual) into a unified or composite model for motion and orientation perception. Although the component models are in various states of refinement and validation, this first composite model represents a significant accomplishment.

Impact/Utilization: By allowing direct comparison of the model's prediction of pilot perception in the actual aircraft with that predicted for a simulator, this model makes it feasible to simulate the

perceptions of motion and force, rather than attempting to duplicate the actual motion of the aircraft. Similarly, the model should allow direct comparisons of different motion systems and drive methods.

Benefits: The model has the potential for increasing training effectiveness if it is used by motion system designers to develop high fidelity systems with minimal false cueing. It also has potential as a tool to aid in the decision making process by providing data for cost-performance evaluations of several motion systems.

Title: Improved CIG Edge Utilization Study

Description: In order to better utilize the capability of a computer image generation (CIG) system, an area-of-interest (AOI) algorithm has been developed. The function of the algorithm is to control the level of detail in the scene as a function of its location in the pilot's instantaneous field of view. Thus, if imagery fell within the pilot's foveal vision, it would be displayed at full detail, and as the imagery moved into the region of lesser acuity, its detail would be reduced. Another aspect of CIG edge utilization is the implementation of a level of detail concept. Imagery or models stored in the CIG data base may have a number of levels of detail where each level of detail is used to represent the presence of the model for a predetermined set of ranges. Without level of detail, the CIG system would frequently process more edges than could be resolved on the display. Past attempts at implementing level of detail algorithms produced distracting effects, such as the popping in and out of models as they change from one level of detail to another. The algorithm developed under this program eliminates the undesirable effects by smoothly transitioning from one level of detail to the next.

Utilization: The AOI algorithm provides the capability to control the level of detail within a scene and with respect to the given view direction for which the image was computed. Before the algorithm can be employed in an operational system, the parameters which control the algorithm must be identified. These parameters will vary, depending on whether the view direction is sensed from the pilot's head position or from his eye position. The improved level of detail concept has been developed; however, its implementation will require hardware design and development.

Benefit: Since the AOI algorithm will permit the user to specify a CIG system of lesser edge capacity, there is potential for reduced cost without compromising training effectiveness. The level of detail algorithm removes the distracting effects caused by abrupt changes in a model's level of detail.

Title: Monochrome Holographic Window

Description: The Air Force has a continuing need for more effective visual displays used in conjunction with flight simulators for pilot training. One very powerful display which has been developed in the past is the in-line infinity optical display or Pancake Window. These Pancake Windows have been utilized and very favorably evaluated on both the Advanced Simulator for Pilot Training (ASPT) and Simulator for Air-to-Air Combat (SAAC). Their primary advantage is in providing an infinity image and in being constructed in discrete channels which can be mosaiced together to provide a wraparound field of view. The Pancake Windows built for ASPT and SAAC, however, were expensive and very heavy, primarily due to the large, glass, spherical mirror/beamsplitter which is intrinsic to their operation. A technique was conceived whereby the cost and weight of the Pancake Window could both be significantly reduced. This technique involved replacement of the glass spherical mirror/beamsplitter with its holographic analog, thus resulting in a Holographic Pancake Window. Research aimed at producing monochrome holographic analogs of the required spherical mirror/beamsplitter has been supported and has resulted in the successful production of 32-inch diameter holographic Pancake Windows.

Utilization: A wide angle display consisting of a horizontal mosaic of three 32-inch holographic Pancake Windows has been fabricated and will be subjected to evaluation at the AFHRL Advanced Systems Division in the near future. Technical details on the development of the holographic Pancake Windows, and their performance characteristics, will be provided to the Simulator Systems Program Office and other Government agencies so that this technology can be considered for inclusion in future simulator acquisitions.

Benefits: The potential benefits of the Monochrome Holographic Window include significant cost and weight savings in those simulator applications where a

mosaic of in-line infinity optical displays is utilized to provide wide field-of-view capabilities. A secondary cost savings is achieved when the simulator incorporates a motion base, since the reduced display weight means that a smaller capacity, less expensive, motion base can be utilized.

Title: Scanned Laser Visual System Development

Description: Despite significant advances in computer image generation (CIG) capabilities, it still cannot provide the scene detail available from camera/modelboard image generation systems. Conventional modelboard systems, however, have much difficulty in providing the wide field of view required of most visual simulation systems. These considerations are important for low altitude and nap-of-the-earth simulation. For simulation applications where the scene detail levels available from CIG are acceptable, a high resolution, high brightness, color, continuous wide field-of-view projection device would provide an important increase in display capability. For these reasons, AFHRL has participated with the Army Project Manager for Training Devices (PM TRADE) in the development of the scanned laser visual system. This effort culminated in the assembly of a breadboard scanned laser system in August 1978. The breadboard system provides a convincing demonstration of the promise of this kind of visual simulation system. A continuous 180° horizontal by 60° vertical field of view is generated and displayed with 8 arc minutes per line pair resolution and about 1 foot-lambert luminance. Only a monochrome breadboard system was built in order to conserve development funds, but addition of other lasers to provide full color is not expected to pose unsolvable problems. In addition, it is expected that further refinement of the breadboard model will improve the resolution to less than 6 arc minutes per line pair and increase the luminance to 2 foot-lamberts using the present 5 watt lasers. Higher power lasers and more efficient optics would increase the luminance further. The success of the breadboard scanned laser system represents the solution of many challenging subsystem and integration technical problems. For example, the synchronization between the camera and display scanners is maintained to an accuracy of 2 nanoseconds. In addition to the final report now being prepared, the most convincing documentation of this achievement is the breadboard system itself, which has been demonstrated satisfactorily for personnel from the Army and Air Force, as well as for many other interested parties.

Impact/Utilization: Clearly, further investment is required to continue refinement of this visual simulation system. The breadboard model assembled here has been used to demonstrate the system concept and will form the basis for future development. Ultimately, of most interest for Air Force applications is the scanned laser display, which should be useful in many simulation applications with a suitable CIG input. The scanned laser system would also form the basis for a hybrid CIG/modelboard system, perhaps useful for training air-to-ground weapons delivery as part of a full mission simulator.

Benefits: The scanned laser system represents several significant improvements over previous modelboard systems. The system provides higher resolution and a wider field of view than previously possible, both of which should increase training effectiveness. The system requires considerably less energy than a conventional modelboard or a CIG system. By itself, the display makes possible a continuous 180° presentation with a single device, which should reduce maintenance requirements and eliminate alignment problems.

Title: Simulator Higher Order Language Study

Description: The trend in the computer industry today is toward using the higher order languages as much as possible, even in those applications where previously only machine language could meet the time and efficiency constraints. The benefits to be gained from the use of higher order languages are the possibility of software reusability and improved understandability and maintainability of the resulting programs. Consequently, the higher order language FORTRAN has been used in recent simulators to a great extent. However, FORTRAN has certain deficiencies when used in a real-time environment. As a result, its use in flight simulation has been both limited and non-stanardized. The primary objectives of this effort were to identify the characteristics required for an ideal simulation higher order language and to evaluate several existing languages as candidates for modification and standard use in flight simulators.

Specific characteristics of an optimal language were determined by formulating and studying a simulation benchmark problem which describes the software characteristics of a generic flight simulator. Five existing languages were evaluated, and the IRONMAN description of the proposed DoD common language was reviewed and assessed. Results show that PL/I and JOVIAL J3B are better suited as bases for an optimal simulation language than are FORTRAN, PASCAL, or JOVIAL J78I. It was also found that the proposed DoD language appears to be generally suitable but that certain desirable characteristics were not mentioned in the IRONMAN specification. The results of this study have been documented in AFHRL-TR-78-34, *Simulation Higher Order Language Requirements Study.*

Utilization: The AFSC Aeronautical Systems Division (ASD/EN) representative to the DoD common language working group has been briefed on the results of this study so that the requirements of the simulation area might be made known at the development stage. Computer manufacturers interested in the simulator market for their computer system will find the results very useful for improving their higher order language software for simulator applications. The simulation benchmark problem is being used in a subsequent effort that is investigating the problems associated with partitioning software in multiple computer systems.

Benefits: The use of higher order languages for programming increases the efficiency of the programming process, improves the maintainability of the resulting software and subsequently results in dollar savings over the entire life-cycle. This study has identified the characteristics of an optimum simulation higher order language, which will aid in implementing a more cost-effective higher order language. In addition, the simulation benchmark problem is being used in other efforts which require a detailed characterization of the software system of flight simulators.

Title: The Potential Use of State of the Art Simulation Techniques in Flight Simulator Maintenance Training

Description: The Airman Training Devices Career Field (AFSC 341XX) has the responsibility for maintaining and repairing Digital Flight Simulators and Digital Navigation/Tactics Trainers. The high utilization rates and increased sophistication and cost of these simulators has adversely affected their availability and suitability for training. The purpose of the effort was to determine maintenance simulator requirements for training the Digital Flight Simulator Specialty (341X4) and the Ditital Navigation/Tactics Training Devices Specialty (341X6). A task analysis and training analysis was conducted, and two concepts for maintenance simulators were identified. One device is intended for use in resident training and the other device is intended for use in both resident and field training environments. The resident training device would be a three dimensional simulation of the major subsystems of flight simulators identified during the analysis phase. The other device, primarily for field training use, is envisioned as a stand-alone troubleshooting simulator utilizing two-dimensional simulation. The field training device would be capable of conceptually simulating the functions of any flight simulator, e.g., F-15, F-4E, FB-111, C-5A, etc. The final product of the effort was functional specifications for both the resident and field training maintenance simulators.

Impact/Utilization: Air Training Command (ATC) submitted a General Operational Requirement for a maintenance simulator for the Resident School for the 341X4 and 341X6 specialties (ATC GOR 01-77). The functional specifications for the resident maintenance simulator will be made available if future procurement is approved to satisfy the ATC request. Functional specifications for the field training simulator will be used to develop a prototype device to serve as a basis for research in the field training environment.

Benefits: If the resident training simulator functional specifications are used, a time and dollars savings should be realized as well as increased training effectiveness. The field training prototype, when developed, will help determine whether systems logic and troubleshooting skills can be acquired and maintained more efficiently for specific flight simulators through its use.

Title: The Training Effectiveness of Three Types of Visual Systems for KC-135 Flight Simulators

Description: This research was conducted to satisfy a statement of technical need from the Simulator

System Program Office (SIMSPO) (ASD/SD24) and Headquarters Strategic Air Command. Pending simulator hardware procurement by SAC required an evaluation of the visual systems under consideration. The objectives of this study were (a) to evaluate the effectiveness of flight simulator visual system training for application to KC-135 Combat Crew Training School (CCTS), (b) to determine the relative training effectiveness of three generic types of visual systems—a TV Model Board system, a Daylight Color Computer-Generated Imagery (CGI) system, and a Night Only/Point Light Source CGI System, and (c) to specify any deficiencies associated with these three visual systems which might adversely impact training. Thirty Undergraduate Pilot Training graduates enroute to KC-135 CCTS were divided into three equal groups. Each group received 8 hours of simulator training on the KC-135 landing task utilizing one of the three visual systems. Each subject then flew two evaluation sorties in the KC-135 aircraft. Performance on the evaluation flights showed simulator training on the Daylight Color and Night Only systems to be superior to training on the TV Model Board system. Overall effectiveness of the simulator training was reflected in 60 percent of the test participants receiving a final CCTS evaluation of "highly qualified" as opposed to 30 percent of the non-participants. The results of this study have been published as AFHRL-TR-78-16, *Training Effectiveness of Three Types of Visual Systems for KC-135 Flight Simulators.*

Impact: This was the first study to explore the use of various types of visual systems in an operational environment. The study was conducted to influence pending simulator hardware procurement. The results are applicable to future expenditures on all flight simulator visual systems. The study results have been briefed at high levels in DoD.

Benefits: The nature of the research did not lend itself to a finite determination of cost savings. The study did indicate that one visual system provided more effective training than another system which costs approximately $500,000 more per unit. Several future simulator procurements could be influenced by the study findings.

TECHNICAL SUPPORT

Title: File Item Data Organizer (FIDO)

Description: The File Item Data Organizer (FIDO) evolved from the need of research efforts involving present and longitudinal sample selection where codes contained in the AFHRL unique data bases had to be identified and interpreted by research scientists with English meanings for coded information including: description of the code, frequency of occurrence, and other descriptive statistics. FIDO also contains an automated inquiry/retrieval system, vital for the establishment of data bases for personnel research projects and probe analysis to determine the feasibility of proposed major research efforts involving data bases. FIDO has been implemented and placed on-line on the AFHRL UNIVAC 1108 computer system. It consists of 674 Air Force and DoD defined data elements used in automated Air Force Personnel Data Systems; examples are security classification, grade, Air Force Specialty Code, and major academic field. Present efforts are to provide more accurate and timely data by improving the update procedures now in use and by developing procedures to get this information directly from the Air Force Data Systems Design Center AFM 300-4 data base which is supplied to AFHRL monthly by magnetic tape.

Impact/Utilization: FIDO directly supports virtually all facets of personnel and manpower research across AFHRL divisions. Many research efforts involve longitudinal studies of specific samples cutting across many different data files and code values over varied time periods. Automated availability of Air Force and DoD defined data elements, as well as other nonstandard data elements, with their data items and meanings across time represents a sizeable savings in workhours which would otherwise be spent in manually researching hundreds of manual binders and/or microfiche in order to find the needed code properly identified for a given historical time period. As implemented, scientists may, on retrieval, specify all code values in effect dating back to the establishment of a given data element or may specify inclusive dates and get only those codes in effect during the interval in question. The data can be displayed on a remote interactive terminal or a hard-copy may be requested showing title, data name, definition/explanation, coded values, effective dates, and explanation of code values.

Benefits: FIDO makes it possible to carry out research studies which would be prohibitive in terms of workhour required without an automated inquiry/retrieval system.

Title: Human Resources Research Data Base

Description: A series of data bases containing information on personnel and training systems has been developed. The data bases are stored on magnetic tape. Software to process, organize, and display selected information from a single data base and to consolidate information on a common subgroup from two or more data bases has been implemented. The data bases include records on all active duty Air Force enlisted and officer personnel at 6-month intervals; Air Force Reserve and National Guard personnel; records of graduates from basic military training, technical training, and flying training programs, and from the Officer Training School and Reserve Officer Training Corps commissioning programs; and records reflecting separations and losses from active duty. Special-purpose longitudinal files have been derived from these data bases. These longitudinal files significantly reduce data processing requirements in many personnel and training research studies.

Impact/Utilization: The data bases represent a low-cost means of acquiring and maintaining information used in the development and validation of personnel selection and classification instruments, development of assignment procedures, derivation and revalidation of promotion systems, and special-purpose analyses to determine the long-range impact of specific personnel and training policies.

Benefits: Availability of these data bases makes it possible to carry out studies on numerous aspects of the personnel and training systems which would otherwise be infeasible. A conservative estimate of an annual cost avoidance of 400 thousand dollars can be attributed to the use of these automated data bases as an alternative to manual screening, selection, and automation of records maintained in archival storage.

Title: Mathematical and Statistical Software Index

Description: Short descriptions of mathematical and statistical computer software resident in the AFHRL Univac 1108 computer system have been assembled in AFHRL-TR-78-66, *AFHRL Mathematical and Statistical Software Index,* to provide a software index for Air Force personnel researchers on general-purpose mathematical and statistical software which is available to them for use in their research projects. The index, which contains information on 27 stand-alone programs, three subroutine systems, and two nationally recognized statistical packages, is designed to facilitate and expedite the work of the researcher by providing a single abridged source on AFHRL mathematical and statistical software.

Impact/Utilization: Information contained in the software index will be used in the design of personnel and training research data analyses to be carried out on the AFHRL Univac 1108 computer system. More than 130 copies of the software index, which will be available by late December 1978, have been requested by the Laboratory Divisions for use by their principal investigators and software users.

Benefits: Availability of the software index to AFHRL principal investigators and software users provides potential time savings and increased effectiveness in the design of data analyses for Air Force personnel and training research. By referring to the index, principal investigators will be able to obtain information which previously was obtainable primarily through consultations with AFHRL Computational Sciences Division software experts. With the availability of the software index, principal investigators have the potential for expanding the range of methodologies routinely used in their data analyses by becoming aware of other appropriate software in the library which they previously did not know was available. Additionally, knowledge of the range and general capabilities of AFHRL Mathematical and Statistical software library will improve communication of data analysis requirements to the Analysis and Programming Branch of the Computational Sciences Division where the actual data analyses are carried out.

Title: Officer Effectiveness Report (OER) System

Description: Officers in the grades captain through colonel are normally given OER evaluations once a year with lieutenants being given evaluations twice a year. Exceptions produce an abbreviated report.

There are several uses for the evaluations: (a) a tool in determining the best qualified for promotions, (b) a tool for making assignments, (c) a counseling device, and (d) a general personnel management tool. In addition, this report aids in the monitoring of the rating trends. The automated OER report system uses the OER records which have been transcribed to magnetic tape to produce summary reports which aid career monitors, assignments, personnel, and OER monitors.

Impact/Utilization: The OER summary reports are used by senior Air Force managers, the Promotion Secretariat, and career monitors.

Benefits: The Air Force is in a better position to monitor the OER system and its built-in controls as a result of the summary report system developed by the AFHRL Computational Sciences Division.

TECHNICAL TRAINING TECHNOLOGY

Title: Automated Data on Instructional Technology (ADIT)

Description: Automated Data on Instructional Technology (ADIT) is a computerized file of technical information on human learning for use by anyone within DoD concerned with instructional system development (ISD). The development was accomplished with funds from the Air Force Office of Scientific Research, the Army Research Institute for the Behavioral and Social Sciences, the Navy Personnel Research and Development Center, and the Advanced Research Projects Agency (through FY 78). The file consists of computerized abstracts of technical reports, journal articles, books, and other original sources bearing on ISD. Aside from the abstract proper and the normal bibliographic citation, records containing up to 35 other kinds of information about the source are helpful for special purposes. Some are of a technical nature, such as the evaluation of the article, variables studied, and subject population. Others provide the kind of bibliographic information found on the Report Documentation page (DD Form 1473) in technical reports. But the most important feature of the file is the comprehensive character of the abstract proper for all research items. The intent is to make the description of each study so complete that for most purposes the original source is not needed. About 12,000 records are now available. Continual additions of the current work are planned. Access to the records is by computer terminal through an on-line, interactive, full text retrieval system (INFOCEN) operated by the Computer Center of the Aeronautical Systems Division, AFSC at Wright-Patterson AFB. Any dual-up terminal of common configuration may be used for this purpose. The system may be reached through both military Autovon and commercial phone lines.

Impact/Utilization: Although not publicized, the system is presently being used by some 20 elements of the Army, the Navy, and the Air Force. It is anticipated that eventually all principal training agencies and concerned R&D organizations within DoD will access the file—probably through various offices. With the efficient access thus afforded to technical data, decisions on training can be based upon the latest pertinent data. Further research can be better planned with knowledge of existing information.

Benefits: A conservative estimate is that ADIT topical analyses can be conducted in 10% of the time for performing library analyses. On that basis, several hundred thousand dollars may be saved annually in technical personnel time when the system is in full use. More important, however, is the probable long term savings in improved training efficiency fostered by the use of the latest information in design and planning and through expedited research.

Title: CAI Authoring Support Software for Use in a Technical Training Environment

Description: Under this effort, a series of computer programs were produced to aid in the development, presentation, and analysis of Computer Assisted Instruction (CAI) materials. The primary components of the system are the CAI Authoring Editor, Presentation Program, Data Analysis System, and

Material Print Program. The Authoring Editor is used by a coder or author to enter and format questions and pages of text to be seen by a student and to control the order of information presentation. The Presentation Program is designed to display pages of text, process question responses, process decision table data to determine which CAI material is to be presented next, and record several classes of data. The Data Analysis System uses CAI response and decision data recorded by the CAI Presentation Program to generate a series of reports used for the formative evaluation of CAI material. The data base can also be used for instructional research. The Material Print Program provides a means by which the authors can receive a listing of their developed CAI materials. A technical report is currently being finalized that will document this effort.

Impact/Utilization: The software developed under this effort is currently being used by a companion effort "Development of Efficient CAI Authoring Procedures for Use in a Technical Training Environment" to produce CAI materials for a demonstration test within the Computer Based Instructional (CBI) system currently operational at the Lowry Technical Training Center. The fully operational CAI system for use within the Lowry CBI should be available by January 1979.

Benefits: Preliminary indications are that the software developed under this contract has aided in reducing the cost of developing and delivering CAI materials. This has been accomplished by providing an interactive system that even a novice author can use efficiently to develop CAI materials.

Title: Development and Evaluation of Student Skill Modules to Reduce Training Time in Computer Managed Instruction (CMI)

Description: For the average student entering Air Force technical training, computer-managed, individualized instruction is a new experience for which many students are unprepared. Computer-management requires that students have the capability to utilize their time appropriately. Individualized instruction requires that sutdents take more responsibility for their own learning, and this in turn requires that they have adequate study skills. This effort, funded by the Defense Advanced Research Project Agency, provided specific study materials for orientation to CMI and time management and for the individual study skills of memorization, reading comprehension, concentration, and familiarity with procedures test wizeness. The results of this effort are documented in a forthcoming AFHRL technical report.

Utilization: The student skill modules were evaluated for their effectivensss in three advanced instructional system courses at Lowry AFB. The results were positive with better student performance attributable to the modules. Subsequent to the research, local training managers have implemented the student skill modules as part of their on-going operations.

Benefits: The results of the time management module evaluation showed an average 10% time reduction with use of the module procedures by students. Students who were identified through the use of a contractor-developed Study Skills Questionnaire as having poor study skills improved their performance by approximately one standard deviation after being administered one or more of the study skill modules. An ancillary benefit of the study skill modules and questionnaire in that their use has created a new role activity for instructor in computer-managed, individualized instruction which has improved the attitudes and role perceptions of those instructors who participated in the study and the evaluation.

Title: Development of a Microterminal for Testing and Instruction

Description: A low-cost, prototype, stand-alone terminal was developed for support of testing and instruction in a large computer-based instructional (CBI) system, such as the Air Force Advanced Instructional System (AIS). A significant cost component for CBI systems are the terminals utilized. If computer-assisted instruction (CAI) is utilized, terminal costs can become very critical, since one terminal has to be provided per student utilizing a CAI lesson. As part of the AIS effort, it was soon realized that, if CAI was to become a cost-effective component of CBI, there was going to have to be a better match between terminal hardware and instructional tasks supported. In this context, it was realized that there were a great number of instructional instances wherein the presentation of

instructional materials on tests could be handled by more conventional media (i.e., programmed text, microfiche, etc.) yet benefit from being under computer control in terms of student response feedback and branching or sequencing the student through the materials. The microterminal was design to function with off-line instructional or test materials. It has a limited display capability consisting of four alpha-numeric characters and five light emitting diodes for signaling the student to attend to specified directions. It has a 16 key keyboard providing digits 0 to 9 and characters A to E, plus special function keys. The terminal has a removeable memory module which stores a student's responses and which is used to transmit these student responses back to a central CBI system computer. Results are documented in AFHRL-TR-78-50, *Development of a Low-Cost, Stand-Alone Microterminal for Support of Testing and Instruction.*

Utilization: Though the microterminal is still in its prototype stage, fully operational units could be utilized in resident and field training courses, for support of extension course institute (ECI) materials, and in large-scale testing operations such as enlistment testing.

Benefits: Evaluation of the microterminal in support of testing in an Air Training Command resident course within the AIS has shown that students prefer the device over the use of computer readable answer forms for recording of their answers to block-examination items. Cost studies of the prototype units show that the microterminal can be built for $500, or less, per unit. At this price, the microterminal offers a cost-effective alternative for certain levels of computer-assisted testing and instruction in a CBI system. Preliminary evidence also indicates that the microterminal contributes to maintaining on-task behavior leading to reductions in time and better scores.

Title: Development of Efficient Computer-Assisted Instruction (CAI) Authoring Procedures for Use in a Technical Training Environment

Description: The instructional effectiveness of computer-assisted instruction (CAI) has been demonstrated repeatedly for a large variety of instructional applications. The principal drawback of CAI has been the cost of developing and delivering CAI materials. This effort has concentrated on the development tasks to decrease development costs. CAI lesson development times may range from 100 to 400 hours to prepare 1 hour of instructional material. Often a team approach is employed, involving a subject matter expert, an instructional programmer, and a computer coder. This requirement for specialized personnel expending many manhours to develop 1 instructional hour is the chief reason for high development costs. This effort developed a set of procedures which allows existing Air Force technical training personnel to efficiently prepare instructional materials and employ instructional strategies. The procedures are structured about an author editor that allows the lesson developer to sit at a terminal and concentrate on material production since lesson design is somewhat guided by the editor, and the coding of the computer is automatic. The results of this effort will be documented in a technical report that is currently being developed.

Impact/Utilization: The authoring procedures are in the final stage of refinement at Lowry Technical Training Center, users of the computer-based instruction (CBI) system there will have this capability by January 1979. CBI systems using compatible hardware and software may readily adapt these procedures. The procedures can also be used to efficiently develop certain types of materials intended for delivery by other types of media.

Benefits: Preliminary information suggests that lesson development times average about 85 development hours per student hours of contact. This indicates a higher degree of efficiency in the lesson development process. It also appears that strategies employed are reducing student failure rates. CBI users have been pleased with the results and the enhanced capabilities for delivering and developing instructional materials.

Title: Dual-Fiche

Description: The microfiche medium offers proven advantages in the management, storage and retrieval of information. Advances in computer-output-to-microfiche (COM) technology, especially, brings together the efficiencies of computer processing and the cost advantages of microfiche. COM technology, however, deals exclusively with, and is designed to accommodate, narrative information (in traditional vertical formats), which has limited its use in training

(where pictorial and horizontal formats are commonplace). While both narrative-only and pictorial-only microfiche can be produced, a combination of the two formats presents production problems. The dual-fiche concept separates the production of the narrative, or text, component from the production of the pictorial, or graphic, component yet combines the two types of information at the point of use (i.e., the microfiche reader). The dual-fiche product is a fiche "sandwich"—one fiche containing text or narrative information, the second fiche containing graphics. Both images are projected simultaneously, with words and pictures in perfect registration. This development brings the power of COM to bear directly on the problems of writing and revising instructional materials. The dual-fiche approach was developed under Air Force Contract F33615-77-C-0057 by the Denver Research Institute and utilizes the operational context of the Advanced Instructional System (AIS) at Lowry AFB, Colorado. The effort is described in an AFHRL technical report to be published in February 1979.

Impact/Utilization: The contract effort resulted in a scenario which places the development and maintenance of instructional materials in the hands of Air Training Command AIS instructors. Using an interactive computer terminal, an instructors may write or edit materials which, upon completion, are transferred to tape. The tape is then loaded into a COM machine which produces the microfiche. As this effort is a demonstration of the approach and the technology, a fully functional program was not implemented. Further developments and refinements are anticipated by AFHRL prior to wide scale implementation.

Benefits: The dual-fiche, COM-based system increases AIS material development and maintenance capabilities, greatly reducing production turnaround times. It also increases AIS computer capabilities. Full implementation carries a potential cost avoidance to AIS operations budgets as well as increased efficiencies. Most importantly, the scenario places both the means and the technology itself at the disposal of learning center instructors eliminating reliance on time-consuming, traditional, microfiche-producing agencies.

Title: Integrated System Test of the Advanced Instructional System

Description: The Integrated System Test (IST) for the Advanced Instructional System (AIS) was designed to provide quantitative answers regarding (a) training time reductions resulting from computer-managed instructional functions of the AIS, (b) reliability of the computer managed instruction CMI functions, and (c) reliabilities of the AIS support systems (media and computer hardware and software). The IST was accomplished in order to validate the overall system effectiveness and reliability of the AIS. The results of the IST have appeared in draft form, which is currently being processed for publication as an AFHRL technical report.

Impact/Utilization: The results of the IST will be used by the Air Force Systems Command and Air Training Command to evaluate the efficacy of the AIS concept as applied to Air Force technical training. Moreover, the experience gained from the development, implementation, and testing of the AIS provides a rich source of expertise for expanded Air Force utilization.

Benefits: As a result of conducting the IST, the following benefits were demonstrated for the AIS:

1. Disregarding the benefits derived from self-pacing, the IST showed that training time savings ranging between 12 and 14 percent could be obtained by utilizing a computerized student management system and tailoring instruction to student needs. Considering only the two courses which were the prime IST focus, these savings potentially amount to 90 student workyears per year.

2. AIS graduate performance in the field is equal to or superior to conventionally trained graduates.

3. The reliability and maintainability data collected indicate that the CMI support functions, media devices and courseware, and the computer hardware and software meet or exceed AIS specifications.

In addition to these major results, the following general remarks are appropriate: (a) the AIS is

operating as an integrated system with extremely flexible capabilities for studying training innovations, (b) the AIS provides a continuous quality control mechanism for Air Force technical training, and (c) student attitudes toward AIS computer-based instruction are generally favorable.

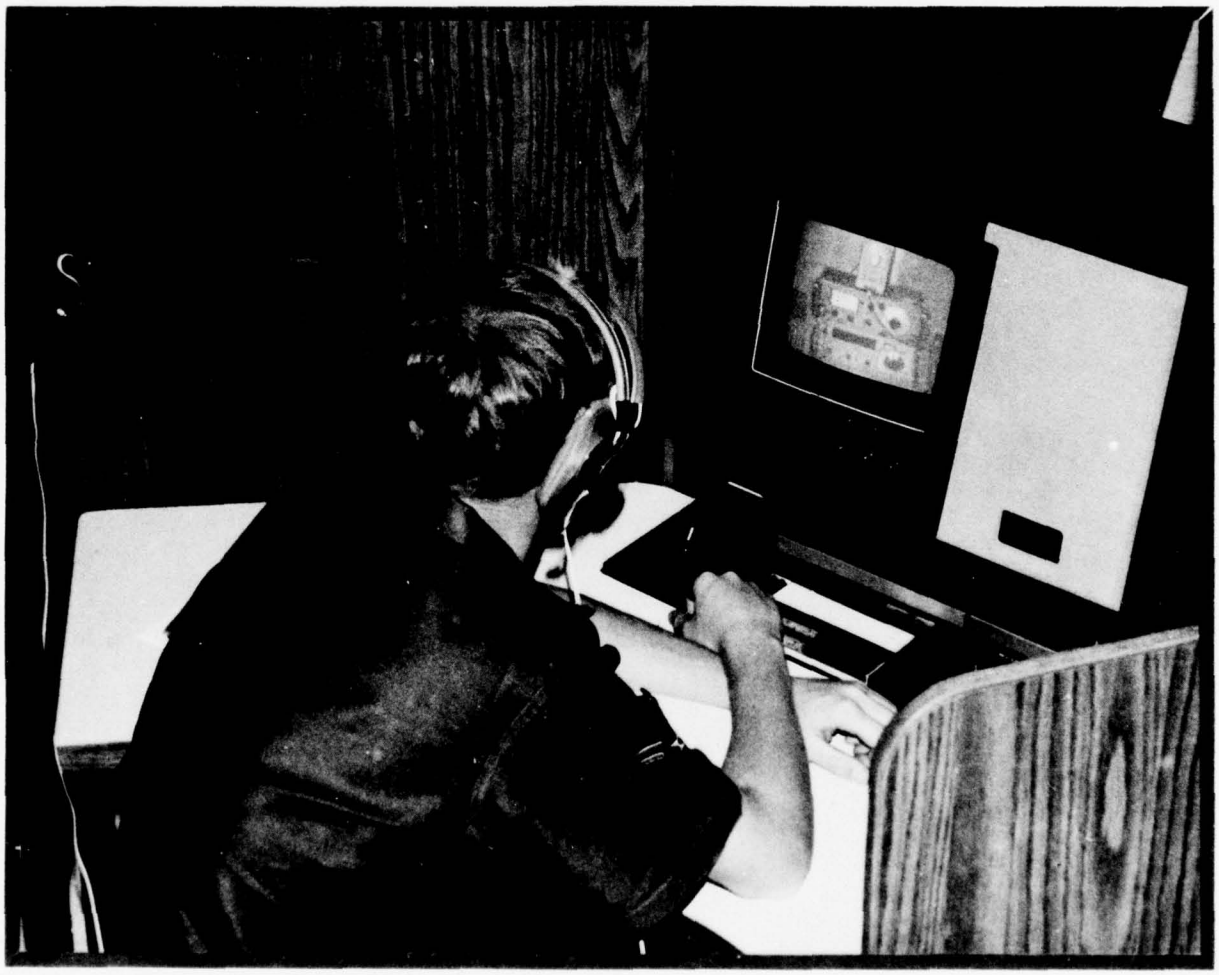
Title: On-the-Job Training Cost Model

Description: The Air Force inventory comprises a vast array of complex and highly technical weapons and delivery systems. The sophistication of these systems, the need to maintain a high level of readiness, and the inherent personnel turnover of a voluntary military system demand a high level of technical training and skill upgrading activity. The Air Force mission is to be ready. To be ready, the Air Force must train. To meet this need for continual training, the Air Force has evolved complementary systems of resident technical schools and formal on-the-job training (OJT). Costs of resident training are fairly easy to capture and are frequently calculated for evaluation of proposed training changes. Formal OJT, however, is not nearly so well defined an entity. OJT is part of almost every airman's job description and is an integral component of every unit's mission. It has been very difficult to single out that part of operational funds which supports OJT. Without the ability to establish cost parameters, it is impossible to evaluate benefits of proposed training changes. To meet this need, the Technical Training Division of AFHRL has developed a prototype OJT cost model. With the operationalization of this cost model, the Air Force will finally have the capability of determining these costs.

Utilization: When fully operational, the OJT cost model can be used by properly trained personnel at unit, consolidated base personnel office, major command, and USAF level.

Benefits: For the first time, every level of OJT management will be able to compute the cost of its OJT program. Resource managers will be able to quantify comparative efficiency of various OJT techniques. Proposed changes in training can be studied for increased cost or cost savings over current methods. Planners will be able to evaluate OJT contribution to projected budgets. The result will be the most effective possible Air Force OJT program for the defense dollar.

PROMISING ON-GOING RESEARCH



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Title: Application of Item Response Theory to Air Force Instructional Testing

Description: Instructional or achievement testing for the purpose of student measurement and course evaluation is an integral part of any training system. Since the Air Force operates one of the world's largest technical training systems, it has a vital interest in test development, administration, and interpretation. Recent developments in measurement theory and computer technology have made feasible a new approach to testing which may well supplant traditional testing methods. This approach is variously called item response theory, latent trait theory, or item characteristic curve theory. The advantages of these new theoretical approaches over classical methods are numerous and include (a) student ability estimates which are independent of particular test items, (b) item difficulties which are independent of particular examinees, and (c) test information functions which are mathematical expressions that can aid the test developer in constructing a test to a given set of specifications. Most of the work done to date in this field has been in the realm of aptitude testing, but increasing attention is being given to achievement tests, both norm and criterion referenced. It remains to be determined how well latent trait models fit the achievement test situation. Work has been undertaken by the Air Force Office of Scientific Research and the Technical Training Division of AFHRL to address basic questions in this area. Specifically, the assumptions underlying latent trait models are being investigated to discover how robust these models are to violation of the assumptions. In addition, work is being done to ascertain the minimum number of examinees and test items that are needed to apply latent trait models. One product of the research will be a handbook, oriented toward practitioners, which will make available the concepts and methods of modern test theory.

Impact/Utilization: The handbook could be a valuable addition to the tools used by test developers and analysts in the Air Training Command. Step-by-step guides for the implementation of an item response theory approach to test construction should result in more accurate estimates of student achievement. However, considerable theoretical work needs to be done before these newer methods can be recommended for routine operational use.

Title: Development of an On-the-Job Training (OJT) Capacity Model

Description: As budgetary considerations force program restrictions in the Air Training Command, much of the training previously conducted in resident courses is moved into the OJT setting. When field supervisors become responsible for additional training over and above their operational mission, the danger exists that quality of training, mission performance, unit readiness, or all of these, may suffer. The Air Force lacks a quantifiable model for determining the relationships between these outcome variables and amount of OJT conducted in various units. Optimum training load in OJT is being studied in this context. Attempts are being made to specify, in objectively measurable terms, the factors which impact a unit's capacity to conduct OJT without mission requirements being impaired. Training load is conceptualized as the residual when resources devoted to mission accomplishment are subtracted from total resources (i.e., manpower, equipment, etc.) available to a unit. It is hoped that more precise and measurable definitions of these factors can be formulated.

Impact/Utilization: When the capacity model is developed, demonstrated, and validated, Air Staff and Air Training Command managers will be able to make more objectively verifiable, data-based decisions with regard to whether a course of instruction should be taught in residence or in the OJT program.

Title: Force Cue Requirements for Air-to-Surface Weapons Delivery Simulation

Description: Whether the presence of platform motion actually enhances the training effectiveness of simulation is an issue of considerable importance to the Air Force. Gray and Fuller (AFHRL-TR-77-29, *Effects of Simulator Training and Platform Motion on Air-to-Surface Weapons Delivery Training*) conducted a study to determine the effects of generalized simulator training and platform motion

upon the acquisition of air-to-surface weapons delivery skills. They concluded that (a) six-degrees-of-freedom platform motion does not contribute to effective training, and (b) generalized training (achieved using low-fidelity simulation) has significant transfer to a specific aircraft. Students in Gray and Fuller's study were trained in the Advanced Simulator for Pilot Training (ASPT) which was configured as a T-37 aircraft cockpit; however, they actually flew the F-5B. The use of two different systems for training and transfer may weaken the argument that platform motion does not contribute to effective training. For this reason, students in this study will receive training in ASPT configured as an A-10 and then actually fly in the A-10 aircraft. Using a motion platform to provide vestibular and kinesthetic cues to the pilot is a costly process. Not only are initial expenses increased but life cycle costs are also increased. Cyrus (AFHRL-TR-78-39, ***Motion Systems Role in Flight Simulators for Flying Training***) recently reviewed the literature relating to the use of platform motion systems in flight simulators for flying training. He concluded that platform motion is not required for most tasks and indicated that other less expensive methods of providing force cues should be able to serve in its stead. The g-seat or g-suit, either alone or in combination, might provide an effective substitute for platform motion by providing the necessary vestibular and kinesthetic cues. A transfer-of-training study will be conducted using recent Undergraduate Pilot Training (UPT) graduates as subjects. The flying tasks were taken from two categories of A-10 maneuvers: transition training and air-to-surface training. The students fly these maneuvers in the A-10 ASPT (where automated performance measures of basic aircraft maneuvers and weapons delivery scores will be recorded) and in the actual A-10 aircraft (where instructor pilot ratings of flying performance and gunnery range cues will serve as criteria). For the ASPT portion of the study, the two conditions of force cues will be (a) six-degrees-of platform motion on; g-seat and g-suit off and (b) six-degrees-of-platform motion off; g-seat and g-suit on. Two aspects of performance are of interest: rate of skill acquisition and final level of proficiency attained. The A-10 ASPT performances will be compared with aircraft performances to determine the relationship between flying skills as exhibited in the two systems. If simulator force cueing can be shown to have minimal effects on pilot training, or if necessary force cues can be generated by simple and inexpensive methods, reductions in the life cycle costs of A-10 simulators would be realized.

Impact/Utilization: This research is expected to produce data that will have direct impact upon the definition of A-10 simulator requirements.

Title: Methods for Determining Safety Training Priorities for Job Tasks

Description: The Air Force Inspection and Safety Center (AFISC) and the Air Training Command are interested in defining factors believed or known to be predictive of accidents. They are concerned with job safety training and the avoidance of injuries and loss of equipment, time, and materials due to on-the job accidents. Initially, a feasibility study was undertaken, using the Aircraft Armament Specialty (412X0), to determine a method for prioritizing job tasks in terms of hazard, frequency of accidents, and/or other pertinent factors which could assist training designers in determining needs for safety training. Two additional specialties, Fire Protection (571X0) and Fuels (631X0), are also being studied. Comprehensive Occupational Data Analyses Program (CODAP) techniques are used in the analysis of criterion data supplied by AFISC and of task factor data collected by AFHRL and the Occupational Measurement Center.

Impact/Utilization: Successfully determining safety training priorities will improve job safety training. Specifically, there can be an avoidance of injuries and a loss of time and materials due to on-the-job accidents.

Title: Performance Measurement for Air Combat Maneuvering Training

Description: The specialized flying training environment provided by the Simulator for Air-to-Air Combat (SAAC) can support new concepts of aircrew performance measurement. A series of studies are underway at the Tactical Research Branch (Luke AFB, Arizona) to analyze the unique features of Air Combat Maneuvering (ACM) training and identify the measures that best predict criterion behavior. Two contract efforts and two in-house studies are nearing

completion. The studies assess Tactical Air Command (TAC) ACM training practices.

Impact/Utilization: Results of the studies will be used to evaluate the potential for performance measures (PM) in simulated environments at training and operational units. Extension of the conceptual ideas to ACM instrumented range systems will be evaluated to determine transfer of simulation training to the aircraft. Implementation of contractor recommendations will depend on further analysis of the candidate systems and TAC/DOOS decisions on automated performance measurement for ACM training. Development of a PM system for ACM training will provide an indicator of training effectiveness (accountability) for training received in advanced simulators. Defined PM systems will provide a step to the objective measure of training transfer to the aircraft. The long-term outlook is that pilot performance can be measured in the ACM environment with sufficient accuracy to make useful assumptions about the impact of simulated ACM training. The end result should be increased training efficiency, improved training systems development, and an enhanced operational readiness training program for tactical aircrews.

Title: Perishability of Skills and Knowledges in Maintenance Specialties

Description: The objective of this study is to research the extent to which training and retraining scheduling decisions can be predicted by occupational survey ratings in order to plan experimental programs in the skills maintenance area, and to generate experimental input for use in the design of prototype systems for task training scheduling decisions. A minimum of two criterion scales will be tested—one for the amount of time to regain proficiency if the task/skill is not performed for one year, and one for the frequency of practice to retain proficiency. Average person and incumbent ratings will be obtained from two electronic and two mechanical career ladders. The data will be cross checked, i.e., average expert opinion versus incumbent opinion, and also correlated with the existing task factors of consequences of inadequate performance, task delay tolerance, and task learning difficulty.

Impact/Utilization: Application of this methodology will provide a quantitative basis for determining task retraining priorities and the scheduling of that retraining.

Title: Retraining and Transferability of Skills

Description: A continuing problem for Air Force personnel managers is the imbalance in career field manning created by attrition, fluctuations in the recruiting pool, organization and mission changes, and technological advances in weapon systems and other hardware items. To adjust to manpower shortages and overages in career fields, managers rely heavily on the Air Force's capability to retrain enlistees from one occupational specialty to another. A systematic evaluation of the operational retraining system is now being conducted by the Occupation and Manpower Research Division. The types of reassignment actions which are operating smoothly and those which are generating problems are being examined to distinguish the characteristics of successful retrainees. A further research thrust is the impact of past experience and acquired skills on the enlistee's accommodation to his new occupational role. Preliminary analyses of the scope and impact of retraining in 35 occupational specialties were completed in FY78. In general, this pilot study revealed that the career progress of retrainees, their attitudes towards their jobs and training, and their job assignments were comparable to a sample of non-retrained airmen when the influence of amount of military service was controlled. Additional research in the areas of technical school performance, aptitude, skill upgrading, and reenlistment is ongoing.

Impact/Utilization: Current research will provide managers of the Airman Retraining Program (HQ USAF/MPPPN) and related programs, such as Palace Balance and Careers Job Finder, with an empirical basis for evaluating and effecting policy decisions. Improvements in retraining selection and assignment procedures are expected to stimulate participation in the retraining program and to favorably impact reenlistment decisions. Further, assignments which optimize skill transfer between specialties will result in dollar savings through reductions in the amount of formal and on-the-job training time required for retrained personnel to become proficient in their new specialties.

Title: Skills Maintenance and Reacquisition Training

Description: The Flying Training Division of AFHRL and Headquarters, Air Force (USAF/XOOTD) have prepared a plan for development and validation of an Air Force skills maintenance and reacquisition training program (Project SMART). This research anticipates future Air Force flying-training requirements where energy and aircraft costs preclude application of current training practices. The objective of Project SMART is to develop and implement comprehensive, quantitative objective procedures which will permit efficient management of individualized flying training and provide aircrew mission readiness at minimum cost. Because prospects for reduced flying are more critical for Strategic Air Command (SAC) and Tactical Air Command (TAC) and because the mission of these major commands (MAJCOMs) require a wide variety of flying skills, Project SMART has been designed to focus on SAC and TAC missions. Project SMART will generate the following products of substantial benefit to the Air Force:

1. Analysis of cost tradeoffs for continuation training
2. Improved procedures for management of the rated force
3. Determination of factors in aircrew skill degradation
4. Objective measurement of individual and squadron readiness
5. Development and evaluation of innovative training strategies

Project SMART consists of these program elements: (a) Preliminary Evaluation—a mini-test of the research concepts and procedures of the program, (b) Identification and Definition of Critical Flying Skills—a joint AFHRL/MAJCOM effort to develop an operational definition of mission readiness; (c) Development of Skill Measures—practical, acceptable and meaningful objective, quantitative procedures will be developed, refined, and evaluated; (d) Measure Skill Retention—implementation of skill measurement techniques to document the degradation of critical flying skills as a function of the duration of time during which no flying occurs; and (e) Test of Alternative Skill Maintenance and Reacquisition Training Programs—determine effective training strategies and methods which maintain mission readiness and eliminate skill degradation.

Impact: The TAC preliminary evaluation has identified and defined flying skills required in the pop-up weapon delivery and manual dive bombing maneuvers and the low altitude tactical formation task and has developed and refined skill measurement procedures for these maneuvers/tasks. The accumulation of skill measures has led to these applications of Project SMART products: (a) implementation of *pop-up weapon delivery skill measurement* procedures in a new program for training this maneuver in the Arizona Air National Guard A-7 Fighter Weapons School, Tucson International Airport, Arizona; (b) evaluation of the effectiveness of pop-up weapon delivery skill measures in combat crew training (CCT) by pilots in the F-4 B Course by the 354th TFTS, Luke AFB, Arizona; and (c) modification of the low-altitude, tactical-formation training program, giving increased emphasis to formation mutual support and defensive tactics training by the 354th TFTS, Davis-Monthan AFB, Arizona.

HUMAN FACTORS TECHNOLOGY

Title: Advanced System for Human Resources Support of Weapon Systems Development (Project 1959)

Description: The purpose of this project is to provide a technology capable of predicting, early in the weapon system acquisition cycle, the life cycle cost/human resource/system support impacts of alternative weapon system designs and support concepts. In the past, weapon systems have been designed with little attention devoted to support of the system in the field, largely because little definitive

information was available early in the system design on the effects of alternative designs on system supportability. With the costs of system operation and support approaching 80% of life cycle costs in some systems, and with the costs of the human resources associated with the weapon system being approximately 50% of the systems life cycle costs, designers must be provided with the information necessary to control life cycle costs through the design of the weapon system. This will be accomplished by integrating, validating, and demonstrating a number of techniques, separately developed and validated by AFHRL, into an integrated technology for planning the human resource element of a weapon system. The resulting integrated technology will provide timely feedback of the life cycle costs of alternative weapon system designs early enough in the acquisition cycle to provide decision makers the opportunity to consider human resources life cycle costs in the design of the weapon system. The approach is to integrate, apply, and test the technologies that AFHRL has developed in the areas of (a) including human resources and personnel costs as parameters in design studies, (b) forecasting and controlling manpower requirements through the application of systems analysis and computer modeling techniques, (c) improved technical data for maintenance personnel, (d) training requirements analysis and avanced training techniques, and (e) system ownership costing. The project is conducted in close cooperation with the System Program Office for the Advanced Medium Short Take-Off and Landing Transport (AMST) and with the AFSC Aeronautical Systems Division Deputy for Avionics Control (ASD/AX).

Impact/Utilization: This research should have a significant impact on the methods used to design, and on the actual design of, future weapon systems. It will also affect the weapon system development approval cycle, as different information requirements and trade-off study results will be required for system approval to proceed at major Defense System Acquisition Review Council (DSARC) reviews. The results of this research can be used by System Program Offices, weapon system contractors, Air Logistics Centers, and others involved in the design and major modification of weapon systems.

Title: Computer Based Maintenance Aids for Technicians

Description: The increasing complexity of Air Force weapons systems has resulted in a greatly increased need for technical data. As a result, the number of pages of technical orders required to provide technical data has increased greatly. The huge volume of technical data is overloading the already cumbersome paper based technical order system. The problem is further compounded by the increased use of newer types of technical data such as job guide manuals, which have been shown to improve the efficiency of maintenance personnel, but these types of technical orders require more pages. An economical, non-paper based method for storing, updating, and distributing technical orders is urgently needed. A computer based system has the potential for meeting this need. The objective of this project is to develop, demonstrate, test, and evaluate a prototype computer-based system to meet this need. The prototype system will provide for the storage, retrieval, and display of technical data for use by maintenance technicians. Emphasis in designing the system will be placed on designing a system that is easy to use, provides all information needed by the technician to maintain a system, and enhances the technician's performance. The prototype system will include an electronic display device (CRT/ plasma), a mini-computer/micro-processor, and a storage device. Off-the-shelf components will be used. Specialized software will be developed to control the retrieval and display of the technical data. After the prototype is developed, technical data for a representative test bed system will be placed upon the prototype system. The effectiveness of the prototype will then be evaluated by measuring the performance of technicians using data presented by the prototype system to maintain the test bed system. The study will evaluate the feasibility and desirability of an automated technical order system and will define the requirements for an effective system.

Impact/Utilization: The prototype system, specifications, and lessons learned in the evaluation will be used by the Air Force Logistics Command in the development of the computer based technical order system for operational use throughout the Air

Force. This program will contribute to reducing the cost of maintaining weapons systems by improving the efficiency of Air Force maintenance technicians and by reducing the cost of maintaining the Air Force technical order system.

Title: Develop Models of Maintenance Resources Interaction

Description: The accurate forecasting of maintenance manpower requirements to support a weapon system is greatly influenced by the status of other major resources (e.g., spares and support equipment). The computer simulation, previously developed at AFHRL (the maintenance manpower model, utilizing the Logistics Composite Model (LCOM) is used by the Air Force to determine the manpower requirements for weapon systems. Currently LCOM requires that the other resources be held constant. LCOM would be more valuable if models of the maintenance resources interaction were developed. The determination of the LCOMs sensitivity to the resources interaction for a weapon system (F-15) under a peacetime environment will provide the basis for the development of models of the interactions. The outcome will be models of the interaction between manpower, spares and support equipment required to support a weapon system's operations and maintenance.

Impact/Utilization: The results of this study will be used to provide a means for more accurately forecasting manpower along with the requirements for spares and support equipment. The results also have the potential to provide the Air Force with a means for determining readiness. The users of the end products will be all Air Force LCOM users, working with both developing and operational weapon systems.

Title: Handbook for Selection of Format Options for Procurement of Technical Data

Description: Significant progress has been made in recent years to improve Air Force technical data for maintenance. Application of job guide manuals, logic tree troubleshooting aids, functionally oriented maintenance manuals and other types of improved technical data have significant potential for improving Air Force maintenance. However, implementation of these data is handicapped by the fact that many technical data managers are not sufficiently familiar with the various options and the applications for which each type of data is appropriate. Available information on the various types of data is widely scattered in technical reports and other documentation which is not readily available. A handbook describing the types of improved technical data that are available and providing guidance for the selection of technical data options for selected applications will be very helpful in overcoming this problem. The handbook being developed will contain information about what technical order formats are available, how to determine which format to select, and how to procure and manage the development of the technical orders. Guidelines will also be included for implementation of the technical orders in an operational environment.

Impact/Utilization: The handbook is expected to become the basic source of information for technical order managers in the system program offices in the Air Force Systems Command, the Air Force Logistics Command, and the major operational commands. When available to technical order managers, the handbook should have a favorable impact on the technical order procurement process. The end result should be more realistic determination of requirements, more appropriate and accurate data, and improved performance from the maintenance technician because of the improved data.

Title: Weapon System Design and Need for Human Resources Data

Description: The weapon system design process is being described, and its need for human resources data is being outlined. This is being done in order to outline a unified data bank that would serve the data needs of Air Force Test and Evaluation Center (AFTEC), Air Force Acquisition Logistics Division (AFALD), Aeronautical Systems Division (ASD), and the aerospace companies. This unified data bank is to be consistent, tractable, traceable, and accessible to all of the above users.

Impact/Utilization: AFALD, AFTEC, ASD, and the aerospace companies will all use the unified data base which could emerge from this study. Assurance will

be provided that they would all be using consistent data and that the data would be available in the very earliest design stages.

MANPOWER AND PERSONNEL MANAGEMENT TECHNOLOGY

Title: Advanced Research on Adaptive Testing Systems

Description: The policy of the Air Force has been to develop uniform standardized aptitude tests for all enlistment applicants. These tests must be as short as possible, accurate at all levels of ability, and valid for training and performance criteria. When every applicant for enlistment must be administered the same test, compromises in test design are necessary and accuracy of measurement is limited to a range around the mean of the ability spectrum. This means that misclassification of an applicant is more likely to occur in the ability regions which are outside the range of best measurement. Adaptive testing is a strategy for tailoring the number and difficulty of test questions during test administration. The actual presentation of items reflects the applicants responses and the system avoids the presentation of inappropriate items. The topic is being studied through a combination of theoretical simulation and live testing of subjects.

Utilization: Adaptive testing will be used by USAF Recruiting and by the Military Enlistment Processing Command.

Title: Armed Services Vocational Aptitude Battery (ASVAB) Subtest and Composite Revisions

Description: A validation study of current Armed Services Vocational Aptitude Battery (ASVAB) subtests and composites for predicting Air Force technical training course grades is presently being accomplished. Analyses already completed have demonstrated the absolute and relative value of the test measures and have aided in determining which subtest should be dropped from or replaced in future ASVAB forms. On the basis of Air Force and other service validations, changes are being made in ASVAB forms 8, 9, and 10 (to be implemented in October 1979) which will increase validity and reliability of the battery. Analyses now underway will identify optimal subtests for Air Force composites. These changes will enhance battery validity and insure fairness for sex and race subgroups.

Impact/Utilization: ASVAB is used for the initial screening and classification of all non-prior service Air Force accessions. In this context improvements in predictive validity could enhance the utility of the applicant pool and tend to place more easily trainable personnel in each vocational area.

Title: Assessment of Job Physical Requirements

Description: Despite a general awareness that enlisted specialties differ in their requirements for physical strength, stamina, and coordination, there has been very little systematic research done to support definitive assignment criteria. Recently, Air Force management has expressed concern about the adequacy of current standards and evaluation procedures for qualifying applicants in heavy and very heavy work assignments. The problem has become particularly acute as increasing reliance is placed on the utilization of women in both traditional and non-traditional careers. A research program directed toward establishing physical requirements for Air Force jobs and developing associated personnel testing procedures has been initiated jointly by AFHRL and the Aerospace Medical Research Laboratory (AMRL). The project has four identifiable phases. In the first phase, a comprehensive job analysis will be conducted for all enlisted specialties based on supervisory surveys and quantification of selected task requirements in the field. The second and third phases involve the development and evaluation of personnel testing devices suitable for measuring relevant dimensions of strength and stamina. Validation of the test measures with regard to job performance would be pursued in the fourth phase with a view toward eventual implementation via the person-job-match system.

Impact/Utilization: Significant improvement in force readiness are expected to result from the use of personnel assignment procedures based on (a) detailed analysis of work requirements and (b) improved methods of assessing applicant capabilities in the strength and stamina domain. Cost savings would also accrue to the extent that the qualified applicant pool is expanded to include a larger proportion of the female work force and fewer persons are assigned to jobs which exceed their physical capabilities.

Title: Career Progression and Performance of Air Force Personnel Enlisted in CY 1970–1975

Description: The Air Force, as well as other military services, incurs varying degrees of turnover. As the peacetime military budget decreases and the cost of recruiting and training personnel increases, concern with turnover becomes prominent. The detrimental effect of turnover is not limited to losses in personnel procurement investments alone; organizational effectiveness and the combat readiness posture of the force also suffers. This work unit is aimed at identifying characteristics of enlisted personnel who are not likely to succeed in their first enlistment tour. Enlisted airmen data files covering the period 1970–1975 serve as the data base for this effort. Biographic, attitudinal, and performance data have been compiled from airman record files on yearly input of male and female enlistees. Criterion data of special interest include disciplinary actions, airman performance reports, unsuitability discharges, medical data, and reenlistment eligibility information. Particular attention is directed to factors which may be related to early separation prior to completion of initial tour of duty. Both distributional and correlational techniques are used in examining the data base. A technical report will be produced which describes the different phases of this effort.

Impact/Utilization: This research effort will work toward the reduction of costs associated with attrition by investigating and identifying factors related to successful career progression, successful first term completion followed by non-reenlistment, and involuntary loss. Insofar as these factors are identified they can influence Air Force policy or contribute to modification of selection standards and classification procedures.

Title: Design and Validation of Relative Time-Spent Scales

Description: The use of relative time-spent rating scales to collect work time from job incumbents has been and is the best method of data collection. However, the rating scale that will provide the best information is open to challenge. This study will determine which scale formats provide the most reasonable estimate of time spent on the job. In scope, the problem is not isolated to the Air Force, but includes all other branches of the service, many civilian government agencies, foreign military establishments, and in fact any organization that is using the Comprehensive Occupational Data Analysis Program (CODAP) which relies upon time spent rating scales for input. A series of rating scales are being used to collect job data from incumbents in two Air Force specialties (AFSCs 631X0 and 461X0) on a time 1/time 2 basis. Time 1 data collection is in the form of time-spent ratings, while time 2 collection is in the form of confirmation of percentage of time spent on tasks. The desired outcome of the study is confirmation of the best relative scale to use in collecting time-spent data from job incumbents.

Impact/Utilization: Research results will impact heavily on both government and private industry and also on foreign agencies who are using the CODAP system.

Title: Development of an Appraisal System for USAF Civilian Personnel

Description: The development of a system for the evaluation of job performance and the assessment of promotion potential for civilian personnel is underway. This system includes a module for each element indicated above. The job performance module pivots upon a supervisor-worker agreement of the dominant elements, or tasks, of the job upon which ratings should be rendered and includes a system establishing the priority of those tasks and standardizing the ratings across positions. The promotion potential model will include biographical, experiential, aptitudinal, and performance-based variables which will be collected across the full spectrum of Air Force civilian employees. Experts in each vocational area

will define the variables critical to promotion in that area through a policy capturing exercise. Although the requirement for this effort predates the Civil Service Reform Act of 1978 by 2 years, it is believed that the evolved system is precisely in accord with the objectives of that act.

Impact/Utilization: The results of this effort will be used for all civilian employees throughout the Air Force. It will be the basis for selection for promotion, special assignments, training, or other personnel actions. This system will permit management and career development of the civilian workforce on the basis of an objective appraisal system established on the basis of experimental studies. It is believed that over time this system will be seen as responsive to the needs of management and of the employee.

Title: Development of Improved Methods for Predicting Involuntary Separation

Description: The classification accuracy of the Motivational Attrition Prediction (MAP) method is being compared to the classification accuracy of other statistical methodologies, such as Bayesian classification theory and multiple linear regression analysis, in binary classification problems. The MAP computer program was obtained from the Air Force Manpower and Personnel Center (AFMPC), implemented on the AFHRL UNIVAC 1108 computer system, modified to increase its data-handling and computational capabilities, and thoroughly tested. The first phase of this effort, comparing the classification accuracies of the methodologies in identifying first-term airman involuntary dischargees, and examining the computer resources required to perform the computations for each methodology has been completed and documented in a draft technical report. Additional research efforts have been initiated to evaluate the predictive efficiencies of the various methodologies using other binary criteria such as graduation/elimination from technical training, basic military training, and undergraduate pilot training. A major difference between the follow-up studies and the completed effort is that the test design for the follow-up studies requires the validation samples to be randomly selected from personnel who entered training 1 year and the cross-validation samples to be randomly selected from personnel who entered training the following year, rather than selecting the validation and cross-validation subsamples from the same population.

Impact/Utilization: Various Air Force agencies (such as AF/DPXXOA, AFMPC/DPMMA, and ATC/RSM) concerned with the problem will use the results of this research for the development of improved selection standards for initial obligated tour of duty and various types of training programs. The results could also be generalized to improve prediction in other areas of the personnel system such as promotions and retirements.

Title: Empirical Analysis of the Supply and Retention of Air Force Personnel Using A Simultaneous Equations Approach.

Description: This effort provides a new approach to the problem of modeling military manpower supply. In this approach, the retention and accession markets are linked together simultaneously within an uncertainty framework. This coupling provides some important new insights into military manpower markets because it accords equal importance to the demand for new accessions which, in turn, is linked to retention experience and accession supply. Preliminary tests of the developed model with recent Air Force data indicate that the model has greater explanatory power than the conventional career-choice-based single-equation-supply model. The preliminary work done to date, while confirming the approach, contains only a fraction of the information that can be extracted from the data. A second effort is now in progress to extend the model in order to quantify the basic behavior elements in a manner that will characterize the dependence of enlistment supply, personnel retention, the mean inventory of personnel, as well as factors in the civilian market.

Impact/Utilization: Results of this research will be used as the foundation in the subsequent development of a Skills Market Model (SMM). The SMM will be designed to predict the demand and supply of the labor skills which are required by the Air Force to accomplish its mission and their impact upon attrition and retention. The SMM will be designed to function either as a Labor Market Module of (ISEM) the Integrated Simulation Evaluation Model or as a stand-alone model for manpower studies. Dollar savings at this stage are unknown, although the potential for savings is quite great. Increased knowledge of the impact of various economic variables and Air Force policies on accession and retention rates can lead to the implementation of the most appropriate Air Force policies.

Title: Integrated Simulation Evaluation Model (ISEM)

Description: The Integrated Simulation Evaluation Model (ISEM) is an AFHRL effort to develop a total system simulation model of the Air Force manpower and personnel system, including active duty and reserve military forces and civilian employees. ISEM departs from most other manpower personnel modeling efforts in its emphasis upon the Air Force manpower and personnel system as a single, unified, integrated system which procures and translates human assets into mission capabilities. The total system orientation constitutes the basis for development of ISEM as a large-scale simulation model which integrates subsystems across functional specialties and evaluates performance of total system effectiveness and efficiency.

Impact/Utilization: ISEM will be used to provide decision-makers with information of a fundamentally different type. This information is different in that it systematically incorporates the total system perspective into high-level policy analysis. This perspective is highly desirable but difficult to incorporate into policy analysis unless it is designed into policy analysis from its very conception. In today's environment, policy analysis frequently must be done very quickly, leaving insufficient time to develop the required model. Instead, existing models must be used. While these models generally do an excellent job of performing the specific task for which they were designed, they are specialized to satisfy the unique requirements of a particular part of the Air Force manpower and personnel system. Some pieces of the Air Force manpower and personnel system are highly modeled and others are not, and since these piecewise models are specialized in varying ways, they are difficult to interface in a timely manner into an effective high-level policy analysis tool. As a result, the total systems perspective is difficult to achieve in policy analysis with existing tools. Rather, a generalized model is sorely needed for high-level policy analysis so that the potential consequences of various policy options may be more completely understood by senior decision-makers before policy choices are made. With today's policy analysis tools, understanding the total system impact of policy options is very difficult. ISEM would make this important requirement much more attainable by providing a generalized capability for analyzing how policy interacts with all the elements of the system (manpower, personnel, and training) to affect (a) mission capabilities, (b) costs, and (c) the efficiency with which the system operates. ISEM will provide the decision-maker with improved information for understanding the total system impact of policy options. This will provide the senior decision-maker with a substantially improved basis for resolving many important high-level policy issues within the Air Force manpower and personnel system and with an improved rationale for justifying policy.

Title: Likelihood Function Estimation (LIFE) Model

Description: A prototype mathematical model was developed to better model binary or dichotomous variables. Tests showed that the technique had a good capability to model this type of variable and should be further developed. Under contract, the prototype is being taken from its rudimentary form and developed into a finished product. The model can be used to model dependent dichotomous variables (such as pass/fail, promote/not promote) and to develop a prediction system for use as a selection criterion.

Impact/Utilization: The Likelihood Function Estimation (LIFE) methodology was used to develop a prediction system for first-term attrition of Air Force enlistees. This prediction formed the basis for a new Air Force eligibility criterion which is currently being tested by Air Force Recruiting Service under Project IMAGE. If successful, the new eligibility criterion could qualify more people for Air Force enlistment without increasing the previously experienced first-term attrition rate. The methodology can also be applied to other selection situations such as officer training, pilot training, and technical training.

Title: Methods for Collecting and Analyzing Task Analysis Data

Description: This effort is aimed at determining methods to define standardized task analysis methodology for use in the Air Force technical training environment. The contract is to identify methods for collecting and analyzing task analytic data that are simple to use, reliable, valid, and

practical, for standardized application by instructional systems development staffs at Air Training Command training centers. A handbook will be developed outlining procedures that would provide some degree of uniformity and quality control at various training centers and schools. To accomplish these objectives, a survey of current task analyses procedures has been conducted, an experimental task analysis handbook has been developed, and the handbook has been field tested at selected training centers.

Impact/Utilization: This research will permit the identification of objective information regarding essential skills and knowledges which the trainee must learn. It also holds the potential for increasing training efficiency while reducing training costs.

Title: Prediction of Quality and Quantity of Potential Enlisted Recruits

Description: With the use of the person-job-match (PJM) system in optimally assigning recruits to their first jobs, it is important to accurately predict the quality and number of future recruits. Two contract efforts were initiated in FY78 to devise forecasting packages that could be implemented into the assignment system. One effort will research traditional time-series forecasting packages with a special emphasis on practical applications. The second effort is exploring the possible use of Kalman filtering and other control theory techniques in forecasting the time series of recruit quality and quantity. Whatever forecasting package is developed will be implemented in the PJM computer assignment system.

Impact/Utilization: An accurate prediction of recruit quality should have a dramatic effect in improving the payoff to the Air Force of the first-term enlisted assignments. The mathematical assignment formulas presently operating are very sensitive to the assumed or predicted aptitudes of future recruits. The operational PJM assignment system now uses very rough estimates of future pools of recruits in its mathematical formulas. Differences in estimates across Air Force Specialty Codes (AFSCs) can cause important differences in assignment procedures for those AFSCs. The second research effort, dealing with Kalman filtering, is somewhat exploratory in nature. Beyond its use for this particular area, the effort will help determine the applicability of control theory and state-space modeling to human resource time series in general, possibly opening new areas for broader application.

Title: Research and Development of an Air Force Occupational Information Center

Description: The objective is to establish an Air Force Occupational Information Center that will be concerned with the collection, analysis, maintenance, ready retrieval, and reporting of a wide variety of current and historical information describing all airmen and officer occupations. Data elements from widely dispersed data bases will be integrated and related to each other in a systematic fashion. In addition to information about personnel resources, information about the correlates, antecedents, and consequences of selected occupational requirement variables will be included in the integrated data base.

Impact/Utilization: In addition to providing a quick response capability when information is requested from AFHRL's many data bases, the Occupational Information Center will provide new information about important policy issues that have not been properly addressed before, simply because the data from one subsystem (e.g., percent fill in an organization) have never been adequately related to data from another subsystem (e.g., accidents).

Title: Screening for Adaptability

Description: Over 50 percent of the DoD budget covers personnel costs. These costs include the procurement, training, selection, separation, and retirement of personnel. One portion of cost associated with separation of military personnel prior to completion of their normal obligated tour represents an avoidable expenditure if personnel not

likely to adapt to the military environment could be identified prior to enlistment. To reduce these costs, personnel managers have directed attention toward possible ways for minimizing attrition. Identification of attrition-prone individuals has been an area of current interest for all branches of the military service. Studies in this area indicate that high-risk individuals can be identified with an acceptable degree of accuracy; however, with the projected decline in the number of service-eligible young men and women in the 1980's, we cannot tolerate screening which identifies a large number of potential maladaptive personnel and at the same time incorrectly identifies, as high risk, a sizeable number of recruits who would be successful. To remedy this situation, research is now focusing on the prediction of attrition-prone individuals with more precise selection instruments to differentiate more accurately between potentially successful and unsuccessful personnel. The current project continues the assessment of the utility of various screening instruments in predicting separations during the first term and the development and validation of screening composites to identify individuals most likely to be lost during the initial 4-year term. The purpose of this research effort is to determine the usefulness of screening devices for adaptability to military life, for both male and female personnel, and to investigate the applicability of utilizing biographic, demographic, and aptitudinal data in conjunction with screening devices to increase predictive accuracy.

Impact/Utilization: If screening composites comprised of aptitudinal, biographical, and inventory data appear to indicate that a preliminary screening device can be effective in the identification of high-risk personnel, such a screening methodology will be recommended for use on potential recruits prior to entry into service. A final decision for implementation must be carefully evaluated by considering savings which would accrue by early identification of high-risk personnel versus the loss of potentially successful personnel who might be denied the opportunity to enlist.

Title: Voice Spectral Analysis as a Measure of Stress in Air Combat

Description: Available methods of assessing operator stress have limited applicability for airborne aircrew operations where interference in task performance is not tolerable and post hoc measures provide a poor assessment of specific stress-task relationships. However, recent literature suggests that analysis of the spectral qualities of an operator's voice can provide an unobtrusive, real-time or historical (via audio recordings) indication of the operator's stress level. The objectives of this research are to investigate the relationship between stress and the voice output of aircraft operators and develop a system of stress quantification based upon voice analysis. To achieve the objectives, historical voice communications from aircrews operating in actual combat environments will be used as data bases and subjected to spectral analysis and evaluation.

Impact/Utilization: A stress assessment methodology based upon voice spectral analysis would have value in a number of military related applications. In research, a valid stress indicator could serve as a predictor of future operator performance in arduous environments or as a criterion in studies involving stress management training. In the selection and classification process, a stress management factor might add relevant information for particular fields. In training, stress assessment could aid in monitoring student performance in critical areas of flight training, such as emergency procedures, and also help in assessing the psychological realism of simulation scenarios. In the operational environment, this technology could provide a real-time evaluation of operator stress, or through radio and flight deck recordings, be used in investigating the relationship between operator stress and aircraft accidents. Overall, an unobtrusive methodology of stress assessment could be useful in a variety of applications, all centered on increasing the performance of Air Force personnel resources.

TRAINING DEVICES AND SIMULATION TECHNOLOGY

Title: A-10 Training Research Engineering Support

Description: The objective of this project is to modify Cockpit A of the Advanced Simulator for Pilot Training (ASPT) to an A-10 aircraft configuration to provide a tactical weapons delivery capability, heads-up display (HUD), advanced g-suit/g-seat, A-10 flight dynamics, and weapon

scoring in support of transition training research and Air-to-Surface research capabilities. A two-phase approach is being used. Phase I provides limited research/transition training and air-to-surface (A/S) capability including a HUD. A temporary A-10 cockpit will be configured over the existing T-37 cockpit and appropriate software changes will provide the necessary flight dynamics. Phase II will provide advanced transition and A/S research/training capability. A modular A-10 cockpit (including a programmable flight control system) and weapons control panel will be developed from a Cockpit Procedures Trainer (CPT). Additional basic and visual changes will be made to support the expanded weapons system requirements. The Phase I ASPT conversion was completed in FY77. Phase II status follows: Manual Reversion (MRFCS) math model is complete. Software programming will be finished by the end of January 1979 for integration into ASPT. Programmable control loading software design is complete. Hardware for control loading has been tested and functions as designed. Expanded airspeed and altitude envelopes are complete. Expanded engine envelope is finished. Weight and balance for a clean aircraft is finished, additional weapons configuration specifications are known, math models and programming will be finished by mid-February 1979. Force cueing (g-suit, g-seat, platform motion) is complete; however, optimization with different hardware will start 1 March 1979. Nap-of-the-earth visual capability is in the testing phase. Performance measurement, excluding studies conducted in a hostile environment, is finished. A hostile environment scenario is not available from TAC at this time. CPT shell has been obtained. A platform to accommodate motion has been designed. Electra-luminescent panels have been fitted to the CPT shell. Phase II cockpit configuration will be placed in ASPT cockpit A bay 1 March 1979 for research on 1 May 1979.

Impact/Utilization: The engineering modifications made to ASPT provide an A-10 simulation capability 2 years ahead of the first projected operational A-10 simulators, resulting in: (a) increased flight safety through transition training for pilots of this single seat aircraft; (b) A/S training reducing the number of aircraft sorties which saves about three million dollars for pilot weapons qualification and, most importantly; (c) the training research gained will significantly modify the A-10 training syllabus, thereby greatly enhancing the effectiveness of the operational simulator.

Title: Advanced Tactical Air Combat Simulation (ATACS)

Description: The Air Force is currently on contract for the development of competitive visual simulation systems for the A-10 and F-16 flight simulators. Although these visual simulation systems will represent the current state of the art, they will not be capable of meeting the Tactical Air Command (TAC) requirements for multiple, high resolution, friendly and aggressor targets and high detail, realistic computer-generated color imagery. Conventional visual simulation techniques, including dome and optical mosaic visual display with projector and cathode ray tube inputs, cannot fully satisfy these requirements. AFHRL has been aware of this problem and has developed several diverse technologies under Projects 6114 and 1958 which, when combined under Project 2363, have great potential for satisfying the TAC requirements. In order to satisfy the requirements, a new type of image input device is being developed. The liquid crystal light-valve projector (LCLVP) holds the promise for a high brightness, high resolution, color visual display. To display this color imagery at infinity and collimated, a trichromatic holographic Pancake Window (TCHPW) is also being developed. In addition, a computer image generation system is being developed with new features such as surface texturing, elliptical and ellipsoidal objects, and improved shading techniques.

Utilization: The advanced visual simulation technology from the ATACS Project will be applicable to the next generation fighter/attack visual systems and Project 2360, the current generation fighter/attack visual system engineering development project, to improve its performance through incorporation of components into later production versions and through retrofit of operational simulators. The delivered Project 2363 hardware will be utilized during the first 6 months after acceptance for training utility evaluation (using TAC pilots), including engineering refinement and re-evaluation. After this initial evaluation period, the hardware will

be used to support other planned advanced development efforts and simulation psychophysical studies.

Title: Area of Interest/Field-of-View Research Using Advanced Simulator for Pilot Training (ASPT)

Description: A cost constraint for computer image generation (CIG) visual simulation systems is computer edge capacity. The larger the field of view (FOV), the greater the edge capacity required to generate detailed visual scenes. A promising technique with the potential for increasing scene detail without an associated increase in computerized edge generation capacity is the head-slaved, area-of-interest (AOI) approach. With this technique, the FOV, the size of which may be varied, moves with the frontal plane of the pilot's head. The existing edge capacity of a CIG system may therefore be concentrated within the FOV, thus permitting increased scene detail in the area within which the pilot's attention is most likely to be concentrated. Further, visual cues peripheral to the AOI may also be displayed, the detail level of which may be varied as needed. For example, a degraded image, just sufficient for spatial orientation and to cue further head movement might be displayed peripheral to the AOI in order to preserve maximum edge detail within the FOV employed. Research is needed in order to determine optimum AOI sizes for various tasks and associated detail level/FOV size tradeoffs. The proposed research will compare air-to-surface (A/S) weapons delivery performance in the Advanced Simulator for Pilot Training (ASPT) across various AOI sizes and detail levels inside and external to the FOV. It is anticipated that the results will establish the smallest AOI size feasible for A/S delivery and optimum associated detail levels.

Impact/Utilization: The results will be of value in determining the applicability of the AOI approach to future simulation procurements. In addition, the results will establish the feasibility of implementing AOI technology in existing simulators in order to enhance their training capability.

Title: ASPT F-16 Engineering Support

Description: The objective of this project is to modify Cockpit B of the Advanced Simulator for Pilot Training (ASPT) to a nominal F-16 configuration for limited transition and air-to-surface research/training. A modular cockpit concept will be used, replacing the T-37 cockpit on B side of ASPT with a hybrid F-16 Cockpit Familiarization Trainer (CFT). The CFT will have operable flight instruments, side arm controls, weapons management systems, and heads up display. ASPT software will be developed to represent the handling qualities and performance of the F-16 aircraft up to a minimum of 40,000 feet and 0.9 mach number. Sufficient weapons system simulation will be conducted to accomplish the research/training objectives. The modification of ASPT to a F-16 configuration was approved August 1978.

Impact/Utilization: The engineering modification that will be made to ASPT provides a F-16 simulation capability 5 years ahead of the first projected operational F-16 simulators, resulting in (a) increased flight safety through transition training for instructor pilots using sensitive side arm controllers for the first time, (b) assist in defining wide field of view requirements for air-to-ground training, (c) reduce fuel and other flight-related costs required for initial F-16 training by an estimated savings of at least two million dollars, and most importantly, (d) conduct training research which will have far reaching impact on the F-16 training syllabus and the effectiveness of the operational F-16 simulator.

Title: ASPT G-Seat Optimization – Phases II and III

Description: The first wide field-of-view simulators for the F-16 aircraft are scheduled for delivery in 1985. During the interim period before delivery, it is important to provide the best possible substitute. To support the critical Tactical Air Command (TAC) training requirements and answer associated research questions, Hq USAF has directed that cockpit B of the Advanced Simulator for Pilot Training (ASPT) be modified to a nominal F-16 configuration. The purpose of this effort is to provide more effective high performance (F-16) aircraft simulation g-cues throughout various maneuvers and flight conditions with the ASPT pneumatic g-seat system. Although the pneumatic g-seat hardware response will be optimized through the Phase I effort, it remains to determine the most effective software drive technique or philosophy. The improved response will also make feasible special effects such as buffet, runway rumble,

gear effects, and turbulence. The objective of Phase II is to determine the most effective drive philosophy for the basic ASPT g-seat. The objective of Phase III is to attach and evaluate new g-cueing devices to develop new drive techniques (e.g., onset cueing), and to develop methods for applying special effects such as runway rumble, gear effects, buffet, and turbulence. Under Phase II, the optimized system of Phase I will be used to vary the drive philosophies of each g-seat component. Pilot feedback will be used primarily to determine the optimum ASPT g-seat drive philosophy. Accessory equipment will be attached to and driven by the ASPT equipment under Phase III. Finally, an onset cueing philosophy will be developed and implemented into the software.

Impact/Utilization: The results of this research will be applied to the A-10 and F-16 ASPT simulation to provide better high-performance aircraft g-cues and to apply the findings to future g-cueing device developments.

Title: Boom Operator Part Task Trainer (BOPTT) Initial Operational Test and Evaluation

Description: The purpose of the initial operational test and evaluation (IOT&E) of the prototype Boom Operator Part Task Trainer (BOPTT) is to assess the utility of this system as an alternative to aircraft flight training for boom operators. Essentially, the BOPTT will serve as a research vehicle to determine the contribution of simulation to skill acquisition in boom operator training programs. The ultimate goal of the IOT&E is to make long-range determinations of the cost-effectiveness of simulator training of boom operator skills in a limited flying environment. These determinations will include consideration of undergraduate training in the Combat Crew Training Squadron (CCTS), training of instructor boom operator personnel and device usage to maintain the proficiency of experienced personnel. If the combined test results prove the concept depicted in the Strategic Air Command (SAC) Concept of Employment, a favorable production decision could result in the award of a contract for production trainers. These devices would be deployed to SAC, Air National Guard (ANG), and Air Force Reserve (AFRES) units to serve as an integral element in the support of KC-135A force readiness. During the IOT&E, three studies will be performed simultaneously: the first with undergraduate boom operators to study skill acquisition, the second with highly experienced boom operators to study skill maintenance and reacquisition; and, the third to study the training requirements for instructor boom operators. The three studies will use a transfer of training methodology in which matched groups of subjects undergo a test-treatment-posttest procedural sequence. In Study 1, this methodology will incorporate proficiency advancement in order to accurately assess the training contribution of the BOPTT. Study 2 is essentially a classical learning/retention paradigm, while Study 3 uses a "job sample" approach involving real-world tasks. The statistical model for all studies is based on a univariate group-by-treatments analysis. The primary dependent variables are quantitative with questionnaires and expert ratings providing supplemental data.

Impact/Utilization: The costs savings potential of the BOPTT is impressive. According to SAC accounts, the direct cost per aircraft contact attempt required for the average CCTS student to reach proficiency is $432.17. The equivalent cost in the BOPTT is $80.39 for the first 20 contact attempts. Since preliminary data show that a direct substitution can be made in the early phases of flight training, the total savings per CCTS student would be $7,035.60. Based on an estimated CCTS output of 170 students per year, the resultant savings would be $1,196,052. The research performed in this IOT&E will be applied in two ways: (a) it will provide information required for an Air Force decision on a large production buy of similar devices; and (b) it will provide SAC a model for the conduct of future IOT&Es.

Title: Cost-Effectiveness Methodology for Aircrew Training Devices

Description: The objectives of this project are to develop and test a cost-effectiveness methodology that can be used to optimize the training devices of an existing or planned weapon system. The model will establish an optimal mix of training devices based on input data on procurement costs, operating and support costs, device capabilities, device availabilities, training requirements (numbers of crews and training

times required per crew), length of course, and possible numbers of devices. It contains options which allow device capabilities and costs to be input in alternative formats, depending on the type training program and the type of data available. The model tests all possible combinations of devices between given minimum and maximum values. For each alternative combination, it establishes whether the alternative is effective (i.e., whether or not it can accomplish the training specified by the requirement); for effective alternatives, it calculates the total life-cycle cost of each, and compares the values generated to select up to 10 least-cost alternatives. (More than one least-cost alternative is identified to allow the user to investigate cost differences and to facilitate decisionmaking involving tradeoffs between cost and other factors. For the same reason, several types of outputs are provided, including total cost, annual cost, cost per device, and cost of various components of the total cost.)

Impact/Utilization: This work will provide major command (MAJCOM) budget personnel, design engineers, operations analysts, MAJCOM commanders, and Air Force Chief of Staff personnel, with a tool for justifying training device acquisitions, tracking system costs, developing device specifications, determining tradeoffs between cost and effectiveness, and developing priority listings for new system acquisition and existing system modification. As a result of this project, a model will become available which determines the optimal mix of training devices from a cost-effectiveness standpoint. This should provide a valuable tool for decisionmaking, particularly as more cost and effectiveness data on training devices becomes available. The completed methodology will be available to the user by 1 May 1979.

Title: Depth Perception in Visual Simulation

Description: As simulation capabilities and cost pressures increase, more and more simulator training is being conducted. Tasks are now being considered for simulation which require distance judgment in a range where stereoscopic vision may be an important depth cue. This effort will examine the depth cues used by pilots in landing, air refueling, formation flight, and low altitude tactical maneuvers to help determine requirements for the presentation of depth cues in visual simulation systems. Current systems will be evaluated and recommendations for changes will be made. Experiments will be designed to obtain more detailed information concerning the use of depth cues by pilots, but will not be performed under this study.

Impact/Utilization: The results of this effort will be used to direct future visual simulation technology development. If it is found that improved cues are required for the performance of these tasks, then techniques must be developed to provide those cues.

Title: Design and Delivery of Flat-Panel 6883 Simulator for Comparison with Three-Dimensional Maintenance Simulator

Description: The objective is to develop and deliver a flat-panel simulation of the 6883 Converter/Flight Control Test Station associated with the maintenance of the F-111 aircraft. The simulator will subsequently be used in studies of the impact of psychological fidelity inherent in real equipment, three-dimensional simulators, and flat-panel simulators on technical training and subsequent job performance. Civilian contractors will design a flat-panel simulator providing comparable training capability to three-dimensional simulators previously developed. The flat-panel simulator will provide comparable training to three-dimensional simulators. To maximize comparisons between the two simulators, parameters will be contrasted insofar as practical. Initial areas where contrasts appear to be feasible are (a) physical fidelity, (b) one integrated system vs. a series of coordinated modules, (c) minicomputer vs. microprocessor control, (d) FORTRAN programming vs. an ATLAS-like language, (e) degree of integration with theory portions of course, (f) environmental requirements, (g) indigenous vs. adjunctive knowledge of results, (h) relative emphasis on procedures and system logic, (i) degree of performance monitoring, and (j) efficacy of stand-alone part-task trainers associated with the simulator.

Impact/Utilization: This research will result in a flat-panel simulator and associated documentation required for update and modification. The simulator will be utilized in subsequent investigations of the impact of physical fidelity on training in an effort to ascertain degree of realism required for cost-effective training. Results bear promise of having utility in the development of trainer requirements and specifications. These results would be meaningful both in terms of developing training systems for new weapons and also for improving training on existing systems. One area of particular interest would be the impact of lowered fidelity on the time required to develop and implement training programs.

Title: Handbooks and Model Specifications for the Design and Development of Maintenance Simulators

Description: The objective of this study is to collect, analyze, and document data in order to develop a set of introductory handbooks for Instructional System Development (ISD) teams and Training System Acquisition managers involved in requirements development, design, and procurement of maintenance simulators. In addition, this effort requires the development of model functional specifications for the design of both organizational and intermediate level (0 and I level) maintenance training simulators for utilization in resident school and field training environments. The six-step approach which will be used involves the collection, analysis, and documentation of information on the design, fabrication, and life cycle maintenance of maintenance simulators. The research is being conducted by civilian contractors through a process of information requirements analysis to include (a) development of techniques and decision aids based upon an analysis of maintenance task classifications and (b) development of guidelines/handbooks and model specifications which incorporate the preceding data collection and analysis. The ISD handbook is expected to specify procedures for (a) determing the most effective mix of training equipment (trainers primarily used by students to practice required task/part-task activities) for all types of maintenance training requirements, (b) prescribing the most appropriate design features and characteristics of maintenance simulators as a class of trainers, and (c) documenting maintenance simulator design so that it can be efficiently translated by a System Program Office (SPO) Training Device Acquisition Manager into a procurement specification with the aid of the SPO handbook.

Impact/Utilization: It is anticipated that the resultant documents will be of use to ISD teams during the development of training specifications for maintenance simulators and to the SPO activities in the translation of these training requirements into equipment specifications in such a way that efficient and effective training devices will result.

Title: Helmet Mounted Display (HMD) Prototype Development

Description: The requirements for visual simulation systems for aircrew training devices have become increasingly demanding on the display systems used to present the out-the-window view to the cockpit crew. Present display devices, which must be mounted outside the cockpit, are very massive and costly when used to provide a very wide field of view (filling the cockpit windows). In addition, they are inefficient in their use of image source resolution and computer image generation capacity since only a portion of the displayed scene is actually viewed at any instant in time. For several years, the Aerospace Medical Research Laboratory (AMRL) has been developing helmet mounted displays as potentially efficient man-machine interface systems. AMRL has recently started a program to develop an advanced HMD using new display optics and a new helmet mounted sight (head position sensor) with state-of-the-art computer image generation technology. AFHRL is participating with AMRL in this program since it is expected that the display will provide an instantaneous field-of-view sufficient for a number of training tasks by presenting separate, but overlapping scenes to the two eyes of the observer. This program includes investigation of display requirements, design of the display optics, development of the helmet mounted sight, and integration of the display hardware with the image generation system. AFHRL is participating in this program to exploit this technology for training simulation application.

Impact/Utilization: It is expected that the results of this effort will require further development before a useful visual simulation display device is available. Programs are now being planned to continue this development which, if successful, will result in a low cost, light-weight display device that has potential application in a number of training simulator systems and in particular in a portable combat readiness training device.

Title: Human Operator Control Strategy Model

Description: To conduct flight simulation, training, and transfer of training research, sensitive techniques are required for characterizing and measuring human performance. Conventional pilot performance measurement techniques were developed mainly for operational applications, where a general assessment of the man/machine system in accomplishing the assigned mission is of central interest. However, when research on training and simulation methods is the main concern, these techniques are usually not adequate because of their insensitivity to many learned aspects of perceptual motor skills. This includes, in particular, those aspects that can only be assessed by examining human performance techniques as opposed or in addition to the effect of those techniques on the system being controlled. Learning or selection of a control technique or strategy involves both the sampling and selective use of available cues and the resulting selection, development, or modification of a particular mode of response. Therefore, the control strategy which a person selects or acquires in a training device or flight simulator and carries forward for extended use in the operational environment is directly influenced by the cues made available during training (i.e., by simulator design). Therefore, a capability to model a human operator's control strategy as it evolves or changes as a function of training would be invaluable in characterizing and measuring performance for research in simulation and training techniques.

A control strategy model entitled the Human Operator Performance Emulator (HOPE) has been designed. The model consists of a computer simulation of many cognitive processess involved in psychomotor skill learning. These processes include perception of the current task and of a preview into the future, developing associations between control actions and their effect on the system, storing these associations in long term memory, predicting results, generating and executing sequences of motor commands, evaluating actual and predicted performance and allocating attention. The model's control strategy is determined by parameters describing internal error criteria, the length of various motor command strings, the attention devoted to the task, the use made of new information, and the techniques of control used in completely new situations. To test the model, a one-dimensional preview tracking task has been implemented. Using this task, basic model characteristics will be demonstrated. Future efforts will be directed toward full model validation tests, refinement, and evaluation of the model's potential in simulation and training research.

Impact/Utilization: Results will be used by the research community in developing and evaluating simulation and training techniques. Model validation tests will be completed by July 1980, at which time the techniques will be available for use.

Title: Instructor/Operator Station (IOS) Design Techniques

Description: Flight simulators typically employ an Instructor/Operator Station (IOS) from which the progress of training can be monitored and controlled. The design of an IOS has progressed from a panel of aircraft repeater instruments to several cathode ray tube (CRT) displays and a keyboard for selecting display options and inserting control information. At the same time, new instructional features have been incorporated in simulators to provide the instructor such capabilities as automatic malfunction insertion, automatic demonstrations, and record/playback of student performance. As a result, the task of the simulator instructor has evolved to include a great deal of information insertion and retrieval and manual selection of display and instructional features options in addition to the basic performance monitoring and instructional tasks. New concepts for instructor/simulator interface and information display are required which are designed with these kinds of tasks in mind. These new concepts should minimize instructor workload and distraction from primary instructional duties and should be based on the use of state-of-the-art equipment and techniques.

They should also capitalize on and be congruous with known user characteristics such as the ability to use multidimensional information, the inability to rapidly assimilate quantities of data displayed in the form of digital readouts, and the difficulty of interacting both accurately and rapidly through a keyboard requiring multiple, sequential inputs. It is believed that significant improvements in interface design can be realized by developing a systematic procedure for applying known characteristics of displays, control devices, and user information acquisition and processing to the problem.

Three efforts are underway to develop such a procedure and demonstrate how it may be applied to derive new interface concepts for applications in future simulators. These efforts deal respectively with (a) synthesizing displays which are theoretically optimal for a given application (b) objectively evaluating alternative displays by measuring their impact on instructor performance, and (c) developing new concepts for the overall interface with emphasis on non-display aspects of the problem. These efforts should provide all the tools required for systematic IOS design. They will culminate in the development of an IOS design guide for use by simulation engineers in determining interface requirements and approaches.

Impact/Utilization: The results will be used by The Aeronautical Systems Division (ASD/EN and ASD/SD24) in developing simulator IOS specifications and by industry in developing feasible IOS designs.

Title: Instructor/Operator Station (IOS) Display Evaluation Technique

Description: As the simulator comes to be used ever more widely and to grow in complexity, there is a growing need for more efficient use of this equipment. The efficient use of such equipment will depend on how well the instructor/operator can monitor the progress of the student pilot. The more activity the instructor can monitor, the more economical simulator training will be.

The major problem from the standpoint of instructor/operator station procurement is the task of conducting an objective evaluation of such equipment. Since the primary task for the instructor is that of monitoring, the type of display to be used for this purpose is a prime candidate for the application of objective evaluation techniques to replace the usual subjective approach.

In a recently completed AFHRL supported study, a technique was investigated which involved the display of flight parameters for short flight segments followed by questions to the subjects (pilots) testing their memory of display contents at indicated points in the maneuver. A display which resulted in superior recall ability is obviously preferred.

During this phase of the research, four trial subjects were tested. The results were encouraging, but four subjects were too few for any statistically significant conclusions, either about the displays or the display evaluation methodology. However, the results were sufficiently encouraging that it was determined a more meaningful number of subjects should be tested and performance measures should be refined. This research is now in progress, and is expected to result in a technique for scientifically measuring and quantifying display effectiveness as it relates to the performance monitoring task of an instructor pilot during aircraft simulator operation.

Impact/Utilization: It is expected that the results will lay a foundation for more meaningful future research in Instructor/Operator Station (IOS) displays and may be used by the simulator SPO and IOS designers to evaluate candidate displays. It is expected that the results may also be incorporated into an IOS Design Guide to be developed by AFHRL.

Title: Integrated Cueing Requirements (ICR) Study

Description: In order to design effective and efficient aircrew training devices (ATDs), detailed information is needed about human sensory/perceptual characteristics and capabilities. In the past, this information has not been readily available in a form directly useful to training device designers. As a result, current and previous training device designs have not fully capitalized on human sensory perceptual characteristics.

The amount of sensory/perceptual data in the literature is staggering. Individual training

psychologists and simulation engineers cannot review or keep abreast of all of this information. Hence, an urgent need exists to compile and integrate sensory/perceptual data which has potential applicability to ATD design. Such an approach should result in (a) the identification of areas in which new research must be directed, (b) generation of sensory/perceptual principles applicable to simulator design and evaluation for retrofit design, and (c) development of design concepts based on human sensory/perceptual capabilities.

Two major products should result from this effort:

1. The integrated cueing requirements (ICR) data base, which will be a comprehensive data base which indexes, catalogs, describes, and defines the relationships among training requirements, perceptual cueing requirements, stimulus requirements, control inputs, piloting activities, and training device characteristics.

2. The ICR data guide, which will provide procedures for using the ICR data base to influence the design and evaluation for retrofit design of aircrew training devices. The ICR data guide should provide detailed approaches and instructional procedures for (a) determining cueing requirements from task requirement data, (b) evaluating conflicting and artificial cues and their effect on perception and performance, (c) determining ATD system/subsystem design characteristics from stimulus and cueing requirements data, (d) determining cueing capability/deficits on the basis of existing ATD system/subsystem characteristics, and (e) design considerations as these may differentiate between basic training, transition training, skills maintenance, and advanced uses of ATDs for tactics development.

Impact/Utilization: It is expected that the ICR data base and data guide will be indispensable tools for simulation engineers and training psychologists concerned with (a) the design of advanced simulator systems and subsystem and (b) evaluation for retrofit design of existing aircrew training devices.

Title: Life Cycle Cost (LCC) of Simulated vs. Actual Avionics Maintenance Equipment for the F-16 Training Program

Description: The objective of this effort is to compare the LCC of F-16 avionics intermediate level training when conducted on simulated vs. actual aircraft and maintenance equipment. This work is being performed for the F-16 System Program Office (SPO). Phase I of this effort was a preliminary LCC analysis which indicated that simulated equipment would save approximately 50% over actual aircraft equipment when used for training. A more detailed and complete analysis (Phase II) is being performed during FY78–79 at the request of the F-16 SPO.

Impact/Utilization: The results of Phase I have been reported to the F-16 SPO. Based on the Phase I results, the SPO has requested that the more detailed Phase II be conducted. Phase II will be one factor used by the F-16 SPO to decide if a training simulator should be procured.

Title: Liquid-Crystal Light Valve Projector

Description: The Air Force has increasing requirements for wide field-of-view visual displays on aircraft flight simulators used for pilot training. Alternate display approaches, such as the projector/dome, mosaic of in-line infinity optics displays, mosaic of refractive elements, and Fresnel lens mosaics are being developed to fulfill these wide-angle requirements. All of these approaches, however, require a high-brightness, high-resolution image input device, usually in the form of a television projector. A television projector of the required performance capabilities does not currently exist as an off-the-shelf device. Furthermore, the requirement for full color simulation is now being specified in the current generation of flight simulators. The development of a high-brightness, high-resolution, color television projector suitable for simulation applications is thus being supported. The specific approach being pursued utilized imaging liquid-crystal light valves (LCLV). These devices are light modulators which produce images by virtue of an external light source and do not require operation in an evacuated environment. Currently, a three channel LCLV projector is being designed and fabricated. It operates in an additive color mode, and modulation of the LCLVs is accomplished by means of small, high-resolution cathode ray tubes (CRTs). The CRTs can be feed with video in the form of a television raster, line scan, or other mode so that image generation can be accomplished by means of a television camera or computer generation. The projector design has been completed, and fabrication is nearly completed. When delivered, the projector

will be subjected to evaluation by the Advanced Systems Division of AFHRL.

Impact/Utilization: Projector evaluation/performance data will be furnished to the Simulator Systems Program Office (SPO) and other Government agencies for consideration of the technology in future simulation acquisition. Initial accomplishments in LCLV projectors are sufficiently encouraging that the technology will be utilized in Air Force Project 2363.

Title: Psychological Aspects of Sensor Simulation

Description: The objectives of this program are psychological criteria for effective computer generated sensor display images for training purposes. Advancement in electro-optical sensor systems, e.g., forward looking infrared (FLIR) and low light-level television (LLLTV), greatly enhance terrain-following, terrain-avoidance, reconnaissance, navigation, target acquisition, and damage assessment. However, such sensor systems present two formidable problems for the development of effective training equipment. First, the image presented to the operator is dependent on many factors, e.g., the thermal emissivity of ground objects and their surround, sun angle (time of day), meteorological condition, and season. Second, the flight profiles that must be simulated for training purposes necessitate that extremely large ground areas be represented for long range missions. These two problems cannot be solved with current techniques for simulating sensor displays. Under a related program (Project 6114), efforts are underway to develop the technology of using computer generated imagery (CGI) to simulate FLIR and LLLTV sensor displays. The cost of such computer-based systems for sensor simulation is influenced most markedly by the degree of detail in the synthetic image and the degree of fidelity in the representation of many conditions. Thus, the fundamental problem in CGI simulation design is how much detail and fidelity are required in the synthetic display in order to produce adequate training of prospective sensor operators. In this program, experimental studies are being carried out to obtain information about the fidelity needed in training displays. These studies are pertinent to engineering variables such as edge count, edge smoothing, texture patterns, and other variables associated with the complexity of the displayed images. The results should provide psychological criteria that are necessary for making trade-offs among the requirements for detail and fidelity in order to train sensor operators for various tasks and the cost, size, and processing time of the computer to generate synthetic sensor display images having the desired characteristics.

Impact/Utilization: This research should have a significant impact on current and future work dealing with computer generated imagery for sensor simulation. More specifically, it will identify the amount of fidelity needed for adequate training of sensor operators. The results of this research can be used by organizations such as the AFHRL Advanced Systems Division Simulator Program Office as well as other agencies and individuals dealing with research and development of CGI for training.

Title: Psychophysical Criteria for Visual Simulation System

Description: The specification of desired visual simulation system performance requires a knowledge of human visual perception capabilities, as well as an understanding of the limitations of current technology. However, the relevant information on perceptual capabilities is rarely in an accessible form and much required data is simply not available at all. As a result, current specifications are usually based on insufficient data or on criteria derived from other sources such as expected technology limits, specifications (of unknown basis) for other types of optical systems, or informal feedback from users of previous visual simulation systems. This study is developing the necessary information by identifying those aspects of visual simulation systems for which perceptual criteria are relevant, obtaining the data from exisitng literature if possible, and designing appropriate psychophysical experiments to obtain the needed data which is not available in the literature. A few experiments will be selected to be performed within the resources of this study. For the purpose of this effort, consideration has been limited to hardware specifications for visual simulation systems; questions concerning scene content are not being investigated.

Impact/Utilization: It is not expected that all questions concerning psychophysical criteria for visual simulation systems will be answered by this study. Whatever results are obtained should be

immediately useful in assisting to develop more cost-effective specifications and perhaps in directing future technology developments. Experiments designed but not performed here may be pursued later under another effort.

Title: Refractive Optical Displays

Discussion: The use of visual simulation in the training on an entire crew of a wide-bodied aircraft (of the bomber, tanker, or cargo type) is particularly demanding for the simulation display. Virtual image display systems capable of covering a wide field of view cannot accommodate the large exit pupil needed to provide that field of view to the pilot, co-pilot, and other required crewmembers in a large cockpit. Conversely, display systems which provide the necessary exit pupil cannot cover the required field of view (180 degrees horizontal by 60 degrees vertical). Recent design studies sponsored by AFHRL concluded that a large spherical mirror wrapped around the cockpit with a rear projection screen mounted above the cockpit would satisfy this requirement. However, the technology for fabrication of such a mirror is untried, leading to consideration of other display techniques, which may provide lower quality imagery at lower risk and lower cost. This effort will investigate the use of large plastic lenses, as the image-forming element in a virtual image display system for a wide-bodied aircraft. In the past, this type of display has produced considerable color aberration, distortion, and collimation error. A new system, using a doublet lens with aspheric surfaces, a curved input screen, and raster shaping in the projector, should greatly reduce these problems. This effort will accomplish the design and fabrication of a breadboard system using this display concept.

Impact/Utilization: The results of this effort should be directly applicable to future simulator procurements for wide-bodied aircraft. Actual use will depend on cost/performance tradeoffs made on an individual case basis.

Title: Simulator Training Requirements and Effectiveness Study (STRES)

Description: The basic objectives of this effort are to define, collect, analyze, and present data, findings, and conclusions relevant to the cost and training effectiveness of each important characteristic of aircrew training devices (ATD). To accomplish these objectives, the study has been structured around the following goals: (a) Develop criteria for matching training requirements with ATD features and fidelity considerations; (b) Define principles of effective and efficient utilization of the ATD within the context of total training systems; (c) Develop criteria for matching instructional features and techniques with specific training requirements; and (d) Identification of cost factors, models, and data which influence the total cost and worth-of-ownership of ATDs. This effort is being accomplished with both contract and in-house resources, and has the active participation of an advisory team composed of members of each of the major commands (MAJCOMs), the Army, and the Navy, as well as procurement and research and development (R&D) agencies. Current estimated expenditure for ground based ATDs exceeds a billion dollars over the next few fiscal years. In the current and expected climate of restrcited spending coupled with the constant requirement to maintain operational force readiness, valid information must be available to allow management and user tradeoff decisions regarding training capability vs. cost. In addition, such data must allow maximization of already existing devices within the inventory and currently on order. Such data may, in large measure, be provided by this study.

Impact/Utilization: It is anticipated that the primary users of this study will be management and operational personnel tasked with the use of ATDs to achieve and sustain operational readiness. The final conclusions and recommendations resulting from this study will not be available until 1981. However, periodic interim reports will be issued that reflect findings and conclusions of immediate value.

Title: Tactical Performance Characterization

Description: Data displayed at the instructor/operator station (IOS) of a flight simulator must characterize performance sufficiently well to permit both instruction and proficiency assessment to occur. The problem of data portrayal is compounded by the requirement for succinctness due to a limited display area and the necessity for minimizing the instructor's workload imposed by scanning and

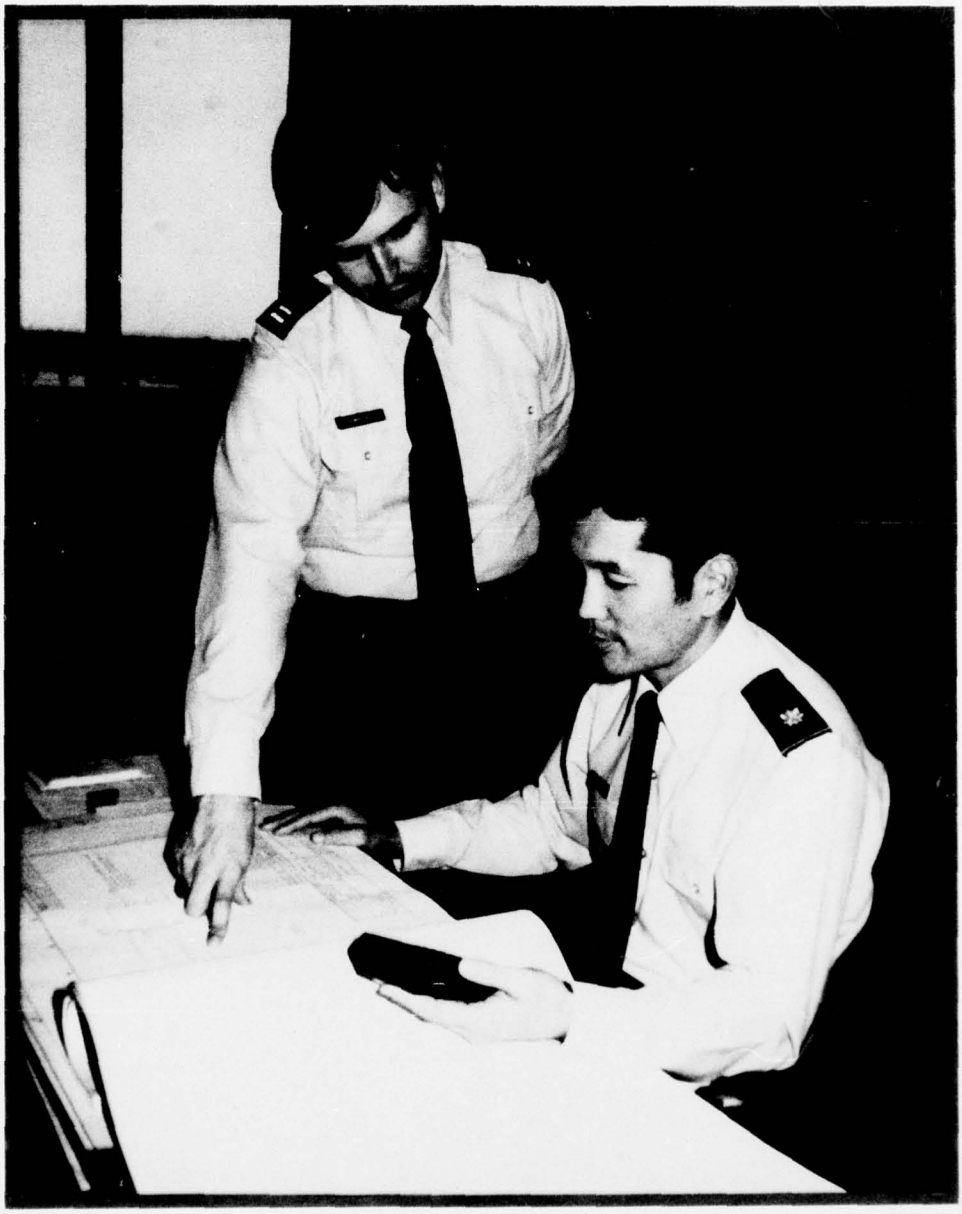
integrating data from many sources. Data normally made available at the IOS are usually limited to status information about the aircraft and the environment. This type of data is plentiful in quantity, often requires considerable mental processing to meaningful relate to instructional requirements, and does not provide certain information that is fundamental to training and proficiency assessment. A technique has been developed for characterizing important aspects of tactical performance in a new way for display at the IOS. The method will provide valuable training data not otherwise available through conventional displays and should minimize the need to display large quantities of aircraft status data.

The technique employs an adaptive maneuvering logic (AML) program originally designed to fly as an automated opponent in a one-on-one combat training environment. This program operates by periodically computing a score for each of several candidate maneuvers and then selecting and executing the maneuver with the highest score. The score consists of a weighted sum of states identifying the relative positions and energy configurations of the two vehicles. The technique which has been developed involves examining actual flight data to determine the weights that would need to be applied to the various states in order for the AML program to fly just like the pilot. By this means, the weights or importance that the pilot attaches to these states are inferred. This should provide valuable insights on the intent and internal goals of the pilot as he flies combat. By viewing a display showing what the pilot is training to accomplish, instead of merely aircraft status information, the instructor should be able to provide more relevant instruction and proficiency assessment using less data and effort. The results of phase 1 of this work, covering development of the basic technique, are documented in a technical report now in press. Phase 2 includes test and validation work and is in progress.

Impact/Utilization: Results of this work will be used initially in FY 79/80 by AFHRL to fully implement the technique and test its utility in training. After FY-80, the results will be used by the AFHRL Advanced Systems Division (ASD/EN and ASD/SD24) in developing specifications for new simulators and by the Tactical Air Command in adding retrofit capabilities to simulators already designed.

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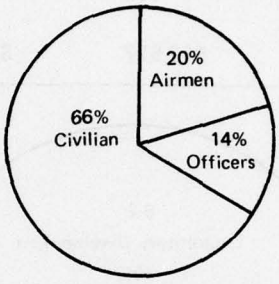
AFHRL RESOURCES



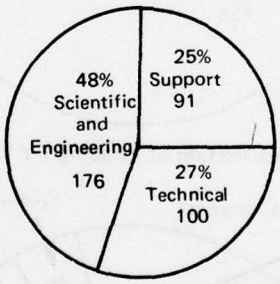
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Authorized Personnel FY 78

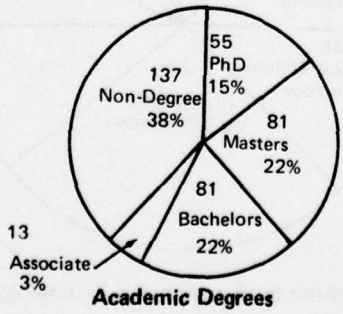
Officers	53
Airmen	73
Civilians	241
Total	367



Distribution of Authorized Personnel FY 78



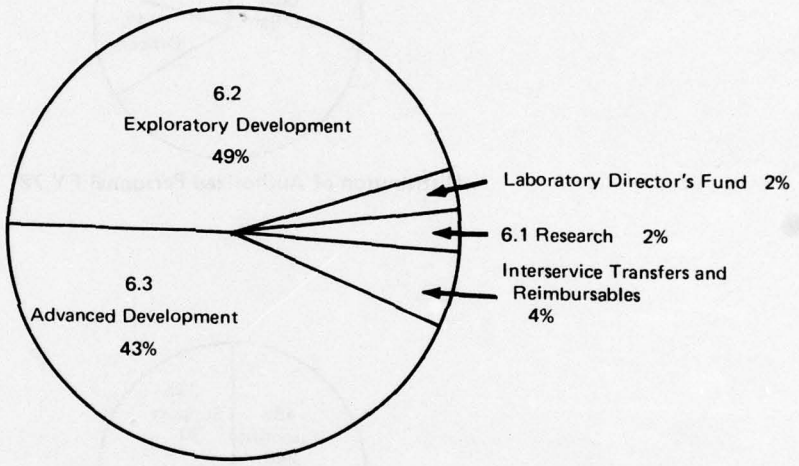
Personnel Type



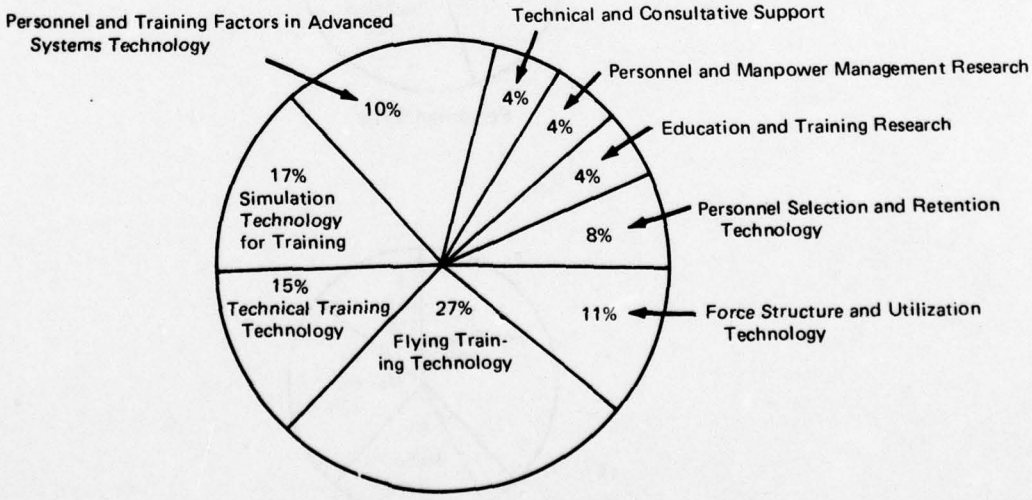
Academic Degrees

Funding Summary ($1,000)

Funding Category	FY 76	FY 77	FY 7T	FY 78
Laboratory Director's Fund	$ 380	$ 405	$ 105	$ 450
Research (6.1)	249	556	26	453
Exploratory Development (6.2)	6,087	8,872	2,118	10,630
Advanced Development (6.3)	5,702	9,232	2,198	9,475
Interservice Transfers and Reimbursables	109	1,719	2	948
Total	$12,527	$20,784	$4,449	$21,956



Distribution of Funding FY 78



Distribution of Expenditures by Research and Technology Objectives FY 78

DOCUMENTATION AND PRESENTATIONS FY 78

AFHRL-TR-78-44

AIR FORCE HUMAN RESOURCES LABORATORY

ENHANCING PRODUCTIVITY THROUGH FEEDBACK AND JOB DESIGN

By

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West Lafayette, Indiana 47906

OCCUPATION AND MANPOWER RESEARCH DIVISION
Brooks Air Force Base, Texas 78235

August 1978
Final Report for Period 1 October 1976 – 31 December 1977

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TECHNICAL SYMPOSIA AND CONFERENCES

In FY78, AFHRL was the host or cohost of several professional symposia and conferences that brought together experts in many disciplines to report on new research, to discuss the findings of current projects, and to share ideas on common problems. The diversity of subjects covered by these meetings is shown by the following list:

October 1977	Nineteenth Annual Conference of the Military Testing Association, San Antonio TX
January 1978	Fifth DOD/NASA Simulation Coordination Group Meeting, Phoenix AZ
April 1978	Tri-Service Research Applications Meeting, AFHRL, Brooks AFB TX
June 1978	Annual ADP Information Seminar and Vendor Exposition, San Antonio TX
August 1978	Chair, American Psychological Association, Division 19 Panel on Test and Evaluation at the 86th American Psychological Association Convention, Canada
September 1978	Tri-Service CIG R&D Coordination Meeting, Advanced Systems Division/AFHRL, Wright-Patterson AFB OH
October 1978	Air Force and NASA Annual IR&D Meeting, San Antonio TX