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Robert W. Bailey, COL, MSC
Commander

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U. S. ARMY AEROMEDICAL RESEARCH LABORATORY
Fort Rucker, Alabama 36362

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Fiscal Year 1976 and 77
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Reported by:
ROBERT W. BAILEY, COL, MSC
Commander

30 September 1976

U. S. ARMY AEROMEDICAL RESEARCH LABORATORY
Fort Rucker, Alabama 36362

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U. S. ARMY AEROMEDICAL RESEARCH LABORATORY

MISSION

Conducts fundamental and applied research on the medical aspects of Army aviation, airborne and ground operations that affect the health, welfare and efficiency of the soldier; perform medical research on visual/auditory functions; man/machine integration; the medical aspects of nonmedical materiel; physiological/psychological response to the operational environments; and military operational training impacts upon ecology. Provides technical advisory and consultant services to all elements of Department of Defense and other government agencies in support of helicopter, combat crew and airborne medicine.

FOREWORD

The US Army Aeromedical Research Laboratory (USAARL), a field service activity of the US Army Medical Research and Development Command, Office of The Surgeon General, was established in 1962 to perform medical research in Army aviation and airborne operations.

USAARL, along with several other research organizations, is a tenant activity at the Army Aviation Center, Fort Rucker, Alabama. The concentration of men and equipment at the Center provides assigned research personnel an ideal opportunity to maintain a current knowledge of the developments in Army aviation which affect mission accomplishment. A further opportunity is afforded by the cooperative research being accomplished by this activity and other laboratory groups such as the US Army Aviation Test Board, US Army Agency for Aviation Safety (USAAVS), US Army Research Institute and our counterparts in the Navy, Air Force and Federal Aviation Agency.

The identification and investigation of problems in aviation medicine that are both soluble and important are the activity's goals. Problems presently being considered range from long-term fundamental research in the areas of vision, hearing loss, communications, and crash protection to the more immediate problems of the environmental characteristics of particular aircraft.

Considering the future, it is impossible to determine the problem areas which will be of most importance, but by maintaining a close relationship with the aviator and the active work of other research organizations, this laboratory will continue to work upon the problems it can identify and for which it has the resources in order to provide the service that the Army and Army Aviation has requested.

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Foreign Intelligence Considered					NAME: HALEY, J. L.			
					NAME: JOHNSON, J. C., CPT DA			
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25. TECHNICAL OBJECTIVE ^a 26. APPROACH ^a 27. PROGRESS (Furnish individual paragraphs identified by number. Precede text of each with Security Classification Code)								
23. (U) To provide valid, meaningful and medically pertinent information, new designs and equipment developments based on research with respect to immediate field aeromedical problem areas found in US Army aviation.								
24. (U) The approach will always be based on sound and accepted experimental methodology, but particular techniques of application will vary as a function of the problem under investigation.								
25. (U) 75 07 - 76 09. Progress in this area is reflected in the publication of five papers on the biodynamic evaluation of protective headgear, implementation of major alterations to existing helmet impact test methodologies, redesign of the UTTAS crashworthy troop seat legs, established valid correlations of 1600 in vivo porcine thermal burns to physically measured thermal flux, publication or presentation of 4 papers on the thermal analysis program, validation of the dynamic in vivo surface electromyographic technique to assess neuromuscular stress induced by whole and segmental body vibration.								

^a Available to contractors upon originator's approval

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1 MAR 68

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U.S. GPO: 1974-540-843/8691

GENERAL DETAIL SHEET

TITLE: Research of Bioengineering Problems: Medically Significant to Army Aviation

OBJECTIVE:

Provide US Army aviation medically pertinent information derived from research of bioengineering problem areas.

BACKGROUND, METHODOLOGY, STATUS:

Statements concerning the above for this area of research can be found on the following pages numbered 3 through 7.

RECOMMENDATIONS:

It is recommended that research in this area be funded on a continuing basis.

DEVELOPMENT OF A CRASHWORTHY TROOP SEAT FOR THE UTILITY TACTICAL TRANSPORT AIRCRAFT SYSTEM (UTTAS)

OBJECTIVE

To develop through a joint USAARL-USAAAVS and contractual effort a biodynamically sound crashworthy troop seat for UTTAS, test it statically and dynamically, and submit it to AVSCOM and Eustis Directorate Air Mobility Laboratory for dynamic evaluation and field service tests.

BACKGROUND

Current utility passenger and troop carrying helicopter seats do not meet the crashworthy standards available with current technology and as outlined in the "Crash Survival Design Guide", Technical Report 71-22. Excessive morbidity and fatality rates result during the crash sequence. UTTAS is a new aircraft system under development as a follow-up to the UH-1. This aircraft is programmed to incorporate the latest in crashworthy design. One exception to the original design was a crashworthy troop seat. Development of the new seat constitutes a major historical landmark as the first, full-scale joint medical engineering effort to develop a safe passenger seat for Army helicopters.

METHODOLOGY

An engineering development proposal and report, authored by Mr. Joe Haley of USAARL has been modified and revised by USAARL and USAAAVS to incorporate the latest human tolerance and orthopaedic design criteria. A joint program to fabricate aft and forward facing flight worthy prototype seats has been completed. USAARL has evaluated the prototypes using static strength analysis and the energy absorbing/attenuating characteristics have been refined. The seats have been flight evaluated for anthropometry, comfort, safety of egress, ingress and human factors in the USAARL JUH-1H helicopters. The Naval Air Rework Facility, Pensacola has fabricated four redesigned forward and four rearward facing seats.

STATUS

Dynamic testing was conducted on these two-place troop seats in the 4th quarter of 1976 at the FAA Aeronautical Center, Oklahoma City, Oklahoma. The seats passed the combined pitch, roll, and yaw tests at 40 ft/sec, but the seats failed the forward 30 ft/sec side load test and the forward 50 ft/sec, 30 degree yaw test. Insufficient bending strength in the diagonal braces was the primary cause of the failures. A redesign of the failed seat components was completed and materials were ordered; however, the shop work has not been completed due to higher priority work. It is currently planned to conduct three additional seat tests at the FAA Center in November 1976. A final report for this project is planned for completion in February 1977.

ELECTROMYOGRAPHIC ANALYSIS OF NECK AND BACK MUSCLE
STRESS INDUCED BY WHOLE BODY VIBRATION AND
ASYMMETRIC HEAD LOADS

OBJECTIVE

The purpose of this project is to develop a reliable, sensitive and quantitative technique for evaluating muscular activity and fatigue and to apply this technique to determining the extent to which whole body vibration and asymmetric head loading effect muscular stress levels in the neck and back of human subjects.

BACKGROUND

The inevitable use of some type of helmet mounted sight in armed rotary wing aircraft raises the following question, "Will the shift in the center of gravity of the helmet and the added weight accompanying the addition of a helmet mounted device to the existing aviator's helmet cause a significant increase in muscle fatigue of the neck and back when used in the dynamic environment of rotary wing aircraft?" The dynamics of this situation and subjective reports from the field suggest an answer in the affirmative. However, in order to make a recommendation on the medical implications of employing helmet mounted devices, one should have quantitative data to support subjective findings. This project will seek to provide this information.

METHODOLOGY

This experiment seeks to provide data which will negate the following null hypotheses.

- a. The vibration to which an aviator is exposed during normal flight in a rotary wing aircraft does not increase the muscle activity in his back or neck over that necessary to maintain a similar posture in a static environment.
- b. In the vibration environment increased head mass due to heavy or asymmetrically loaded helmets does not significantly increase muscle activity in the neck or back.
- c. The muscular activity of the neck and back encountered during vibration does not depend on the power-frequency distribution of the vibration input.
- d. Clinically apparent physiological indications of muscle fatigue will not be accompanied by a change of one or more characteristics of the electromyographic activity of the muscle.

The first part of the project consists of three sections. In the first, head loading is maintained as a constant while the vibration, simulating that found in the helicopter environment, is turned on or off. In the second part, the vibration environment is maintained throughout while the load on the head of the test subject will be varied. In the third part, the head loading of the subject is held constant while the frequency content of the vibration environment will be varied. In the second part of the project vibration effects on the neuromuscular system of the forearm flexors is investigated.

STATUS

A safe and effective means of obtaining surface EMG in the vibration environment has been developed. A preliminary study performed on the forearm flexors suggests that muscle activity is increased by indirect vibration. A real time computer program to handle data reduction has been developed and tested. A test protocol has been written and an approval to use human subjects has been received.

MATHEMATICAL MODEL OF THERMAL TRANSFER THROUGH SKIN

OBJECTIVE

To determine mathematical relationships between heat input and resultant burn production in skin and to verify published studies of the relationship between temperature and tissue damage.

BACKGROUND

Although there has been a considerable amount of experimental work done on burn production and thermal protective clothing, there is a great deal of disagreement over the interpretation of the results. This disagreement arises as a result of the incomplete understanding of the nature of burn production and the factors involved in thermal protection in a given environment. A computer model of the thermodynamic factors involved in burn production and thermal protection should provide valuable insights into the nature of these problems as well as improved methods for testing thermal protective clothing.

METHODOLOGY

An initial computer program using constant parameters of conductivity, density, and heat capacity (simulating a uniform material), with heat conduction in only one direction will be written to determine whether or not an iterative method of computation will give accurate answers. Furthermore, this program will determine the increment sizes of time and distance. After these parameters have been determined a final program with heat conduction in two dimensions and with three layers of skin will be written. The results of this program will be correlated against burn data as presented by Stoll, Hardy, and Knox. The results of these correlations will demonstrate relationships between heat input and burn production.

STATUS

1600 in vivo porcine thermal burns have been correlated to the physically measured thermal flux. Gross burn on a 16 point scale, microscopic burn on an 8 point scale and burn depth were used. The correlation is extremely good for 1000 of the burns and poorer but useable in 400. These data will be now incorporated into a analytical mathematical model to predict clinical skin burns given thermal flux at the skin surface. These results and model are critical to the standardization of a non-biologic method of evaluating clinical protection afforded by fabrics that has biologic relevancy.

Publication of the following:

Wachtel, T., F. Knox III, and G. McCahan: Methods of Preparing Porcine Skin for Bioassay of Thermal Injury. Military Medicine. In press.

Knox III, F., S. Knapp, T. Wachtel, and G. McCahan: Bioassay Determination of Thermal Protection afforded by Candidate Flight Suit Fabrics. Aviation, Space and Environmental Medicine. In press.

Knox III, F., S. Knapp, T. Wachtel, and G. McCahan: A Fire Simulator/Shutter System for Testing Protective Fabrics and Calibrating Thermal sensors. Aviation, Space and Environmental Medicine. In press.

Knox III, F., S. Knapp, T. Wachtel, and G. McCahan: The Effect of Fiber and Dye Degradation Products on Burn Wound Healing. Aviation, Space and Environmental Medicine. In press.

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(U) Direct Field Research Support to Immediate Army Aeromedical Problems							
12 SCIENTIFIC AND TECHNOLOGICAL AREAS							
001300 Aircraft; 006000 Escape Rescue and Survival; 013300 Protective Equipment							
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NAME ^a US Army Aeromedical Research Lab				NAME ^a US Army Aeromedical Research Lab			
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21 GENERAL USE				ASSOCIATE INVESTIGATORS			
Foreign Intelligence Considered				NAME GRIFFITH, S., LTC			
				NAME SLOBODNIK, B., LT DA			
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23 TECHNICAL OBJECTIVE, 24 APPROACH, 25 PROGRESS (Furnish individual paragraphs identified by number. Precede text of each with Security Classification Code)							
(U) Drugs; (U) Safety; (U) Personnel Selection and Maintenance (Medical)							
23. (U) Provide US Army aviation with sound and timely bioengineering information to solve operational problems generated in the interface of the physical and life sciences.							
24. (U) The techniques employed will vary, depending on the problem area, but will be based on sound accepted experimental methodology designed to provide the required information as expeditiously as possible.							
25. (U) 75 07 - 76 09. Progress in this area is reflected by three publications on Crash Injury Economics, two publications for the Life Support Equipment Retrieval Program (LSERP) implementation of three major injury reducing Equipment Improvement Reports worldwide on LSE, publication of two papers on transmeridian travel, one paper on the Effects of Oral Contraceptives on Performance, approval of a precis to develop an automated inflight blood pressure monitor.							

^a Available to contractors upon originator's approval

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U.S. GPO. 1974-540-843/8691

GENERAL DETAIL SHEET

TITLE: Direct Field Research Support to Immediate Army Aeromedical Problems

OBJECTIVE:

To provide valid, meaningful and medically pertinent information based on research with respect to immediate field aeromedical problem areas found in US Army aviation.

BACKGROUND, METHODOLOGY, STATUS:

Statements concerning the above for this area of research can be found on the following pages numbered 10 through 19

RECOMMENDATIONS:

It is recommended that research in this area be funded on a continuing basis.

GENERAL BIOENGINEERING SUPPORT FUNCTION

OBJECTIVE

To provide an easily accessible investigatory, educational and consultative function to government agencies in those areas of engineering, design, production and evaluation of equipment, systems and sub-systems in Army aviation for which a physiologic man-machine interface occurs. Inquiries and requests for answers to operational problems are received daily that often require literature searches, short experiments, field evaluation in-flight evaluation of aviators undergoing diagnostic work-ups at the Aeromedical Center, and attendance at equipment IPR's, material need (MN) working groups, mock-up reviews, as well as participation on multiple national and international scientific groups to include American National Standards Institute Committees, National Academy of Science, NATO-AGARD Aerospace Medical Panel, Committees or the Aerospace Medical Association and others.

METHODOLOGY

Consultation service, well-defined experiments, on-site evaluations, specification and document reviews, coordination and liaison functions, and lecturing are some techniques used to provide practical solutions to these operational problems.

STATUS

Voting memberships in:

Aeromedical Consultant Board, Army Aeromedical Center, Ft Rucker, Al.
American National Standards Institute (ANSI) Z90.1 Vehicle Crash
Helmet Committee
Chairman, ANSI, Z90.1 Sub-committee on Helmet Durability
Chairman, Tri-Service Impact Panel (TIP)

Appointed Working Memberships to:

National Materials Advisory Board ad hoc committee on Fire Safety
Aspects of Polymeric Materials.
Aerospace Medical Association Environmental Safety Committee
NATO-AGARD Aerospace Medical Panel (ASMP) Biodynamics Committee
AAH and UTTAS Source Selection Evaluation Board, ad hoc Crash-
worthiness Contract Review Boards, Eustis Directorate, Air
Mobility Laboratory

NATO-AGARD/PEP-SMP-ASMP Working Group on Aircraft Fire Safety

Appointed Consultantships:

NATO-AGARD/ASMP Medical Aspects of Helicopter Operations and Life Support Equipment
Ft Rucker Accident Investigation Board
US Army Agency for Aviation Safety

Teaching appointments formal or by invitation:

Flight Surgeon, Aeromedical Center, Ft Rucker, AL
Global Medicine Course, Department of Preventive Medicine, Walter Reed Institute of Research, Washington, DC.
Aircraft Accident Investigators Course, Arizona State University, Tempe Arizona
Department of Education, University of Alabama at Birmingham.

Participation by invitation to:

Working Party 61, Air Standardization Coordinating Committee
Army-Navy Research Panel
Tri-Service Life Support Equipment Panel

Directed Consultations and Support Activities:

UTTAS Program Manager, Technical Consultation as working member to UTTAS Source Selection Board.
UTTAS Program Manager, Co-chairman, COEA on crashworthiness features. Edgewood Arsenal, XM 79 Gas Mask Project, Technical and Laboratory Support.
XMI Vehicle Project Officer, Technical Consultation.
ASCC, Technical Consultation and review of standards of significance to Army.
USAAAVS, Technical Consultation, teaching and analysis of special accidents.
Aeromedical Center, Aeromedical Consultation for aviator flying status dispositions.
AAH Project Manager, Technical Consultation.
Eustis Directorate Air Mobility Laboratory, Technical Consultation and in-house laboratory support of Army safety and crashworthiness programs Specification review.
Natick Laboratories, Technical Consultation, in-house laboratory support design input, and specification review on helmet and personal equipment programs.
Night Vision Laboratories, Technical Consultation on helmets.

CFASH INJURY ECONOMICS

OBJECTIVE

This study is an economic and manpower analysis of Army aircrew injuries and deaths to determine their contribution to total aircraft accident costs.

BACKGROUND

In the usual cost assessment of a helicopter accident, only the aircraft is considered. The tremendous cost of emergency medical care, medical follow-up, long term disability benefits and/or death benefits to the next of kin are not considered. Dollar values become a common denominator between people and objects and influence managerial and policy decisions which will ultimately determine Army aircraft crashworthiness and the quality of personal protective equipment.

METHODOLOGY

Using USAAAVS files, a list of US servicemen killed or injured in Army AH-1G helicopters is to be compiled for FY 71-74. Personnel costs are determined using figures published by DCSPER in DA circulars and by individual communications with military and VA hospitals to determine type of treatment, length of stay and cost of individual treatment.

STATUS

Definitive economic analyses have been accomplished for multiple cost parameters. Statistical computer programs have been written and debugged to facilitate continuing studies in this area. It has been demonstrated that the human economic loss in Army helicopter accidents often exceeds the hardware cost. The data from this study have been used by AVSCOM to justify the Crash Resistant Fuel System Retrofit Program, and by USAAAVS to justify the costs of crashworthiness features to be included in the UTTAS.

Publication and Presentation of the following:

Knapp, S. and T. Erhardt, Head Injury Pathology and Its Clinical, Safety and Administrative Significance, USAARL Laboratory Report 76-22, June 1976.

Knapp, S. and T. Erhardt, Head Injury Pathology and Its Clinical Safety and Administrative Significance, NATO/AGARD Aerospace Medical Panel, Copenhagen, Denmark, April 1976.

Allemond, P., D. Karney, and S. Knapp: Helicopter Crashworthy Fuel Systems and Their Effectiveness in Preventing Thermal Injury, Joint Committee of Aviation Pathology, Halden RAF Base, England, September 1976.

Haley, J.: Crashworthiness Versus Cost: A Study of Severe Army Rotary Wing Aircraft Accidents in Period January 1970 through December 1971, Aircraft Crashworthiness Symposium, University of Cincinnati, Cincinnati, Ohio, October 1975.

LIFE SUPPORT EQUIPMENT RETRIEVAL AND ANALYSIS PROGRAM AND LIFE SUPPORT EQUIPMENT EXHIBIT (LSERP)

OBJECTIVE

To perform bioengineering analysis, evaluation and injury correlation of life support equipment that has been subjected to an aircraft crash environment. To integrate hardware and material with the biological requirements of man and insert technical and scientific data into the developmental cycle that will result in product improvement and new design criteria.

BACKGROUND

Life support equipment involved in aircraft accidents is subjected to its ultimate test with human subjects. Until November 1971, this equipment was not formally being evaluated after aircraft accidents. Improvements in life support equipment had, therefore, been made on an empirical, haphazard basis. AR 95-5 requires the president of an aircraft accident investigation board to send all pieces of life support equipment involved in either injury causation or prevention to USAARL for biomedical and engineering evaluation. From these exposures, and the uniquely valuable data resulting from their analysis, recommendations for product improvement or design criteria will be established on a sound basis. The data obtained can never be safely duplicated with human subjects.

METHODOLOGY

AR 95-5 requires the flight surgeon assigned to the accident investigation board to examine the life support equipment involved in aircraft accidents and to send items implicated in injury causation or prevention to USAARL. A biomedical and engineering evaluation and injury correlation is performed on equipment received. Data obtained is coded and added to information stored at USAAAVS. Pathology data from AFIP (JCAP) will be integrated as appropriate. Periodic statistical analysis of all data will be performed by USAAAVS.

STATUS

The acquisition of an enlisted man assigned full time to this program has made it possible to monitor Crash Fact Messages which has increased the flow of equipment retrieved from Army aircraft accidents. An increase in the amount and degree of laboratory analysis performed on retrieved life support equipment has been made possible by the assignment of an Aviation Medical Officer and a Naval Aerospace Physiologist to this project.

A Memorandum of Understanding was drawn up and signed between USAARL and USAAAVS which reestablished the joint participation of both agencies in this program and helped renew the exchange of accident information which had been slowed by the Privacy Act.

In February, USAARL and NARADCOM met to discuss proposed improvements to the SPH-4 aviator's helmet. Based on an analysis of SPH-4 helmets received through the Retrieval Program, USAARL proposed seventeen improvements to the helmet. NARADCOM agreed that nine of these improvements could be accomplished by specification changes only. They agreed to make the nine changes within a two month period following the meeting. To date, action has only been initiated on five of the nine agreed upon changes, and none of the improvements agreed upon has yet reached the field in the form of an improved SPH-4 aviator's helmet. From thirty aircraft accidents, the following life support equipment was retrieved for laboratory analysis: 51 SPH-4 helmets, 2 APH-5 helmets, 9 pairs of flight boots, 2 infantry helmets, 2 ejection seats, 6 sets of flight clothing, 2 pilot's seats, 2 troop seats, 2 jump seats, 2 seat belts, 3 pairs of flight glasses, 1 signal light, and 3 life preservers. In addition, life support equipment pools submitted 40 used SPH-4 helmets that contribute valuable information to an understanding of the mean-time-to-failure of various components. Based on a laboratory analysis of this retrieved equipment, one Letter Report was published and three Equipment Improvement Recommendations submitted. Life Support Equipment Retrieval Program case number 1050-62 was completed which identified the existence of a non-standard UH-1H pilot's seat implicated in the causation of back injury in an aircraft accident. As a result of identifying this seat, a TWX has been sent from Commander, U.S. Army Aviation Systems Command to all operational units recommending that the seat be replaced as soon as possible. Approximately 200 hours of direct life support equipment consultation was provided through this program. The major area of Life Support Equipment Retrieval Program usefulness continues to be in survivable accidents which have injuries or fatalities secondary to shortcomings of life support equipment and/or basic crashworthy airframe design.

Publication of the following:

Slobodnik, B., J. Haley, and J. Patterson, Analysis of SPH-4 Helmet Performance from 1972-1975, USAARL Laboratory Report 76-17-3-2, March 1976.

Johnson, J. and M. Blackmore, The Effect of Interior Coloration on Thermal Loading in Army Aircraft, USAARL Laboratory Report 76-9-3-1, October 1975.

MEDICAL, PHYSIOLOGIC AND HUMAN FACTORS OF LONG RANGE, LARGE SCALE AERIAL TROOP DEPLOYMENTS

OBJECTIVE

To delineate those factors associated with transmeridian, large scale troop deployments that will have a degrading effect on combat units and individual soldier performance, efficiency, and combat effectiveness. To study the identified parameters in detail and arrive at pragmatic operational solutions that can be implemented in existing contingency plans, deployment doctrine and medical operations annexes. To recommend implementation of solutions.

BACKGROUND

Current national and international policy, military strategy and tactics and aviation technology indicate large troop deployments of the future will be made aurally. Problems inherent in protracted aerial flight among combat personnel are not known.

METHODOLOGY

Study selected large scale long range deployments with the intent of identifying environmental, psychological, physiological and operational problem areas.

Develop experimental protocols to study specific problem areas.

Collate experimental results into operational recommendations.

STATUS

A protocol has been developed to study the problem of sleep loss and time for sleep recovery. The independent variables will include, but are not limited to, exposure to altitude, environmental noise, dehydration, high density seating, long period of sitting without exercise and transmeridian translocation. Joint Army Medical Laboratory protocol to collect physiological, psychological and performance data during an operational deployment was completed and staffed at AMRDC in 1973. Readiness Command has accepted and implemented recommendations for improved troop comfort and convenience during deployments. Continual consultations will be provided to operational commands at their request.

Publication of the following:

Knapp, S.: Accommodating to Travel Stress. Consultant 16:7, 1976.

Knapp, S.: Travel and It's Hazards. Audio-Digest 23:28, 1975.

AUTOMATED INFLIGHT BLOOD PRESSURE MONITOR

OBJECTIVE

The objective of this project is to develop a noise and vibration immune vital sign monitor for use in the evacuation of combat casualties.

BACKGROUND

Inflight monitoring of blood pressure in patients transported by helicopters cannot be done using conventional sphygmomanometers currently utilized in hospitals and other medical facilities. Vibration and noise inherent in rotary wing aircraft operation negate usual procedures employing a stethoscope positioned over an appropriate artery and a BP cuff secured around an extremity.

In the rotary wing aircraft environment it is impossible to ascertain with reproducibility or accuracy the systolic sounds, the muffling or Korotkoff diastolic sounds, or the disappearance of these sounds.

A method, without the constraints enumerated above, must be found so that inflight or ground monitoring within the helicopter or ground ambulance can be accomplished in a practical manner.

If actual blood pressure data were made continually available so that shock trends could be spotted promptly, flight personnel could elect to land at a safe spot for patient stabilization or employ inflight measures to stabilize the patient enroute to a place of definitive medical treatment. Without this blood pressure information it is possible to compromise the patient, while treatment would allow these individuals to arrive at their ultimate medical destination in a condition better able to withstand the medical rigors they have yet to endure.

METHODOLOGY

A standard Sphygmomanometer cuff will be used to occlude the brachial artery as in the standard method of blood pressure determination using auscultation. However instead of using a stethoscope to determine the points at which systolic and diastolic blood pressure occur, an ultrasonic blood flow monitor will be used. The relationship between the blood flow in the artery and the points of systolic and diastolic pressure will be determined. The effect of vibration and acoustical noise on the signals received from the ultrasonic flowmeter will be analyzed, and from this data the necessary analog filtering and digital processing required to extract blood pressure information from the noisy signal will be developed.

Concurrent with the program to develop a high degree of noise immunity, will be a program to develop a microprocessor based controller to handle the internal operation of the monitor. The microprocessor will regulate the input of physiological data from the subject, and the pressure in the occluding cuff and from this data will compute essential life sign parameters subsequently displaying the results. In addition to this function, the microprocessor will also control inflation and deflation of the occluding cuff and perform routine checks and adjustments in the calibration of processing electronics.

Once the signal conditioning and control electronics have been designed a breadboard circuit will be assembled and tested. Further refinements will then be made as required to attain the desired degree of noise and vibration immunity. Following this phase a contract will be let to produce a portable unit which may be tested under actual field conditions in rotary wing aircraft ground ambulances and armored personnel carriers.

STATUS

An extensive search of the literature was conducted leading to the following observations. First, no blood pressure monitor currently available has sufficient noise and vibration immunity to provide accurate blood pressure information in the helicopter environment. Secondly, it was discovered that wave propagation delay may be used as an indicator of blood pressure in the event that an occlusive cuff is impractical. Thirdly, it was found that accuracy and repeatability of blood pressure determinations may be improved by use of a totally automated monitor which does not rely on subjective analysis of the operator.

Various means of inflating the occlusive cuff were evaluated. It was determined that an electrically powered air pump would be too massive and put a strain on the battery pack. Currently under consideration are carbon dioxide and freon cylinders. Pneumatic hardware for the inflation of the occlusive cuff was designed and purchased.

After consideration of several microprocessor based control units, one was selected and purchased. It has been received, set up, debugged and is currently operational. In the interest of maximizing flexibility and minimizing data acquisition time, a data acquisition module was purchased and will be attached directly to the microprocessor bus.

DRUGS IN AVIATION MEDICINE
AN INVESTIGATION OF THE EFFECTS OF ORAL CONTRACEPTIVES ON PERFORMANCE

OBJECTIVE

To evaluate the potential compromise of aviation safety from the side effects associated with the use of oral contraceptives.

BACKGROUND

Regulations controlling the use of drugs by the aviation population require strict adherence to prescribed precautions and periods of grounding. The estrogens and progestins in oral contraceptives, included in these regulations, are "contraindicated only if adverse effects are present." A few women who use oral contraceptives may experience any of a wide range of undesirable side effects. Whether the side effects produced by oral contraceptives affect one's ability to perform flying duties is a question which has been largely ignored. The opening of the field of military aviation to women will bring into the services aviators who will be using oral contraceptives. It is assumed they will experience the same adverse reactions to their medications, and in the same proportions, as the general population at risk.

Pharmaceutical houses admit and research studies have demonstrated evidence for the association of certain adverse side effects, some potentially severe, with the use of oral contraceptives. Such events are rare, occurring in about 0.002% of users. Most women experience no difficulties related to the use of oral contraceptives. The question arises as to whether any of the minor physiological changes associated with the use of oral contraceptives might affect task performance.

METHODOLOGY

This study utilized eight basic psychomotor tasks and two psychological tests to measure mood and basic elements of performance. The investigators extrapolated the findings to performance in the aviation environment.

STATUS

Project completed.

Publication of the following:

Altekruse, E. and M. Sanders: An Investigation of the Effects of Oral Contraceptives on Performance, Aerospace Medical Association Scientific Assembly, Miami, Florida, May 1976.

RESEARCH AND TECHNOLOGY WORK UNIT SUMMARY				1 AGENCY ACCESSION ¹	2 DATE OF SUMMARY ²	REPORT CONTROL SYMBOL DD-DR&E(AR)6J6	
3 DATE PREV SUMMARY	4 KIND OF SUMMARY	5 SUMMARY SCTY ³	6 WORK SECURITY ⁴	7 REGRADING ⁵	8A DISB'N INSTR ⁶	8B SPECIFIC INSTA- CONTRACTOR ACCESS	9 LEVEL OF SUM A. WORK UNIT
76 03 01	D. Change	U (No Ch)	U		NL	<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO	
10 NO CODES ⁷	PROGRAM ELEMENT	PROJECT NUMBER	TASK AREA NUMBER	WORK UNIT NUMBER			
a. PRIMARY	61101A	3A161101A91C	00	287			
b. CONTRIBUTING							
c. CONTRIBUTING							
11 TITLE (Precede with Security Classification Code) ⁸ (U) Research of Bioengineering and Vibration problems medically significant to Army aviation							
12 SCIENTIFIC AND TECHNOLOGICAL AREAS ⁹ 001300 Aircraft; 002400 Bioengineering; 015600 Solid Mechanics							
13 START DATE		14 ESTIMATED COMPLETION DATE		15 FUNDING AGENCY		16 PERFORMANCE METHOD	
74 07		Cont		DA		C. In-House	
17 CONTRACT GRANT				18 RESOURCES ESTIMATE		19A PROFESSIONAL MAN YRS	19B FUNDS (in thousands)
a. DATES/EFFECTIVE				PRECEDING			
b. NUMBER ¹⁰ NA				FISCAL YEAR		76&7T	2.7
c. TYPE				CURRENT		77	2.4
d. KIND OF AWARD				AMOUNT		20	20
19 RESPONSIBLE DOD ORGANIZATION				20 PERFORMING ORGANIZATION			
NAME ¹¹ US Army Aeromedical Research Lab				NAME ¹² US Army Aeromedical Research Lab			
ADDRESS ¹³ Fort Rucker, AL 36362				ADDRESS ¹⁴ Bioengineering & Life Spt Equip Div Fort Rucker, AL 36362			
RESPONSIBLE INDIVIDUAL				PRINCIPAL INVESTIGATOR (Furnish SSAN if U.S. Academic Institution)			
NAME. BAILEY, Robert W., COL, Cdr				NAME ¹⁵ GEARHART, John R., CPT, MC			
TELEPHONE (205) 255-5107				TELEPHONE (205) 255-7112			
21 GENERAL USE				SOCIAL SECURITY ACCOUNT NUMBER			
Foreign Intelligence Considered				ASSOCIATE INVESTIGATORS			
				NAME: JOHNSON, John C., CPT, MS			
				NAME: ERHARDT, Thomas M. SP5			
21 KEYWORDS (Precede EACH with Security Classification Code) ¹⁶ (U)Man-Machine Relations; (U)Protective Equipment; (U) Stress Physiology; (U) Safety Engineering; (U)Anthropometry; (U) Musculoskeletal Systems							
23 TECHNICAL OBJECTIVE, ¹⁷ 24 APPROACH, ¹⁸ 25 PROGRESS (Furnish individual paragraphs identified by number Precede text of each with Security Classification Code) ¹⁹							
23. (U) To determine the short-term clinical effect of helicopter vibration on the musculoskeletal system and to develop an orthopaedically, anthropometrically sound helicopter crew seat to reduce vibration effects.							
24. (U) Prospective clinical and epidemiologic study using physical examination subjective reporting forms, Norland Bone Mineral analysis, biochemistry, and x-ray techniques. Seat design and validation will be accomplished statically and dynamically on a three degree of freedom, man-rated vibration table using dynamic EMG techniques. Pilot performance and efficiency are studied. Animal models are used and the techniques of tetracycline bone labeling and scanning electron microscopy of the joint surfaces are employed.							
25. (U) 75 07 - 76 09. The clinical evaluation of personnel subjected to chronic low frequency vibration was completed this year. In the aviator group there was no significant change in bone mineral density or in radiographic examination. A paper describing the results of this study has been accepted for presentation at the Symposium on Biodynamic Models and their Applications. The pilot study using miniature swine was also completed. In this study three pairs of animals were used and accumulated a total of over 200 hours in vibration exposure on the helicopter vibration simulator. These animals were examined by means of joint impedance measurements, chemistry, radiographs, and bone mineral density measurements. Finally bone labeling studies with tetracycline and examination of the joint surfaces with the scanning electron microscope was begun. Comparison of these surfaces to human tissues is planned. A full scale study is to begin in FY 77.							

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AND 1498 1 MAR 68 (FOR ARMY USE) ARE OBSOLETE

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GENERAL DETAIL SHEET

TITLE: Research of Bioengineering and Vibration Problems Medically
Significant to Army Aviation

OBJECTIVE:

To provide valid, meaningful and medically pertinent information based on research with respect to immediate field aeromedical problem areas found in US Army aviation.

BACKGROUND, METHODOLOGY, STATUS:

Statements concerning the above for this area of research can be found on the following pages numbered 22 through 29.

RECOMMENDATIONS:

It is recommended that research in this area be funded on a continuing basis.

ARMY-AIR FORCE VIBRATION STUDY

OBJECTIVE

To determine the effects of helicopter vibration on bone-growth dynamics and possible damage to joint surfaces.

BACKGROUND

The effect of vibration as a work hazard has far reaching consequences for both military and civilian occupations. While the military aviator experiences vibration in all aircraft, it is greatest in the helicopter environment. The results of long-term, low frequency vibration are unknown; however, recent studies on animals at Wright-Patterson Air Force Base indicate that musculoskeletal changes to the intervertebral disc do take place. Chronic vibration of various character and frequency affects the musculoskeletal system in a number of ways.

A recent study of 128 pilots disclosed that 87.5% suffered from back pain generally after 300 hours of flying time. Pilots with slight pathologic conditions of the spinal column began to complain of recurrent low back pain after 50 to 100 hours of flying time. The average figure cited in this study indicates that the threshold of appearance of "pain" occurs when one flies four to five hours per day, 40 to 50 hours per month.

METHODOLOGY

The clinical study involved a group of new aviators and a non-flying control group. These groups were observed to determine any vibration related changes. The groups were examined at similar intervals corresponding to the beginning of flight training, after two months of flight training, and after about 18 months at the termination of the study. Anthropometric measurements, radiological studies, blood chemistry, and bone mineral density determinations, as measured by photon absorption, were made.

The pilot animal study was done using miniature swine as a model for studying the early effects of vibration on the skeletal system before classical radiological changes are present. In this study three pairs of animals were used and exposed to vibration on the helicopter vibration simulator. Surgical implantation of accelerometer mounts allowed the collection of joint transfer function data. Tetracycline bone labeling techniques were used to determine bone growth measurements and scanning electron microscopy was utilized to identify joint surface damage.

STATUS

The clinical study has been completed and showed no significant variations of the bone mineral density or radiological examination in the aviator group. The control group which did show a short term 10 percent demineralization during the stress of basic training, appeared to recover this loss. A paper detailing this study has been accepted for presentation at the Symposium on Biodynamic Models and Their Applications sponsored by the Aerospace Medical Research Laboratory and the Committee on Hearing, Bioacoustics and Biomechanics.

The pilot animal study was conducted with three pairs of animals accumulating over 200 hours on the vibration platform. The specimens from the joints of these animals are currently being evaluated by both biochemical techniques and scanning electron microscopy. Bone dynamics are being studied with tetracycline labeling methods. A full scale project is planned for next year.

Publication of the following:

Knapp, S.: Vibration Effects on Army Helicopter Operations, Joint Services Conferences on Operational Problems in Aerospace Medicine, USAFSAM, Brooks AFB, Texas, February 1976.

ORTHOPAEDIC VSTOL AIRCREWMEMBER SEAT DESIGN

OBJECTIVE

The objective of this project is to develop and validate an orthopaedically sound helicopter crew seat that meets or could incorporate all other human factors, engineering and crashworthy requirements. Goals in orthopaedic design are to reduce involuntary antigravity muscle activity in both static and dynamic (vibration) conditions through optimization of seat angles and measurements (surfaces) and providing arm, leg and neck support. Seat-control configuration (angles and adjustments) will be analyzed and optimized to the extent that is possible in the current UH-1 helicopter.

BACKGROUND

Relationships between the seat back angle and the preferred lumbar and thoracic bend angles were assumptions based on limited human data, analysis of interference between man-model body segments and the seat, MIL-STD relationships between the Eye Reference Point (ERP) and Seat Reference Point (SRP), etc. Until sufficient data are available to determine exactly what these relationships should be as well as the location of the major joints of the human spine in a seated position the present assumptions will suffice. However, accurate seated joint positional data are essential to the Cockpit Geometry Evaluation (CGE) Program as well as to many other man-machine interface studies states P. W. Ryan in the Joint Army-Navy Aircraft Instrumentation Research Final Report on Validation of Cockpit Geometry Evaluation, November 1971.

The relationship of the aircrewmember to the hand and foot controls is based on MIL-STD 1333, Aircrew Station Geometry for Military Aircraft. The criteria for determining this MIL-STD are traced back to 1959 and do not take into consideration certain accepted orthopaedic principles of body support. Design is such that the flying position induces low back muscle fatigue, since the pilot must rest his wrist on the distal thigh to provide adequate stability for cyclic control.

METHODOLOGY

The hypothesis to be tested, is that a seat-control configuration incorporating orthopaedic principles will decrease antigravity muscle activity. Muscle activity will be measured by dynamic EMG activity and comfort evaluation in static and three-axis degree freedom vibration conditions and compared to the standard UH-1 seat-control configuration. Data will be collected in five areas: (1) comfort, (2) egress time, (3) cushion evaluation, (4) anthropometry evaluation, (5) seat-control configuration evaluation.

STATUS

The vibration table is fully operational and man rating is complete. Human Use approval has been granted and EMG studies of muscle activity in both static and dynamic configurations are underway. Due to lack of personnel, no seat design or analysis has been conducted this year.

BIODYNAMIC EVALUATION OF PROTECTIVE HEADGEAR

OBJECTIVE

Design, develop, and validate headgear evaluation methods to fulfill the needs of head protection in Army Aviation. Determine the bump and impact protection provided to the helmet wearer. Evaluate the degree of protection provided in accordance with technical performance criteria outlined in American National Standards Institute (ANSI), Department of Transportation (DOT) and Wayne State University (WSU) documents. These documents are analyzed and changes are recommended as the needs of the Army dictate.

BACKGROUND

Impact tests on helmets are conducted primarily under the ANSI-Z90.1 methodology. Z90.1 was generated for road user helmet testing, but the impact conditions used are similar to aircraft crash conditions in many respects. USAARL is analyzing new test methods which will consider the unique aspects of the aircraft crash; specifically, USAARL is charged with evaluating the biodynamic aspect of head injury causation as related to the design of protective helmets. USAARL also has mission authority for the quality assurance evaluation of all Army helmets in relation to medical and protective performance criteria.

METHODOLOGY

Headgear are evaluated by various physical tests such as: bump and impact weight and center of gravity, POL effects on material and retention characteristics. On the basis of such tests, the relative protective merit of various types of headgear are evaluated. Coordination and liaison have been established with all interested or responsible federal and civilian agencies. New helmet designs are also inspected to determine how well the assembled hardware will fulfill the medical MN requirements, i.e., excess pressure points, durability of materials, toxicology, and fitting adequacy.

STATUS

Improved liaison has been established with DOT and WSU with regards to test methods. For example, the so-called "humanoid" head form and attached guide have been purchased from WSU. Initial drop tests caused a failure of the neck-to-joint, but the joint was repaired and evaluation of this device continues. A small size, metal headform meeting DOT size requirements in most respects has been obtained. This small headform will be used for impact of small size infantry and tanker helmets.

The effect of temperature on helmets and human heads as related to impact protection and test methods has been evaluated. A preliminary draft report indicates a need for changes in the hot and cold impact test methodology. This report is planned for publication.

Impact and other evaluation tests were conducted on the prototype P/N791 Combat Vehicle Crewman (CVC) helmets. Three separate helmet submittals were evaluated in the past year. This prototype did not meet the MN criteria for impact protection as revealed in LR76-15-2.3. A DEVA IPR, held on 18 Feb 76, concluded that this helmet was not acceptable for type classification. The effect of wigs on helmet retention was evaluated at the request of the Air National Guard Bureau. Test data showed that helmet size and proper fit were the major factors relative to helmet retention. Dry, clean, long hair did not appear to pose a problem, but oily hair did permit helmet slippage/rotation on the head. A preliminary draft report is completed; a final report is planned for publication. An improved SPH-4 helmet, weighing approximately 2.9 lbs was developed and evaluated. This improved SPH-4 was suggested to NARADCOM (NATICK) in a 21 Jan 76 meeting. Details of the SPH-4 improvements were detailed in LR76-17-3-2. The major changes included: (a) strengthened retention harness, (b) a reduced shell thickness in the crown area which moved the helmet C.G. nearer the head C.G., and (c) more energy-absorbing foam in the head band area. NARADCOM agreed to change procurement specifications to affect the above changes. The first phase of these changes was to be accomplished in 60 days, while the second phase, which included the shell thickness reduction, was to be accomplished upon approval of development funds. To date, the phase one improvements have not been completed, and the phase two improvements have not begun due to lack of funding. Weight reduction and improved crash protection are very important for the Army airmen's helmet. So important, in fact, that USAARL should prosecute this light weight helmet program in a similar matter to the original SPH-4 introduction into the Army in 1969. Arguments to the contrary that the SPH-4 helmet must be drastically changed in order to accommodate various helmet-mounted devices are not pertinent, because the sling suspension type helmet will satisfy more than half of all operational helmet needs; utility, liaison, and cargo type helicopter pilots have little need for helmet-mounted displays, helmet mounted gun sights, and other weapon systems devices. The new helmet drop tower was completed and is operational. Data from the new drop tower is being fed directly into the USAARL computer. The computer output includes: peak G, time duration, and two different human injury severity indices. Some debugging remains to be done on the computer program; however, the new data retrieval system shows the potential to eliminate laborious hand calculations and to prevent many human errors. The new drop tower was designed to accommodate ANSI, WSU, and DOT test methods. The WSU humanoid headform has been obtained and several hundred drops conducted. Significant mechanical problems have occurred due to the misalignment of the head CG with the CG of the drop guide; this misalignment caused failure of the neck-to-head joint. A reinforcement of this joint was completed and the head form is again in operation. This humanoid head form is being used to evaluate the new infantry/paratrooper helmet; it is also used for impact tests to determine aging effects of old, worn helmets. Redesign of the WSU drop guide is planned to improve the performance of this assembly.

Experimental foam-in-place liners were constructed in-house. Existing SPH-4 shells were used as outer modls. A foam-generating kit, procured from the Air Force, was used to foam the liners. These experiments have shown that the density of foam-on-place liners is highly variable depending upon; (1) the age and storage conditions of the foam chemicals and (2) the skill/experience level of production and fitting. A tentative conclusion from these experiments is that they should be manufactured at a central location and disseminated to the various operational units rather than to attempt the distribution of foam-in-place kits as has been done in the Air Force.

Bioengineering provided assistance to the Bio-Optics Division in the procurement, fitting and evaluation of the 15 foam-in-place gunsight helmets manufactured by Gentex, Inc. Personnel wearing these helmets completed a questionnaire relative to the helmets performance. The results are being analyzed. USAARL also provided assistance to NARADCOM in the development of a light-weight SPH-4 gunsight helmet for use with the Sperry gun sight. A limited number of these helmets are to be procured by NARADCOM for use in AH-1 Cobra aircraft. Auburn University completed a USAARL Report No. 76-13 entitled "Computer Modeling of the Body-Head-Helmet System". This report outlines the potential to use a computer to determine accelerations fo the human head under varying acceleration inputs. A follow-up on this study has begun and is not yet completed. The current study attempts to model the drop tower impact situation so that various helmets can be evaluated by the computer model rather than by actual impact tests. Current plans are to conduct impact tests on 24 experimental helmets at USAARL and to compare the results with those of the Auburn model.

Bioengineering is providing assistance to DARCOM in development of the personnel armor system ground troop (PASGT) helmet. Candidate helmets have been received. These helmets are to be weighed, impacted, checked for centers of gravity location and checked for chin strap tensile strength. These test results are to be evaluated relative to the safety of these helmets for use by paratroopers. Impact testing both by WSU humanoid headform and a new pendulum break away device is scheduled for completion in late Oct 76. Secondary injury as a result of ballistic strikes on PASGT helmets is to be evaluated in the coming year. An electromyographical analysis comparing muscle stress produced by the PASGT helmet and the M-1 helmet will also be conducted. The proposed methodology for the PASGT evaluation was reviewed and approved by the National Research Council Committee on helmets during the annual meeting 22 Sep 76. This project is scheduled for completion in Sep 77.

Publication and Presentation of the following:

Knapp, S.: Recent Advances in Helmet Design, Aircraft Crashworthiness Symposium, Cincinnati, Ohio, October 1975.

Liu, Y. King, K. Chandran, and W. Van Buskirk, The In Vivo Dynamic Material Properties of the Canine Spinal Cord, USAARL Report 75-5, August 1974.

Nelson, W., J. Patterson, P. Allemond, R. Bailey, and R. Camp,
Real-Ear Sound Attenuation Characteristics and Impact (BUMP) Tests
Evaluation of the Proposed Final Modification of the Sierra P/N 791
AVC Helmet, USAARL Report 76-15-2-3, February 1976.

Jemian, W. and Y. Liu, Computer, Modeling of the Body-Head-Helmet
System, USAARL Report 76-13, February 1976.

GENERAL DETAIL SHEET

TITLE: Medical Research Applied to the Problems in Army Aviation

OBJECTIVE:

To provide the US Army information about those variables found in Army aviation in which the state of health of the aviator influences safety of flight or flight influences the state of health of the aviator.

BACKGROUND, METHODOLOGY, STATUS:

Statements concerning the above for this area of research can be found on the following pages numbered 32 through 51.

RECOMMENDATIONS:

It is recommended that research in this area be funded on a continuing basis.

THE AIR AMBULANCE: A STUDY OF ITS USE AND UPGRADING
OF EQUIPMENT AND CREWS - PHASES I, II & III

OBJECTIVE

The purpose of the study is to provide continuing review of the air ambulance helicopter and to update the available medical equipment and procedures to provide the most definitive medical care at the earliest possible time to the patient. Special emphasis will be placed on improving medical care at all levels of aeromedical evacuation.

BACKGROUND

Helicopter aeromedical evacuation has succeeded in reducing the mortality in Republic of Viet Nam to the lowest level of 2.3%. Further efforts to improve the mortality require improved medical care in the helicopter air ambulance at the earliest possible time, i.e., immediate resuscitation and life support.

Evaluation of the helicopter/medical equipment interface, as well as the equipment/air ambulance aidman interface, will be continuous.

METHODLOGY

Evaluation of medical equipment, interface of air ambulance aidman for helicopter use, and changing mission concepts of aeromedical evacuation is an ongoing process.

Evaluation of the rapid advancing technology of emergency medical care equipment for compatibility with helicopter operations is being conducted.

Modification of existing equipment and development of new equipment and procedures for improved medical care in the helicopter environment is continuing.

STATUS

Items of medical equipment are selected as developed for evaluation. Specific utilization techniques and procedures for use are evaluated in helicopter aeromedical evacuation. Items evaluated include portable defibrillator/monitors, physiologic data telemetry, inflight oxygen analyzer, ventilators, and therapeutic/aircrew oxygen sources.

Biomedical evaluation of the Western Gear two speed personnel rescue hoist is complete. The hoist demonstrated improved performance to include speed and safety. Modular components and simplicity provide for component exchange and cable change at user level. Advanced hoists should relieve current "life or death" restrictions.

USAARL-LR-76-11-1-5 reviews the evaluation of the Western Gear hoists.
USAARL-LR-76-20-1-6 provides the evaluative results of the Breeze
(ECP-720) hoist.

DESIGN, DEVELOPMENT, OPERATIONAL EVALUATION AND FABRICATION
OF THE MILITARY ANTI-SHOCK TROUSERS FOR USE BY
PARAMEDICAL PERSONNEL IN THE TREATMENT OF SHOCK

OBJECTIVE

To develop a rapid, simple, and effective means of treating shock syndromes by paramedical personnel.

BACKGROUND

Shock may be defined as a state of circulatory collapse, frequently associated with insufficient return of blood to the heart and manifested by persisting deficiency of blood flow to the peripheral tissues.

The insufficient return of blood to the heart is associated with pooling of blood in the venous system; as the blood pools in the venous system, the pulse rate increases and the arterial blood pressure decreases eventually leading to the death of the patient unless treatment is initiated.

Since all shock treatment takes time, an expeditious way of returning the pooled venous blood into the arterial circulation would benefit the patient and result in a reduction of mortality and increase survival time sufficiently so the patient could reach adequate medical treatment facilities. The simplest, most inexpensive and least time consuming treatment method is the principle of external counter-pressure applied to the abdominal area and lower extremities. The result of counter-pressure to these areas would result in decreased venous pooling, control of abdominal hemorrhage (if present), and allow blood to recirculate and perfuse tissue. External counter-pressure to elevate blood pressure is not new. It was first described in 1903 by Crile and recently Cutler and Doggit reported several case histories of combat casualties whose blood pressures were maintained only by the addition of "G" suits to the treatment regime despite heroic medications and blood transfusions.

METHODOLOGY

The Military Anti-Shock Trousers has been fabricated in four prototype models based on number of chambers in the garment. Velcro fasteners provide rapid application. The counter-pressure maintains a pressure of approximately 80-100 mm Hg to the abdomen and lower extremities.

STATUS

Phases I and II, design and fabrication of basic prototypes, have been completed. The David Clark Company, Worcester, MA, has manufactured the trousers.

Operational evaluation was attempted by military helicopter air ambulance units. Limited data recovery has required dependence on civilian trauma cases.

The Military Anti-Shock Trousers have been utilized by the Miami Fire Rescue Department in civilian trauma cases. The findings have demonstrated life saving value in 36 of 53 patients. Reports of initial series have been published in the Journal of Trauma 18:843-848, October 1973.

Study of the cardiovascular/hemodynamic effects of the MAST have been conducted using the mongrel dog and the non-terminal hemorrhagic condition. The MAST provide a rise in systolic pressure and even greater increase in diastolic pressure. Cardiac output remained unchanged or decreased slightly. Heart rate decreased with rise in pressure. The primary effect of the MAST in acute hemorrhage is an increase in peripheral resistance and retention of central core circulation. Clinical applications in the treatment of cardiogenic shock, treatment of hypotension post-abdominal aortic surgery, and as an adjunct in cardiovascular physical examination are being considered.

EVALUATION OF OXYGEN SYSTEMS FOR USE IN ARMY AVIATION

OBJECTIVE

To develop advanced oxygen systems and evaluate available oxygen systems for use in the helicopter and fixed wing operations.

BACKGROUND

Helicopter oxygen systems have to date been non-standard and of limited use. At present, there are no oxygen systems tested for helicopter usage. An increased need for oxygen occurs as aircraft are now based at high altitude and must exceed the 10,000 ft. ceiling imposed by military regulation in the performance of their duties. The Air Force has required oxygen from the ground up at night for 20 years due to the night vision impairment produced by even slight oxygen tension decrease. Decreased peripheral fields are the first physiologic impairment produced by reduced oxygen tension. In the helicopter flight envelope of confined area operation, this represents a significant hazard. The lack of oxygen on board also prevents its therapeutic use in evacuation of wounded.

US Army fixed wing require routine high pressure gaseous oxygen (1800 PSIG) for combat operations. The ground support equipment and oxygen logistic problems for combat aviation have been well recognized. The USN and USAF have pursued other high energy and excessive weight oxygen sources to eliminate the fire hazard and logistic problems. The US Army is limited in energy and weight and thus must pursue other sources. The molecular sieve oxygen concentration technology provided the most feasible.

METHODOLOGY

Four major available oxygen system types were tested for helicopter use: low pressure (450 PSIG), high pressure (1800 PSIG), LOX, and chlorate candle generators, at altitudes from sea level to 20,000 feet. Regulators were evaluated from 0 to 40,000 feet. The systems were required to deliver crew oxygen for seven men for three hours and have a therapeutic delivery capability. Physiologic oxygen tensions were measured and compared to determine regulator economy and efficiency.

Two advanced Army molecular sieve oxygen generators (AMSOG) were evaluated in bench tests (Phase I) and low pressure chamber (Phase II).

STATUS

The initial investigation concerning selection of an available helicopter oxygen system has been completed as USAARL Report 73-16, "Preliminary Evaluation of Portable Aviation Oxygen Systems." Modifications of initial

two systems have been completed. Additional systems are being modified or constructed. Delivery of first system to the field is planned in mid-December.

Future efforts are concentrated on reduction in operational costs by re-packaging the candles with reusable housings and modularization to decrease space requirements. This effort includes procurement of improved design systems for operational test.

The AMSOG has undergone bench testing and low pressure chamber testing. The AMSOG with adequate bleed air supply pressure (40 PSIG) will deliver 92% oxygen at ground level and 15 LPM (NTPD) flow. This system requires electrical power in limited quantities, and bleed air 35 lbs. per hour and 40 PSIG. The weight is approximately forty pounds for a two man system. Aviation medicine evaluation of the physiologic effects of 93% oxygen, 7% Argon and nitrogen washout are ongoing.

MASS SPECTROSCOPIC ANALYSIS OF A2/23S-1
CHLORATE CANDLE OXYGEN

OBJECTIVE

To identify and quantitate trace contaminants produced by A2/23S-1 chlorate candles.

BACKGROUND

The possibility of accumulator tank toxic residues due to trace gases in chlorate generated oxygen had not been previously evaluated through repetitive candle firing. Although military standards have been set for the system, only the manufacturer had performed quality testing. This study was undertaken to identify and quantitate trace contaminants in chlorate candle generated aviator and emergency medical oxygen supplier.

METHODOLOGY

Twelve chlorate candles were sampled at the candle outlet and at the accumulator outlet. Flow was set at 20/liters/min and the mass spectrometer was set for resolution of 5000, range 0-800 m/e initially, 0-300 m/e during tests and scan time of 2 sec for 500 scans. Sample was drawn into the MS directly on a continuous basis through a Teflon capillary sampling tube.

STATUS

The initial study project is complete. Data summary on processed results is as follows:

- a. Average ignition time 7.5 min, average output 257 liters.
- b. At 800 ms - 2 sec into the burn there is a peak of chlorine and CO probably due to high rapid heats in the ignition cone.

Samples:

CO₂ (manifold) = 290ppm

CO (manifold) = 8.40ppm at 1 sec

Chlorine (Cl₂) (manifold) = 0.8ppm at 1 sec

CO₂ (accumulator) = 39ppm

CO (accumulator) = 27ppb max

Cl₂ (accumulator) = 7ppb max

c. Total hydrocarbons were low, 1×10^{-9} M $C_6 - C_7$ maximum. Major constituent appears to be a C_6 fragment with a methyl or/and ethyl side chain at $C_3 - C_4$.

d. Solvents: acetone, probably used in cleaning metal containers, found in 7 of the 12 candles at the 7×10^{-10} M level max. Alcohol was present in 10 of 12 candles at the 6×10^{-8} M level max. Benzene present in one candle at 4.8×10^{-10} M level max. Toluene present in three candles at the 3×10^{-9} M level max.

e. Accumulator washout after 12 candles (2 full banks) showed only trace amounts of contaminants.

f. With delivery of modified chlorate candle systems with candles, monitoring of each system by mass spectroscopic analysis will be accomplished. The systems will be re-studied after firing of approximately 100 candles for contaminants and residue.

EFFECT OF OXYGEN ON RETINAL FUNCTION

OBJECTIVE

To study the effects of slight increases in ambient oxygen tensions on retinal lactate dehydrogenase.

METHODOLOGY

The experimental animals used in this study will be four month old female mice. The first part of the study will consist of in vitro exposures of retinal homogenates to elevated oxygen tensions. In the second part of the study the animals will be exposed directly to high oxygen tensions. Retinal lactate dehydrogenase activity will be assayed according to the method of Worthington (Worthington Biochemical Corp., Freehold, NJ). The measurements will be made at a wavelength of 340 millimicrons by recording the change in absorbency produced by the conversion of NADH_2 to NAD.

BACKGROUND

The retina is the most sensitive tissue in the body to elevated oxygen tensions. It is currently believed that oxygen exerts its toxic effect directly on retinal metabolism. The metabolic changes eventually lead to disturbance of cellular function sufficiently great to produce the symptoms of oxygen toxicity which are manifested through blurred vision as well as a narrowing of the visual field.

Numerous enzymes of the tricarboxylic acid cycle containing sulfhydryl groups have been shown to be reversibly inhibited on exposure to oxygen. The mechanism of this inhibition is believed to be an oxygen induced formation of disulfide bridges resulting in enzyme inactivation. At the present time the effect of elevated oxygen tensions on sulfhydryl containing glycolytic enzymes is not known.

STATUS

Currently lactate dehydrogenase activity from the mouse liver is being quantitated in order to determine the sensitivity of the assay as well as suitable enzyme concentrations for the assay. Lactate dehydrogenase activity from the mouse brain is also being measured so that the sensitivity of two neural tissues, the brain and the retina, to oxygen can be compared.

LDH activity in mouse brain homogenate is decreased significantly by higher than normal partial pressures of O_2 . The presence of reduced glutathione in the homogenate suspension prior to O_2 exposure protects

against the inhibition. Studies in liver homogenate show that O_2 consumption is decreased 50% after exposure to high partial pressures of O_2 . This effect is also prevented by pre-treatment with reduced glutathione. USAARL Reports numbered 75-8, 75-10, and 75-20 provide the complete review of findings. Studies of carbon monoxide in combination with hypoxia and hyperoxia are planned to evaluate the combined stress effects on basic cellular enzyme metabolism. Therapeutic modalities to protect against detrimental effects of these combined stresses will be evaluated.

CHANGES IN PLASMA PHOSPHOLIPID CONCENTRATIONS RESULTING FROM CUMULATIVE FATIGUE

OBJECTIVE

To determine if changes in specific plasma phospholipids can be used successfully on a routine basis to predict fatigue buildup in Army aviators.

BACKGROUND

Previous work by Polis, et. al., has shown that the level of specific plasma phospholipids (phosphatidyl glycerol, phosphatidyl ethanolamine, and phosphatidic acid) increases during the periods of physical and emotional stress. The phosphatidyl glycerol concentration increases independently of the type of stress, while changes in the other phospholipids are dependent on the type of stress to which the individual is exposed. In order for the measurement of plasma phospholipids to be a useful tool in Army aviation medicine, the technique of measurement must be simplified considerably and the changes in phospholipid concentration must be shown to correlate with pilot performance.

METHODOLOGY

The method of phospholipid analysis used by Polis, et. al., involved extraction, hydrolysis, separation by paper chromatography and electrophoresis followed by manual determination of phosphorus for phospholipid quantitation. The method that has been used in this laboratory eliminates the hydrolysis step, replaces paper chromatography and electrophoresis by thin layer chromatography (Silica Gel H), and automates the phosphorus determinations using the Technicon Autoanalyzer.

STATUS

The Technicon Autoanalyzer has been modified by the addition of a more sensitive colorimeter. It is now possible to measure on a routine basis phosphorus concentrations of less than 15 nanograms. Various types of TLC sorbents have been evaluated. A precoated Silica Gel H plate manufactured by Analtech, Inc., provides the best separation of the phospholipids present in blood plasma.

The use of TEAE cellulose column chromatography was necessary to separate the more abundant phosphatidyl choline and sphingomyelin from the more stress responsive acidic phospholipids. The time required for this added procedure, as well as the high degree of technical skill required for reproducible measurements makes this technique undesirable for routine analysis. The methodology developed by USAARL for plasma

phospholipid measurement proved to be specific but not sensitive enough for the level of phospholipid change obtained in the stress studies. A review of the techniques and methodology developed at USAARL was reported as USAARL-LR-75-30-1-8, "Techniques of Phospholipid Analysis".

COMPUTER ASSISTED MASS SPECTROMETRIC ANALYSIS FOR STRESS RELATED BIOCHEMICAL INDICATORS

OBJECTIVE

To evaluate a wide variety of compounds using computer assisted mass spectrometry to survey blood serum and urine for stress related biochemical changes.

BACKGROUND

Present studies of stress related metabolic changes have a serious drawback in only allowing quantitation of suspect stress indicators without surveying for possible unknown indicators. Capillary GC has allowed other investigators to separate about 400 urinary components. Capillary GC-MS in conjunction with computer analysis will allow identification and quantitation of all separable urinary components and direct comparisons with control urines or plasmas.

METHODOLOGY

Preliminary scans were evaluated directly by capillary GC-MS or thermal vaporization programming with both urine and plasma. If the complexity of separation precludes direct analysis, only dialysis will be used initially to fractionate the specimen. This prevents molecular fracture prior to MS analysis, a condition which greatly complicates mass spectral interpretation.

STATUS

USAARL's JMSD100 double focusing, Matsuda geometry, high resolution mass spectrometer has demonstrated resolution $>20,000$. A coupled HP 5711A gas chromatograph is capable of handling 100 meter 2mm capillary columns. The thermal probe allows programming from -100° to 400°C at any rate. Three channel, multiple mass monitoring is also system incorporated. The data system is a Texas Instrument 980A with 733 ASR terminal and CRT display. All portions of the system have been successfully integrated for low resolution (<5000) high speed (>2 sec/0-800 amu) and high resolution low speed (>60 sec/0-800 amu) scanning. Newly developed software allows elemental composition calculation with high resolution (10,000) and short scan times (10 sec/0-800 amu). Ninety-six specimens from 6 sleep deprived helicopter pilots have been compared to control values.

The procedures developed have identified four urinary compounds not previously described. A three-four, dimethoxy benzoic acid had control level of $\sim 2 \times 10^{-10}$ M in six subjects increasing to $\sim 8 \times 10^{-8}$ M in all subjects during hour 24 to 72 of flight during the stress and fatigue

study. A second compound has been identified as an amino acid-a dipeptide with leucine. This dipeptide quantitatively varies from $\sim 1.5 \times 10^{-9}$ M during controls to 5×10^{-7} M at the close of sleep deprivation with the six pilot subjects. These components and at least two others (whose identity has not been fully defined) offer promise as biochemical indicators of stress and fatigue.

CHANGES IN URINARY ORTHO-HYDROXY-HIPPURIC ACID (OHH) DURING CUMULATIVE STRESS

OBJECTIVE

To evaluate the usefulness of OHH as a possible indicator of cumulative stress.

BACKGROUND

There are no present means of objectively determining stress levels. In Army aviation the problem is acute as slight impairment of judgment due to physiological or psychological stress may result in loss of life. This testing is to evaluate a metabolite found in urine which has been shown by Naval investigators to increase during traumatic injury. OHH may provide an indicator of physiological, psychological, or cumulative fatigue.

METHODOLOGY

Preservation of urine specimens by vacuum drying has proven critical as an increase in temperature over 35°C during drying results in a fluorescence shift. (Drying is only necessary if analysis cannot be performed immediately.) 20 ml of acidified urine is extracted 3X with 2 vol of chloroform. The upper phase is re-extracted 3X with 3 vol of 2:1 heptane : isobutanol and the upper phase is taken to dryness by vacuum distillation below 35°C. The residue is extracted with methanol and analyzed with an Aminco Ratio Spectrophotofluorimeter at 428 nm emission and scanned excitation. A series of serial dilutions from 10:1 to 170:1 were used to prevent opacity interference.

STATUS

The following problems were encountered in the extraction procedures:

- (1) Vacuum distillation of the heptane extract at temperatures above 35°C results in a spectral shift from 306 nm excitation to a peak in the 310-360 nm region.
- (2) An interfering urine component recovered in the extraction produces a peak at 354-360 nm excitation. This fairly broad peak, as yet unidentified, masks or completely occludes any OHH peak which has moved due to urinary interference or thermal shifting.
- (3) Subjects from high and low level navigation flights, as well as schizophrenic patients from VA hospital, have been tested and thus far only two individuals have demonstrated OHH production. Further, little correlation can be shown between their stressor activities and OHH levels.

(4) In the $> 5 \times 10^{-4}$ M OHH concentration range, there is a pronounced spectral shift from 306 nm to 328 nm excitation indicating that OHH spectra are concentration dependent.

(5) The assay has proven accurate in the 1×10^{-3} M to 1×10^{-6} M OHH concentration range.

(6) Time dependent decomposition of OHH in methanol solution for standards is indicated by the increasing presence with time of a spectral peak of 276 nm excitation. Standards refrigerated at 4°C last approximately two months.

Based on preliminary data and a review of Naval research, OHH may prove to be an indicator of chronic psychological stress. OHH determinations were performed upon the urine of sleep deprived helicopter pilots. Data analysis to date indicates limited sensitivity to level of stress or activity. OHH levels will be obtained in conjunction with other stress, fatigue and performance studies to attempt to define OHH metabolism and its response to stress. Further evaluation of OHH in low level and NOE fliers in FY 77 will provide more background information on OHH metabolism and its relation to stress.

BIOCHEMICAL CHANGES IN PLASMA RESULTING FROM CUMULATIVE FATIGUE

OBJECTIVE

To determine the usefulness of a number of plasma and urine chemical measurements for the prediction of excessive fatigue in Army aviators.

BACKGROUND

One of the most important areas of medical research in the Armed Forces is the effect of cumulative fatigue on a man's ability to perform his duty. In Army aviation we have a more specific problem of determining the time at which a pilot's coordination and judgment are impaired to the point of compromising safety. This laboratory is presently involved in a search for changes in body constituents that can be used as biochemical indicators of stress buildup, i.e., an objective indicator of stress.

METHODOLOGY

The creatinine phosphokinase (CPK), lactic dehydrogenase (LDH), cholesterol, and uric acid content of blood plasma is being measured by the use of the Biodynamics Unitest System. Plasma lactic acid is being measured by the Sigma colorimetric procedure using the Cary 14 spectrophotometer. Plasma cortisol (17-hydroxycorticosterone) is being measured by a sensitive protein binding procedure. Urinary catecholamines (epinephrine and norepinephrine) are determined by the trihydroxyindol reaction.

STATUS

The Biodynamics Unitest System was evaluated and found comparable in accuracy to other clinical procedures. The portion of the catecholamine procedure following the column separation has been automated.

Preliminary experimentation with human subjects and laboratory animals has given the following results. Stress-susceptible pigs had higher CPK, LDH, and lactic acid levels than stress resistant strains. A comparison of blood and urine chemical levels in helicopter pilots under different types of flight conditions showed that nap-of-the-earth (NOE) flight resulted in higher serum uric acid, lactic acid, LDH, CPK and urinary catecholamines than normal local area flight (1,000 feet AGL). Preflight cortisol and urinary catecholamine were higher than post-flight samples in both NOE and local area flight profiles. The urinary catecholamine levels of student parachutists were monitored prior to, during and following their first jump. There was an increase in total catecholamine excretion as well as a change in the norepinephrine to epinephrine ratio during the jump period. The battery of tests has been

conducted on the plasma and urine sleep deprived helicopter pilots. Data reduction is underway.

The data was reported to the Joint Army Navy Research Panel. USAARL's Report will be available in the near future entitled "Biochemical Differences in Pilots Flying Nap-of-the-Earth and Low Level Flights as Compared to Routine Area Flights".

AEROMEDICAL EVALUATION OF PROPOSED AIRCRAFT

OBJECTIVE

To develop methodology and equipment for evaluation of proposed aircraft to include anthropometry, downwash, heating, ventilation and toxicology.

BACKGROUND

USAARL has previously been requested to provide evaluation and "quick fix" of hazardous medical conditions discovered after aircraft have entered the Army inventory. Recent aeromedical input into future aircraft design and operational requirements has required new technology for evaluation. USAARL was tasked to aeromedically evaluate the UTTAS prototype and the 214A helicopter.

METHODOLOGY

Anthropometry measurements utilized standard human factor engineering techniques. Downwash ventilation studies were performed using calibrated Alnor flowmeters. Heating data was obtained by YSI wet-dry-radiant heat thermocouples. Mass spectrometry was used for toxic cabin contaminants.

STATUS

Anthropometric and downwash studies were accomplished for the Boeing and Sikorsky UTTAS prototypes and the Bell 214A helicopters. Evaluation of heating and ventilation for these aircraft was accomplished using available YSI thermocouples and Alnor flowmeters. To accurately evaluate toxic contaminants due to armament firing and engine exhaust, development of on-line sampling techniques by mass spectrometer was required. A compact mass spectrometer was obtained and suspension designed for continuous use in flight. Data was obtained during 40 day and night flight hours. Analysis of 800 flight profiles for the UTTAS prototypes has been provided the Source Selection Board. The data will be reported in USAARL Laboratory Reports following release by the SSB.

CARDIOPULMONARY STUDIES FOR SELECTION/RETENTION OF US ARMY AIRCREW

OBJECTIVE

To evaluate cardiopulmonary function and disease for selection/retention and preventive medicine application for US Army aircrew.

BACKGROUND

Cardiopulmonary disease to include coronary artery disease, hypertension arrhythmias, and chronic obstructive lung disease, produces a significant loss of the highly skilled and costly trained aviator usually at the mid-point of a flying career. The aeromedical community cannot apply the usual civil clinical cardiopulmonary standards in determination of flying status due to the combination of hypoxia, vibration and thermal stresses not routinely found in the normal ground environment. The Aviation Medicine Research Division utilizes accepted medical evaluation techniques in evaluation of aircrew and flight applicants. The use of pulmonary function testing, arterial blood gas, Holter dynamic ECG monitoring, resting ECG, VCG and treadmill exercise testing provides the most useful data. Aeromedical clinical data from the waiver files in conjunction with the USAAVS accident/incident data and the AFIP autopsy data provides the capability to review natural history of many diseases previously considered rare.

STATUS

Results of studies of Coronary Artery Disease and Preventive Cardiology in Aviation Medicine were published in Aviation Space and Environmental Medicine, October 1975, pages 1299-1304. This study demonstrated a continuing rise in moderate and severe coronary artery disease (CAD) in the 20 to 34 year age group to 26.2% to 21.2%. This data did not support the Vietnam autopsy study that CAD is decreasing.

A study of Sarcoidosis and its effect on the heart demonstrates a significant incidence of electrocardiographic abnormalities of 37%. The risk of sudden death associated with these findings remains to be defined.

GENERAL DETAIL SHEET

TITLE: Research of Visual Problems Medically Significant to Army Aviation

OBJECTIVE:

To provide information about the visual sensory modality which has medical importance for US Army aviation.

BACKGROUND, METHODOLOGY, STATUS:

Statements concerning the above for this area of research can be found on the following pages numbered 54 through 83.

RECOMMENDATIONS:

It is recommended that research in this area be funded on a continuing basis.

FIELD STUDY - AVIATOR OPHTHALMIC FRAME

OBJECTIVE

To determine the acceptability of a new spectacle frame design (style, color, comfort, compability) by aviators and to determine the serviceability of the frame material in varying environmental conditions.

BACKGROUND

The present metal aviator's frame (FG-58) has enjoyed good acceptance among user personnel and has provided reasonable serviceability. Therefore, some design and safety deficiencies have been accepted in the past. However, recent increases in the price of these frames and changes in the material that they are made from have forced a search for an acceptable substitute. This study is a joint Army/Air Force program in which a new frame made from thermo-setting plastic is being field tested.

METHODCLOGY

This field study requires that the test frames be issued to 300 personnel on active flight status. The volunteers are being obtained from the following locations: Fort Rucker (100), Fort Campbell (50), Fort Hood (50), Fort Richardson (50), Fort Clayton (50). The personnel will wear the test frames for a period of one year, during which, at 4-month intervals, they will be questioned to obtained data on the test frame for serviceability and compatability.

STATUS

All necessary coordination to obtain the test volunteers has been completed. The fitting and prescription information is being processed and the spectacles are being fabricated. The Air Force is proceeding for their portion of the test on the same schedule.

DEPTH DISCRIMINATION WITH THE AN/PVS-5 NIGHT VISION GOGGLES

OBJECTIVE

To determine the ability of an observer to make relative depth discriminations under both field and laboratory conditions while using the NVG and to compare these results with naked eye performance under otherwise identical conditions.

BACKGROUND

The NVG are considered an effective interim solution to allow U.S. Army aviators to conduct rotary wing operations at night. While the goggles perform admirably in light amplification, use of them has presented new problems and questions for those of us concerned with the human in this man-machine system. This investigation is one in a series of experiments conducted at USAARL during the past several years to determine the present and potential impact of the NVG on aviators during rotary wing flight.

METHODOLOGY

For this experiment, six experienced aviators made all of the observations using the psychophysical method of adjustment. For the laboratory measures of stereopsis, a modified Howard-Dolman apparatus was used. The observers made depth judgments under each of four different viewing conditions: unaided monocular, unaided binocular, monocular with the NVG, binocular with the NVG. The field measures of relative depth discrimination were made along an inactive airfield runway while the observers were seated in a JUH-1H helicopter. The observers' task was to indicate when two targets, one fixed and one variable, were judged to be at the same distance from them. The targets consisted of white cloth stretched over metal framework, and their actual size was varied to present a constant visual angle at all viewing distances. Observation distances ranged from 200 feet to 2000 feet, and three viewing conditions were used: monocular and binocular during the day, and binocular with the NVG at night.

STATUS

This investigation has been completed and the results are reflected in USAARL Report No. 76-25, Depth Perception with the AN/PVS-5 Night Vision Goggles. The results indicated that stereopsis, the appreciation of depth by means of the disparity of the retinal images, is significantly reduced when wearing the night vision goggles. Also, when many monocular cues are available, as in the field tests, relative depth discrimination is poorer with the NVG for distances of 500 feet or greater.

CROSS-SECTIONAL SURVEY OF SELECTED VISUAL PARAMETERS

OBJECTIVE

To develop a data bank of selected visual parameters which will assist in determining visual standards of medical fitness and which will provide guidance in the design of optical equipment.

BACKGROUND

Equipment developers often request USAARL assistance in the design parameters of viewing devices. For example, design decisions must be made to incorporate interpupillary range adjustments which will accommodate most of the potential users. Likewise, the dioptric adjustment should correct the majority of users. Descriptive statistics concerning the special population represented by the military community have not previously been available. This study was initiated to fill this information gap. It is also envisioned that this study will be used to provide information concerning reasonable visual standards for medical fitness as specified in AR 40-501.

METHODOLOGY

The data for this study will be obtained from optometry exams performed in military medical facilities. A sufficient sample size can be obtained if selective information from visual examination results can be collected for a period of three months.

STATUS

A letter requesting clinic participation has been sent to every Army medical facility having an optometry clinic. Approximately 50% of the clinics have indicated that they will participate in the study. Special data forms have been developed with which to collect the data.

REDUCTION OF GLARE FROM THE LANDING LIGHTS OF THE OH-58:
AN EVALUATION OF FOUR POTENTIAL SOLUTIONS

OBJECTIVE

The objective of this study was to find ways to reduce the cockpit glare from the OH-58 landing light.

BACKGROUND

When the landing lights of the OH-58 are turned on a large veiling glare is reflected from the aircraft windscreens whenever the aircraft is within approximately 30 feet of the ground. The problem is created by the light reflected from the ground area directly below the chinbubble which passes up through the chinbubble and reflects from the aircraft windscreen into the pilots' eyes. Of course, the lighter or more reflective the ground surface the greater the amount of glare. Also, the problem is more severe for the forward landing light which directs its illumination at a more downward angle, including the area directly beneath the chinbubble, than for the rear landing light which directs most of its illumination well in front of the aircraft.

METHODOLOGY

Basically, there are two types of solution to this problem. One approach is to prevent the light from the landing lights from reaching the ground area directly beneath the chinbubble, thereby eliminating the source of the problem. This was the approach used in Solution 1. The second approach is to prevent the light reflected from the ground directly beneath the chinbubble from reaching the windscreen by means of opaque shields or tape. This was the approach used in Solutions 2 and 3. Specifically, the four evaluated solutions consisted of: (1) placing a metal shield beneath each landing light; (2) placing shields on each side of the cockpit extending out laterally and forward from the instrument panel; (3) taping over the inside one-half of each chinbubble; and (4) taping over the sides of the plexiglass sheet and light well.

STATUS

This project is 100% completed and has been published as USAARL Report No. 76-21 entitled, "Reduction of Glare from the Landing Lights of the OH-58: An Evaluation of Four Potential Solutions." The first three solutions were all found to be very effective but the preferred solution was the placing of shields beneath the landing lights (Solution 1) since this involved no visibility loss or extra material inside the cockpit. It was also found that the tape over the inside one-half of each chinbubble is a very good field-expedient "quick fix."

A COMPARISON OF THE REFLECTANCE PROPERTIES OF AN IR ACRYLIC BASE PAINT AND NEXTEL VELVET COATING 101-C10

OBJECTIVE

The objective of this study was to determine the reflectance properties of the above two named paints and to thereby determine which one would be more effective in reducing cockpit glare.

BACKGROUND

A previous report from this laboratory showed the large amount of reflection reduction that occurs when a cockpit is painted with Nextel Velvet Coating (black) rather than the grey lacquer commonly used. However, recent data from the Materials Engineering Division of the U.S. Army Mobility Equipment Research and Development Center (MERDC) indicated that some of the physical properties of the Nextel paint are inferior to those of the acrylic base IR paint currently used on aircraft exteriors. In light of these factors, since photometric data from MERDC were at variance with USAARL data, the U.S. Army Aviation Systems Command requested that USAARL conduct a study to compare the reflective properties of a black version of this IR paint to those of Nextel black and determine whether the IR black paint could serve as an acceptable substitute to Nextel for reducing reflections within the cockpit.

METHODOLOGY

In order to perform this comparison, the left half of a UH-1H cockpit was painted with the black IR paint and the right half was painted with black Nextel. This aircraft was flown to a secluded landing strip having no runway lights, flood lights, or other extraneous lights to confound the experiment. The instrument panel was evenly illuminated by a modified map light and photometric readings were taken to determine the amount of light reflected from the left (black IR) side of the instrument panel versus the amount reflected from the right side (black Nextel). A flash picture, a time exposure, and a time exposure photographed through the night vision goggles were then taken of the instrument panel. Laboratory tests were also performed by taking photometric readings of a black IR sample and a black Nextel. Both the light sources and the photometer were placed at various angles.

STATUS

This project is 100% completed and the results have been published in USAARL LR-76-14-7-6 entitled, "A Comparison of the Reflectance Properties of an IR Acrylic Base Paint and Nextel Velvet Coating 101-C10." It was found that at most angles the black Nextel reflected less light than did the black IR.

COCKPIT COMPATIBILITY WITH NIGHT VISION GOGGLES

OBJECTIVE

The objective of this work is to develop techniques to make the crewstation lighting of Army helicopters compatible with the use of night vision goggles.

BACKGROUND

Army aviators are presently flying low level and nap-of-the-earth profiles at night with the aid of night vision goggles. However, crewstation lighting was not designed to be compatible with the use of these goggles. Both the instrument and warning lights are much too bright. The detrimental effects of lighting which is too bright are twofold: (1) bright lights cause the goggles to bloom which creates a blurring condition and makes legends, indicia, etc. non-legible and, (2) bright lights activate the goggles' automatic gain control which reduces out-of-the-cockpit visibility.

METHODOLOGY

In this work, cockpits are being experimentally configured with different lighting controls and painted with a low-reflection coating to reduce glare. Resistances which can be switched in or out are being added to warning light circuits and higher quality potentiometers are being used to control the instrument lights. In Phase I, an AH-1G was configured primarily for the purpose of determining proper resistance values. In Phase II, a UH-1H is being configured according to a more sophisticated design. Phase III will consist of going to the U.S. Army Aviation Systems Command with proven designs and trying to get these modifications applied fleet-wide.

STATUS

This project is 70% completed. Phase I has been completed and Phase II is nearing completion.

STUDIES OF CONTRAST SENSITIVITY OF MAN-MACHINE SYSTEMS:
II. CONTRAST SENSITIVITY WHILE VIEWING THROUGH
THE NIGHT VISION GOGGLES

OBJECTIVE

The objective of this study was to determine the performance of the naked eye versus the eye-with-night-vision-goggles with respect to contrast sensitivity at various spatial frequencies and various luminances. These data are then used to predict pilot preferences (naked eye vs. goggles) under various moon illumination conditions.

BACKGROUND

Using simple clinical measures of visual acuity, it has been determined that Snellen acuity using the goggle is about 20/60, corresponding to a minimum angle of resolution of 3.0 minutes. Such measures, however, employ high contrast targets. It was felt that a measure of contrast sensitivity would be more appropriate to the low contrast levels found in nighttime field conditions. Such a technique is offered by the visual modulation transfer function (VMTF) which allows control of such external variables as average scene luminance, contrast, and angular subtense of the resolution target. When the optical components of a system are separated by diffusers, the overall system MTF can be determined simply by multiplying the individual MTF's. However, when the various components are directly coupled, as is the case when a man views with the night vision goggle, the individual MTF's cannot be multiplied to determine the overall system MTF. This is because the aberrations of one component may compensate for the aberrations in another, and thus produce an image quality for the combination which is superior to that of either component. Therefore, it was necessary to determine the MTF of the system as a whole even though the MTF of the eye and the night vision goggles are known separately.

METHODOLOGY

The modulation transfer functions obtained in this experiment were determined in the following manner. The subject sat in a darkened room and viewed a television monitor on which was displayed an electronically-generated spatial sine wave grating. The experimenter established and controlled the average luminance on the video display, and the subject controlled the depth of modulation (contrast) of the grating around the average luminance. Two viewing conditions (unaided and with the NVG) and four average luminance levels were used. The average luminance levels used correspond to the luminance of grass (12% reflection) under a 5%, 25%, and full moon illumination with no overcast conditions. The fourth level of 25 footlamberts, considerably above the level with which the NVG would be used, is presented for comparison purposes.

STATUS

This work is complete except for the writing of the final report. It was found that at average luminance levels of 1.2×10^{-4} ft.L and 6×10^{-4} ft.L (corresponding to the luminance of grass under 5% and 25% moon conditions respectively) performance was better, at all spatial frequencies when the night vision goggles were used than when viewing with the naked eye. Under average luminance conditions which approximated full moon conditions (2.4×10^{-3} ft.L), however, naked eye performance was better than NVG-aided performance for high spatial frequency (narrow) targets while remaining poorer than NVG-aided performance at low spatial frequencies. This corresponds well with the fact that under full moon conditions, most experienced aviators prefer to fly with unaided eye than with night vision goggles.

THE USE OF OPAQUE LOUVRES AND SHIELDS TO REDUCE REFLECTIONS WITHIN THE COCKPIT: COMPUTER PROGRAMS FOR TWO APPROACHES TO THE PROBLEM

OBJECTIVE

The objective of this work was to develop computer programs to determine the potential effectiveness of opaque louvres in reducing the canopy reflections caused by the lights from the instrument panel.

BACKGROUND

Opaque shields can be used to channel light and thereby reduce reflections within the cockpit. These shielding devices range from the standard glare shield on top of the instrument panel to the more experimental use of Light Control Film^R and Micromesh^R for this purpose. Previous work in this series has demonstrated two mathematical approaches to a specific reflection problem in the AH-1 aircraft, namely, the reflections coming from the portion of canopy directly above the gunner's head.

One technique of reducing the reflections of the instruments, dials, etc., from the transparent enclosures is the use of opaque louvres and shields. In using these screening materials, one wants to maximize the extent to which they block light from reaching the offending portion of canopy while minimizing the extent to which they block light from reaching the pilot's eyes. This is accomplished by choosing the proper values for the position, width, spacing, angle, etc. of these shields and the analysis lends itself to computer solution. In previous reports, two mathematical approaches to the problem were shown: an analytical geometry solution and a solution in terms of plane geometry and trigonometry. Regardless of the different mathematical derivations, results from these two theoretical predictions of the reduction in interior cockpit reflections were identical.

METHODOLOGY

Due to the nature of the problem, visibility has been classified into three cases. We denoted the projected points of the lower and higher points of the louvre to the vertical axis of the pilot's position by h and H respectively. Case I concerns the visibility of V_I above H . Visibility V_{II} (Case II) is the region between H and h . Below h , visibility V_{III} is classified as Case III. Since Case II is relatively trivial and since Case III is similar to Case I, we will show the equations for Case I by these two methods.

a. Analytical geometry method

$$V_{IA} = 1 - \frac{d_1 \tan \theta - k_1}{c + k_1 \tan \theta}$$

Where V_{IA} is visibility, c is the distance between louvres, d_1 is the thickness of the louvre, θ is the decline angle of the instrument panel and k_1 is constant.

b. Plane geometrical method

$$V_{IB} = k \frac{1 (h-H) \cot^{\alpha} \cos \theta + \sin \theta}{h \sec (\alpha-\theta) - 1 - \alpha \sin \theta \sec (\alpha-\theta) - (h-H \cos \theta \sin \alpha)}$$

Where V_{IB} is visibility, K is constant, h is the minimum height, H is the maximum height, θ is the decline angle of the instrument panel and α is the extended angle.

STATUS

This work is 100% completed and the results have been reported in USAARL Report No. 76-6 entitled, "The Use of Opaque Louvres and Shields to Reduce Reflections within the Cockpit: Computer Programs for Two Approaches to the Problem." The computer solutions showed that Light Control Film^R is of rather limited usefulness in this application because of the rather severe pilot visibility reduction.

LENS MATERIAL EVALUATION (GOGGLES, SUN, WIND, AND DUST)

OBJECTIVE

To evaluate the optical quality of potential replacement lens materials for the sun, wind, and dust goggles.

BACKGROUND

The combat vehicle crewman's goggle (goggle, sun, wind, and dust, NSN 8465-00-161-4068) is presently being modified to provide improved ballistic protection. The modification program consists of two phases. The first phase involves developing an immediate replacement for the visor which will fit into the present lens carrier. The second phase is a longer range attempt to improve the visor and carrier design.

The US Army Natick Research and Development Command has been given overall responsibility to manage both phases of the product improvement. In support of the "quick fix" effort, NARADCOM requested the US Army Aeromedical Research Laboratory to provide an optical evaluation of candidate replacement lenses for the goggles.

METHODOLOGY

NARADCOM provided the lens materials to be evaluated. The lenses supplied were extruded polycarbonate of two thicknesses (.030 inch and .040 inch). The samples included untreated lenses and lenses which had been coated with one of four possible coatings developed to provide increased resistance to surface scratching. All of the optical tests were also completed on a cellulose acetate butyrate (CAB) lens which is currently used in the goggles.

The lenses were evaluated on four criteria: luminous transmissivity, distortion, haze, and scratch resistance. The methods of testing are given in subparagraphs a - d below.

- a. Luminous transmissivity was measured with a Macbeth Quanta Log Densitometer.
- b. Haze was measured with a Gardner Hazemeter Model UX10 and Gardner Automatic Photometric Unit, "Colorgrad" model. Maximum aperture size was used.
- c. Distortion was evaluated according to the method described in MIL-V-43511(GL) for polycarbonate visors. Evaluation is made with an Ann Arbor Optical Company Optical Tester by comparing against visor distortion standards in this Mil Spec.

d. Abrasion resistance was measured by rubbing the surface with an "Optical Coating Tester Abrasion" D7630606 which permits the application of a controlled, uniform pressure of an abrader. During application, a 30-40 psi air jet was played on the surface to blow away particles.

STATUS

1. The light transmission and freedom from surface hazing were adequate in all of the lens samples provided.
2. The abrasion resistance of polycarbonate is very poor and the coatings used to increase resistance to abrasion provide negligible improvement. The cellulose acetate lens presently used in the goggles is far superior in resistance to surface abrasion.
3. All of the polycarbonate lenses (coated and untreated, both thicknesses) have unacceptable levels of distortion. This is attributed to the method of manufacture rather than a property inherent to the material itself since a polycarbonate helmet visor (injection molded) had no observable distortion.

The complete report is contained in USAARL Report No. 76-20.

OCULAR DOMINANCE AND VISUALY GUIDED HEAD AIMING

OBJECTIVE

The helmet mounted sight (HMS) for the AAH requires the gunner/pilot to align a reticle monocularly visible with a binocularly seen target. This study will evaluate the relative accuracy and speed of target acquisitions when the sight is presented to the dominant and nondominant eye.

BACKGROUND

On the basis of a study conducted by Honeywell, the Air Force has taken the expedient position of providing the HMS to the right eye regardless of the gunner/pilot's eye dominance. Several shortcomings in that study -- small sample, large error variance, target presented on a helmet mounted display to the same eye -- raise questions regarding the conclusion that eye dominance has no effect in visually guided head aiming.

METHODOLOGY

Selection of subjects will be based upon an extensive survey of sighting eye dominance using a modification of the Dyer test. Head aiming will be measured using the system constructed for the head aiming/tracking study. This system is described in detail in precis entitled, "Development of Measuring Techniques for the Medical Assessment of Visually Coupled System (VCS) Components."

STATUS

The eye dominance survey is currently underway preparatory to the selection of subjects. The apparatus for the measurement of head aiming is nearly completed.

DYNAMIC VISUAL ACUITY IN FATIGUED PILOTS

OBJECTIVE

The dynamic visual acuity (DVA) task consists of the measurement of visual resolution when there is relative motion between the observer and the object being regarded. Because helicopter profiles involve flying at extremely low altitudes, even at relatively modest air speeds, observer-object angular velocities exceed $100^\circ/\text{second}$, indicating the requirement of good dynamic acuity for the acquisition of navigational landmarks, military targets, and detection of hazards such as power lines. In the present study, an evaluation was made of dynamic visual resolution in the course of a flying induced fatigue regimen which extended for five days.

BACKGROUND

The early evaluation of DVA and its significance for aviation was established by Drs. Ludvigh and Miller, under Navy sponsorship. Their research elaborated the effects of a number of experimental parameters and although they did not test the susceptibility of DVA thresholds to the effects of fatigue, they postulated such a relationship. This expectation is quite reasonable since good DVA performance depends not only upon the resolution ability of the eye, but also upon the integrity of the oculomotor system in providing (a) the prompt saccade to "catch up" to the moving target, and (b) the smooth pursuit movement to minimize eccentric fixation and smearing of the retinal image. Furthermore, because of the brevity of target presentations, DVA depends upon efficient central processing of briefly presented visual targets.

METHODOLOGY

Six rotary wing aviators participated in a "continuous operation" study involving some 14 flying hours daily and severe sleep loss (3 1/2 hours per night) for five days. In addition to DVA thresholds, flying performance, laboratory tests of psychomotor function, and biochemical levels were all measured. DVA varied during the course of fatigue buildup and was related to performance measures.

STATUS

A preliminary report of this study was presented at the sixty-seventh annual meeting of the Southern Society for Philosophy and Psychology, March 27-29, 1975. A detailed report is contained in USAARL Report NO. 76-24. Further studies of DVA are underway or in preparation.

BIO-OPTICAL EVALUATION OF SPECIALIZED EYEWEAR: LASER SAFETY AND DARK ADAPTATION DEVICES

OBJECTIVE

To provide quantitative data and color vision evaluations for several types of goggles. The first two types are laser safety devices and the other three are for dark adaptation purposes.

BACKGROUND

Although several studies for establishing laser safety criteria are known, optical characteristics and spectral transmittances of the laser safety devices are unavailable in any published form. Since underlying laser damaging mechanisms and thresholds to the visual system remain unresolved, and since laser radiation powers and intensities vary greatly with respect to lasing materials and durations, there exists no universal safety device of optical quality which will meet the recent Army safety standards and regulations (AR 40-46).

The increasing use of lasers as military electro-optical research tools, range finders, target designators, and weapons promptly demands stringent safety protection for the users.

A qualitative evaluation of laser protective eyewear has been conducted previously. Test results showed that exposure of laser goggle materials to sufficiently high laser energy would cause damage in the form of melting, bleaching, bubbling or shattering. Furthermore, some eye-safety products would fail to function as protective devices after only several seconds of exposure to laser beams of about 12 w/cm^2 . Nevertheless, no quantitative analysis of the optical quality of the devices has ever been provided. Results from this study will enable the users to calculate the amount of energy being transmitted through safety devices.

METHODOLOGY

The two types of laser safety devices used in this study were denoted as follows: (1) Type I device, manufactured by Omnitech, Inc., Southbridge, MA 01560, designed for protection against He-Ne lasers with power less than 1 mw. (2) Type II device, made by American Optical Corporation, Buffalo, NY 14215, was for use with ruby, neodymium or Ga-As lasers at 10^{-2} j/cm^2 energy density or less. The frame for type I device was a goggle and for type II device, a spectacle. The three red, dark adaptation devices used here were (1) WW II aviator's goggles, (2) Navy dark adaptation goggles, and (3) fluorescence adaptation goggles. The first was manufactured by Polaroid Corporation, Cambridge, MA. The second and third were made by American Optical Corporation.

The two light sources used were (1) Macbeth daylight filter with 100-watt GE tungsten bulb, (2) 0.5 mW He-Ne laser made by CW Radiation, Inc., Mountain View, California. The automatic data acquisition/analysis system had the following main components: (1) Rapid Scan Spectrometer (RSS), (2) Digital Processing Oscilloscope (DPO) with 4K storage memory. (Both are made by Tektronix, Inc., Beaverton, Oregon.) and (3) PDP 11/05 with 24K memory and a cassette I/O drive. Tektronix 4010-1 TTY and 4610 hardcopier were the accessories to the system.

STATUS

Results have been written in USAARL Report 76-7 entitled, "Bio-Optical Evaluation of Specialized Eyewear: Laser Safety and Dark Adaptation Devices." This study concludes that He-Ne laser safety eyewear conforms to the Army Regulation (AR 40-46) specification. It is recommended that one type of the safety device be used for only one specific purpose. Furthermore, the laser safety device cannot be used when a detection of red display or a red light source is required.

SYNTHETIC SPECTRA

OBJECTIVE

To investigate optical characteristics of various combinations of known spectra for vision research.

BACKGROUND

In applied vision research, it is often desirable to obtain an ideal energy spectrum of a light source to serve as a visual stimulus. Due to physical constraints of electromagnetic radiation, the energy power spectrum of a given source is, in general, confined to a certain waveform of energy distribution. For instance, tungsten light emits a very small amount of electromagnetic radiation in the lower portion of visible spectrum (i.e., in the vicinity of wavelength 400 nm or wavenumber 2500 cm^{-1}). It gradually increases its EM energy distribution as the wavelength increases (or wavenumber decreases). On the other hand, the spectral characteristics of a mercury lamp is that its spectral energy is flatly distributed along the spectrum except for distinct line spectra. Various energy spectral distributions such as sodium lamps and carbon arc lamps have their unique distribution characteristics.

METHODOLOGY

Light sources were tungsten, fluorescent and mercury lamps. Tungsten light entered the optical head of the Rapid Scan Spectrometer (RSS) through a plain reflective mirror. Fluorescent or mercury light entered directly with a very small slanting angle. (This arrangement was chosen because if both sources were put side by side, the slanting angle would be too large and thus the input sensitivities of the light sources would be greatly reduced.) Spectral distribution was then digitized in Digital Processing Oscilloscope and stored in PDP11/05 minicomputer. The waveforms could be displayed in a CRT or in a hardcopier printout.

The procedure to obtain the synthesized waveform was to select tungsten and one of the other two sources to combine them one at a time. Thus, two new possible waveforms could be obtained. (In theory, if tungsten source was also varied, we could obtain three possible combinations. Since this study was to demonstrate feasibility of waveform syntheses, we fixed tungsten light source and varied the other two sources in order to avoid time-consuming optical alignment.)

STATUS

Results of this study have been published in USAARL-LR-76-1-7-1, entitled, "Synthetic Spectra." A detailed description with various types of fiber optics design will be presented at the annual meeting of the Optical Society of America, Tucson, Arizona, on 21 October 1976. The paper is entitled, "Digital Spectra Synthesis." We have achieved the combination of various spectra distributions by using a fiber optics technique. The energy power spectra have been evaluated. The method has provided the basis for an ideal (or artificial) light source for radiometric and photometric as well as colorimetric research.

EFFECT OF EXTERNAL PAINT COLOR ON COCKPIT INTERIOR TEMPERATURE

OBJECTIVE

To study the effect of external paint color on cockpit interior temperature.

BACKGROUND

The US Army Aviation Systems Command requested this Laboratory to investigate the effect of external paint color on cockpit interior temperature. As shown by thermodynamics, a white surface reflects solar thermal energy more than surfaces with other paint colors. In other words, an aircraft with white external paint should absorb less solar thermal radiation than those with other colors. Can external paint colors significantly alter interior cockpit temperatures? The purpose of this study is to answer this specific question.

METHODOLOGY

Two UH-1 aircraft were parked side by side on a ramp at Cairns Army Airfield. One of the helicopters had white paint on the upper fuselage surface. The other UH-1 was painted in the standard manner with olive drab paint. Inside each helicopter, a telethermometer with a black globe ball, a dry bulb, and a wet bulb was installed at the pilot's seat. (The telethermometer was manufactured by Yellow Springs Instruments Company, Inc. of Yellow Springs, Ohio.) A thermopile from the telethermometer was extended to above the center instrument console and one was on the ceiling behind the pilot's seat. The exterior temperature was also monitored.

Data were collected every thirty minutes from 9:30 AM to 1:30 PM. This study was conducted on July 22, 1975. The weather prediction from Cairns Weather Bureau was partly cloudy. Visibility was beyond four miles. Wind was SW 6 to 8 knots. Temperature range was 70° to 90° Fahrenheit. The cloud ceiling was 30,000 feet and scattered.

STATUS

This study has been reported in USAARL-LR-76-4-7-3, entitled "Effect of External Paint Color on Cockpit Interior Temperature." Results showed that there existed virtually no temperature difference (within one degree centigrade). The external paint color was ineffective in reducing cockpit temperature.

ATTENUATION OF LIGHT TRANSMISSION IN ARMY AIRCRAFT TRANSPARENCIES DUE TO SLANTING

OBJECTIVE

To examine rates of light transmission reduction due to slanting in eight fixed wing and fourteen rotary wing aircraft transparencies.

BACKGROUND

Most aircraft windscreens are designed to match the contour of the main-frame because of aerodynamic considerations. A slanting windshield not only possesses its inherent optical distortions, but also causes prismatic displacement as well as a loss in light transmission. Investigators in US Air Force Laboratories have quite extensively conducted research in these areas.

In surveying the literature, one notices that most distortion and transmission reduction studies were done on high-speed aircraft windshields. Recently, we have reported several optical and spectral transmission studies on low-speed fixed and rotary wing Army aircraft windshields. We also measured several samples for attenuation of light transmission due to slanting. This study continues the same subject with eight fixed wing and fourteen rotary wing aircraft windshield samples. Transparencies from one of the rotary wing aircraft (UH-1) have been studied in detail. Samples have been prepared from the center, the corner, the side portions of the windshield as well as from the crew door, the sliding door and the fixed portion of the door.

METHODOLOGY

Eight fixed wing aircraft windscreen samples were (1) U-6A, (2) U-8D/U-8F, (3) T-41, (4) T-42/U-8, (5) CV-2, (6) CV-7, (7) O-1, and (8) OV-1. Fourteen rotary wing samples were (1) OH-58, (2) TH-55/Ch-6A, (3) CH-47, (4) Ch-54, (5) CH-54 (armor glass), (6) AH-1G, (7) AH-1G (tinted), (8) UH-1D, (9) UH-1D (center), (10) UH-1 (corner), (11) UH-1 (back), (12) UH-1 (crew door), (13) UH-1 (sliding section), and (14) UH-1 door (fixed portion). All samples were cut into 2" X 2" squares except the sample of U-8D/U-8F where the whole windshield was used.

Model 1980, Spectra Pritchard Photometer was used to measure light transmission. A supporting device, calibrated in one degree increments in both the horizontal and vertical planes, was used to position and rotate the test samples through an angular range of 0° - 90°. A Macbeth Quantalog Transmission Densitometer was employed to read the transmission of some samples at 0° angle only. The light source was a Spectra Regulated Brightness Source (9 ft.L).

STATUS

The study has been completed and reported in USAARL Report 76-23 entitled, "Attenuation of Light Transmission in Army Aircraft Transparencies Due to Slanting." We concluded that the optical quality at various portions of the UH-1 transparencies and all the fixed wing samples possess similar characteristics of transmission reduction. The windscreen and the armor glass of CH-54 samples are similar too. However, the tinted versus the clear AH-1G transparencies are quite different. The tinted sample generally has 27% reduction of spectral transmission compared to that of the clear sample. This reduction could constitute a dangerous loss of visibility for the aviator, especially during periods of reduced illumination and at night.

MODIFICATION OF CIE CHROMATICITY COORDINATE SYSTEM: A PROPOSAL

OBJECTIVE

To propose a modified CIE chromaticity coordinate system which extends the visible portion of the wavelength range from 350 to 1150 nm.

BACKGROUND

Data on foveal sensitivity of the human visual system from about 350 to 1150 nm are readily available in the literature. Nevertheless, the Commission International de l'Eclairage (CIE), in 1931, adopted Wright's and Guild's data with modification from RGB to XYZ system as the basis of the 2° field standard observer only from a wavelength range of 380 to 780 nm. It remains the same for the CIE 1964 10° field chromaticity coordinate system. Walraven and Leebeck have recently suggested a set of non-linearly corrected spectral sensitivity V_λ up to 1100 nm. They have strongly recommended to extend the wavelength range of V_λ up to at least 900 nm or beyond. This modification is necessary since the CIE selective range only represents a fraction of the visible range perceptible by the human eye.

The extension of the wavelength range of V_λ does not change any fundamental formulation of the CIE chromaticity coordinate system. However, it does affect the shape of the chromaticity diagram and other related parameters. The purpose of this study is to theoretically compute various wavelength sets of the CIE chromaticity coordinate system based on Walraven's V_λ with wavelength range from $(380 - \alpha)$ to $(780 + \beta)$ nm where α and β are decrement and increment constants respectively. We will also attempt to derive a set of weighing functions with respect to (α, β) so that present existing CIE colorimetric data may be transformed into the new proposed system.

THEORETICAL COMPUTATION

Apparatus includes PDP 11/05 with I/O unit. Design and procedures are as follow: (1) Set α, β at every five nm intervals and compute the r, g, b ; $\bar{r}, \bar{g}, \bar{b}$; RGB and x, y, z ; $\bar{x}, \bar{y}, \bar{z}$; XYZ. (2) Design a hypothetical chromaticity diagram. (3) Plot data computed in (1) into (2). (4) Compute and evaluate the weighing functions w.r.t. (α, β) . (5) Tabulate the weighing functions systematically.

STATUS

This study conducts the theoretical computation on the modified system in which a major portion of the analysis has been formulated. Nonetheless the idea is relatively new and requires further exposure in international conferences such as the Optical Society Meeting and the CIE Committee Meeting in order to obtain comments and opinions from various color experts from all over the world.

ANALYSES OF PUPILLARY REFLEX RESPONSE TO LIGHT IN FATIGUE STUDY

OBJECTIVE

To investigate the correlation between pupillary reflex response to light versus fatigue of flight personnel.

BACKGROUND

The relationship between waveform characteristics of the pupillary reflex response to light and various types of fatigue has been subjected to many investigations in the past few decades. Ferree and Rand (1952) have shown the close correlation between irregular shapes of pupil size and various light stimulus intensity levels. Lowenstein and his associates have systematically analyzed waveform characteristics of pupillary reflex response to light with respect to chronic, physical and pathological fatigue (Lowenstein and Lowenfeld, 1950; 1951; Lowenstein, Feinberg, and Lowenfeld, 1963). They claimed that analysis of waveform characteristics of pupillary reflex response to light was an objective means for evaluating tiredness. Obtaining results from cats, monkeys, rabbits, and humans, they concluded that both efferent systems - sympathetic and parasympathetic - participate in the product of spontaneous pupillary waves. On the other hand, Meyer, et al (1969) and Yoss, Mayer and Hollenhorst (1970) stated that the parasympathetic system play the primary role for spontaneous pupillary waveforms.

The studies mentioned above are clinically oriented research in a laboratory condition. The purpose of the present study is to analyze the pupillary reflex response waveforms to light obtained from an actual field test. It is intended to establish a quantitative fatigue index for aviators. This study has been conducted simultaneously with other possible fatigue indices such as biochemistry, flight performance ratings and dynamic visual acuity.

METHODOLOGY

Six volunteer rotary wing aviators who had just graduated from the basic flight training school at the Army Aviation School, Fort Rucker, Alabama 36362 were subjects for this study. The main piece of equipment was the TV pupillometer which utilized a closed-circuit television system to measure pupil size. A signal processor and a chart recorder were attached to measure and display pupil diameter. A low-intensity, near-infrared source illuminated the eye without discomforting or distracting the subject. Pupil diameter, in mm, was presented as a direct readout on the analog panel meter, with a scale range from 0 to 10 mm. The integrated base consisted of a fixed and a movable platform. It also

had a chin rest and a forehead restraint, adjustable for height. Supports for the camera and light source were attached to the movable platform, which was precisely adjustable for lateral position and distance from the eye. The equipment was Model 8005 TV pupillometer manufactured by Whittaker Corporation, Massachusetts.

STATUS

This study will be published as a USAARL Laboratory Report in the near future. We found that the waveform has changed from the relatively smooth inverse-gaussian type of response to various types of irregularities as the Ss became more fatigued. Nonetheless, we also pointed out that the correlations between the fatigue index and the pupillary reflex response were inconclusive from our data analyses.

COLORIMETRIC CHARACTERISTICS OF PHOTOSTIMULATOR

OBJECTIVE

To study colorimetric characteristics of a photostimulator.

BACKGROUND

A photostimulator manufactured by Grass Medical Instruments, Inc., Quincy, MA has been widely used as the visual stimulus in VER (visual evoked response), EEG (electroencephalogram) and many other basic and applied research techniques. Although photometric characteristics of this device are available from various sources, its colorimetric characteristics have not previously been available.

METHODOLOGY

Photostimulator manufactured by Grass Instrument Company, Quincy, MA 02169 will be used for the test. Tektronix Digital Processing Oscilloscope - Rapid Scan Spectrometer (DPO-RSS) system will be employed as data acquisition units. Frequency readings will be set at 1, 2, 5, 10, 20, 50, and 100 cycles/min and intensity levels will be recorded for each pair of settings. Spectral power distribution and chromaticity characteristics will be analyzed by the Tektronix DPO-RSS system combining automatic circuitry from the RSS unit with data acquisition and software control from the DPO unit.

STATUS

The automatic gain/shunt control system in the RSS plug-in unit is being constructed. The experiment will be conducted as soon as the equipment is ready. From our preliminary experimental results, we found that the chromatic purity did not behave as a linear function of the intensity. We shall understand why that is so when the experiment is completed.

PHOTOMETRIC AND COLORIMETRIC CHARACTERISTICS OF CHEMILUMINESCENCE - CYALUMER^R

OBJECTIVE

This report investigates and analyzes photometric as well as colorimetric characteristics of chemiluminescence - Cyalume^R.

BACKGROUND

It has been demonstrated that chemical light offers advantages over other light sources because it generates light without thermal energy. It is suitable for situations where use of conventional light could be hazardous. It works in all weather conditions and under water as well. However, its disadvantages include relatively short lifetime of useful light, poor color discrimination because of the narrow band spectral emission and a slight chromatic variation as a function of time. Nonetheless, it has potential military applications such as emergency lighting in aircraft, a guide for hoist missions, a set of heliport markers, a ground guide, or a parachute locator.

METHODOLOGY

a. Photometric Measurement

Light sources used in this experiment were Cyalume^R light sticks manufactured by American Cyanamid Company, Bound Brook, New Jersey. Measurements for luminance were made with a Spectra-Pritchard photometer. Illuminance was measured by another Spectra-Pritchard photometer using a cosine integrator attachment. Three Cyalume^R light sticks were used in the photometric measurement.

b. Colorimetric Measurement

Tektronix Rapid Scan Spectrometer (RSS) and Digital Processing Oscilloscope (DPO) with minicomputer PDP 11/05 were used as an automatic data acquisition/analysis unit. The light source used in this measurement was also the Cyalume^R light stick.

STATUS

Results have been reported in USAARL Report 76-8 entitled, "Photometric and Colorimetric Characteristics of Chemiluminescence - Cyalume^R" and in USAARL-LR-76-5-7-4 entitled, "Photometric Measurement of Chemiluminescence - Cyalume^R." We found from our studies that both advantages and disadvantages of the chemiluminescence light have been accurately described. The short useful lifetime of this device has to be considered in any mission-oriented application. Furthermore, we recommend future test of the reliability and validity of this device such as shelf-life under various storage temperatures and under other environmental factors.

VISIBLE AND NEAR INFRARED SPECTRAL TRANSMISSION CHARACTERISTICS OF WINDSCREENS IN ARMY AIRCRAFT

OBJECTIVE

This report presents an analysis of spectral transmission characteristics from 360 to 1080 nm spectral range of fourteen Army aircraft wind-screen samples.

BACKGROUND

Samples were from six fixed wing and eight rotary wing aircraft wind-screens. We have found that spectral transmittance varies from sample to sample in the visible portion of the spectrum (i.e., 360-700 nm) and remains quite flat for all samples across the near infrared portion of the spectrum (i.e., 700 - 1080 nm). The tinted sample in AH-1 Hueycobra has approximately 27% reduction from that of the clear one across the visible spectrum. This reduction could constitute a dangerous loss of visibility for the aviator during periods of reduced illumination and at night. Furthermore, variance from a flat spectral transmission would result in distorted color perception by the aviator viewing through the tinted windscreen. In short, reference data enable potential users of electro-optical devices such as night vision goggles to compute the light stimulus presented to the aviator after transmission through a transparency.

METHODOLOGY

- a. Fixed Wing Aircraft (total six samples) - (1) O-1 (Bird Dog), (2) OV-1 (Mohawk), (3) U6 (Beaver), (4) T-41 (formed edge sample), (5) T-41 (flat/unformed edge sample), and (6) T-42.
- b. Rotary Wing Aircraft (total eight samples) - (1) TH-13 (Sioux), (2) TH-55/OH-6A, (3) OH-58 (Kiowa), (4) CH-47 (Chinook), (5) CH-54 (Tarhe), (6) UH-1, (7) AH-1G (Hueycobra) and (8) AH-1G (tinted sample).

All sample dimensions were 2 X 2 inches except for CH-47 which was 3 X 3 inches.

The light source used was a Macbeth daylight lamp with a 75-watt Westinghouse tungsten light bulb. The data acquisition unit was the Tektronix Rapid Scan Spectrometer (RSS) and Digital Processing Oscilloscope (DPO) with minicomputer PDP 11/05 and its accessories. The digital processing oscilloscope contains a signal acquisition unit, a display unit and a processor. The processor, which has the ability to digitize an acquired waveform, provides an interface with a minicomputer. The rapid scan spectrometer is capable of scanning the optical spectrum from 300 nm (ultraviolet) to 1100 nm (near infrared).

STATUS

Results have been reported in USAARL Report No 76-14 entitled, "Visible and Near Infrared Spectral Transmission Characteristics of Windscreens in Army Aircraft," USAARL-LR-76-2-7-2 "Infrared Power and Transmission Characteristics of Windscreens in Army Aircraft," USAARL-LR-76-16-7-7 "Infrared Power Spectral and Transmission Characteristics of Windscreens in Army Aircraft: Part II," USAARL-LR-76-29-7-8 "Visible Spectral Transmission Characteristics of Windscreens in Army Aircraft," and USAARL-LR-76-13-7-5 "Visible Spectral Transmission Characteristics of Windscreens in Army Aircraft: Part II." Results from these papers provide very useful reference data for optical and electro-optical testings. We have pointed out the danger of using any tinted windscreen in Army aircraft.

BIO-OPTICAL (VISUAL AND OPTICAL) EVALUATIONS OF WINDSHIELD DISTORTION IN ARMY AIRCRAFT

OBJECTIVE

To study new methods to detect windshield distortion in Army aircraft

BACKGROUND

Current distortion test, using photographic documentation requires a two-step process. This study uses a "spatially" double exposure method so that it only requires a single photographic step for the distortion test. The original method was proposed at the ASTM F7.08 Subcommittee Meeting concerning aircraft windscreen distortion. However, the Subcommittee Chairman has not made any final decision to adopt the so-called "standard" photographic method currently being used in industries. Most committee members cannot even agree what kind of film to use in the two-step photographic method. Our method intends to provide a novel approach to perfect the old two-step photographic method.

METHODOLOGY

The experimental arrangement used in the "spatially" double exposure consisted of two targets, a beam splitter and a camera. The two targets were made photographically mirror-imaged to each other. For simplicity, we used the standard TV raster target as the test target. The alignment of the two targets was very critical since the result of the distortion test depended upon the amount of deviation of one target from that of the other target. The sample was mounted at one of the optical paths before the beam splitter. Photographic film selection was also very important since the distortion would not be apparent when low-grade film was used.

STATUS

This study will be terminated since the American Society of Testing Material (ASTM) will adopt a conventional method for distortion test in industries. Results from the spatially double exposure method will be written as a USAARL letter report. This method has provided a time-saving approach to documenting the windscreen distortion.

PHOTOCHROMIC LENSES

OBJECTIVE

To determine the light transmission characteristics of photochromic glass/lenses and relate this information to the use of these lenses while performing visual tasks at night.

BACKGROUND

In 1939, it was discovered that specially-designed glass would automatically darken and lighten upon exposure to and removal from ultraviolet radiant energy. Further research led to the commercial development of spectacle lenses having this property termed "photochromism." Photochromic lenses have been available for public use for a number of years. Presently, there are two lens colors available, grey and brown. Each color can be obtained in either a light tint ("fashion" or "comfort" lenses) or a darker tint intended for sun protection. Early research by this Laboratory established the non-applicability of photochromic lenses to the aviation environment. This current project includes a "new" generation of photochromic lenses and is primarily intended to establish actual light transmission values. Information obtained will be instrumental in formulating recommendations for the use of these lenses in the military environment. In particular, it may be necessary to recommend a warning be attached to the lenses cautioning the wearer to exercise caution when driving or performing visual tasks under low illumination and at night.

METHODOLOGY

Light transmission is determined with Macbeth Quantalog Transmission Densitometer TD-102. Light and dark sample lenses are exposed for ten consecutive days to "set" them in accordance with manufacturer instructions. For daytime readings, the lenses are exposed to sunlight for two hours and then systematic light transmission readings are taken over an 80-minute period. A second series of light transmission recordings are made during twilight after the lenses have again been exposed to daylight. Outside air temperature is monitored throughout the study since the light transmission is somewhat dependent upon temperature variations.

STATUS

Data collection is essentially complete and a report being prepared.

RESEARCH AND TECHNOLOGY WORK UNIT SUMMARY				AGENCY ACCESSION ¹	DATE OF SUMMARY ²	REPORT CONTROL SYMBOL DD-DR&E(AR)636	
3. DATE PREV. SUMMARY	4. KIND OF SUMMARY	5. SUMMARY SCTY ³	6. WORK SECURITY ⁴	DA OC 6885	76 10 01		
	A. NEW	U	U	7. REGRADING ⁵	8. DES'N INST'N ⁶	9. SPECIFIC DATA - CONTRACTOR ACCESS ⁷	9. LEVEL OF SUM A. WORK UNIT
10. NO. / CODES ⁸	PROGRAM ELEMENT	PROJECT NUMBER	TASK AREA NUMBER		NI	<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO	
8. PRIMARY	6.27.73.A	3E762773A819	00	WORK UNIT NUMBER 017			
9. CONTRIBUTING							
5/19/74/1/1/1	CARDS 114 (f) (m)						
11. TITLE (Precede with Security Classification Code) ⁹							
(U) Bio-Optical Aspects of the XM-29 Protective Mask							
12. SCIENTIFIC AND TECHNOLOGICAL AREAS ¹⁰							
012000 Optics; 012900 Physiology; 001300 Aircraft							
13. START DATE		14. ESTIMATED COMPLETION DATE		15. FUNDING AGENCY		16. PERFORMANCE METHOD	
76 07		Cont.		DA		C. In-House	
17. CONTRACT GRANT				18. RESOURCES ESTIMATE		19. PROFESSIONAL MAN YRS	
A. DATES/EFFECTIVE				PRECEDING		B. FUNDS (in thousands)	
B. NUMBER *Not applicable				76 & 77		.5	
C. TYPE				CURRENT		25	
D. KIND OF AWARD:				77		2.0	
E. AMOUNT:						75	
F. CUM. AMT.							
19. RESPONSIBLE DOD ORGANIZATION				20. PERFORMING ORGANIZATION			
NAME * US Army Aeromedical Research Laboratory				NAME * US Army Aeromedical Research Lab			
ADDRESS * Fort Rucker, AL 36362				Bio-Optics Division			
				ADDRESS * Fort Rucker, AL 36362			
RESPONSIBLE INDIVIDUAL				PRINCIPAL INVESTIGATOR (Precede with U.S. Academic Institution)			
NAME BAILEY, Robert W., COL, CDR				NAME * WILEY, R.W., MAJ			
TELEPHONE (205) 255-5107				TELEPHONE (205) 255-6808/6415			
				SOCIAL SECURITY ACCOUNT NUMBER			
21. GENERAL USE				ASSOCIATE INVESTIGATORS			
Foreign Intelligence Considered				NAME: CROSLEY, J.K., LTC			
				NAME			
22. KEYWORDS (Precede EACH with Security Classification Code)							
(U) Protective Mask; (U) Bio-Optical Evaluation; (U) Ophthalmic Correction							
23. TECHNICAL OBJECTIVE, 24. APPROACH, 25. PROGRESS (Precede individual paragraphs identified by number. Precede text of each with Security Classification Code.)							
23. (U) To provide information and guidance of visual and optical aspects in the design and fabrication material of the XM-29 protective mask.							
24. (U) The approach will include physical optics techniques, photometry, and spectrophotometry to measure the optical quality of images transmitted through the mask, and psychophysical techniques will be used to measure visual performance while wearing the mask. The effort will include a consideration of techniques to provide optical correction in the mask for those individuals with refractive errors.							
25. (U) Progress has been made in an analysis of protective mask optical inserts, from aspects of optical fabrication, medical supply and accountability, and visual effectiveness. A combat spectacle has been designed and will be field tested when it becomes available. A partial survey of foreign and domestic technology relevant to this effort has been completed.							

* Available to contractors upon originator's approval

DD FORM 1498
1 MAR 68

PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE. DD FORMS 1498A 1 NOV 68 AND 1498 1 MAR 68 (FOR ARMY USE) ARE OBSOLETE

U.S. GPO: 1974-540-843/869 1

GENERAL DETAIL SHEET

TITLE: Bio-Optical Aspects of the XM-29 Protective Mask

OBJECTIVE: To provide medical guidance on visual and optical considerations in the development of the XM-29 Protective Mask

BACKGROUND, METHODOLOGY, STATUS:

Statements concerning the above for this area of research can be found on the following page numbered 86.

RECOMMENDATIONS:

It is recommended that research in this area be funded on a continuing basis.

VISUAL AND OPTICAL CONSIDERATIONS FOR THE XM-29 PROTECTIVE MASK

OBJECTIVE

To provide medical guidance on visual and optical considerations in the development of the XM-29 Protective Mask

BACKGROUND

The XM-29 program is being conducted under the authority of a Required Operational Capability to develop a protective mask which will replace all present Army protective masks. One of the principal improvements sought is to provide better vision while wearing the mask. USAARL was tasked by Medical Research and Development Command to provide guidance on visual and optical aspects of the new mask configuration.

METHODOLOGY

Because of recently identified visual problems with the prototype mask configuration, USAARL responsibilities have been expanded from that of consultation to include performing field and laboratory investigations. For example, no method presently exists with the new mask to provide optical correction for those personnel requiring spectacles. A potential combat spectacle has been designed which will be field tested for wearability and compatibility with the mask. Surveys are being conducted to document previous problems encountered with optical inserts. Several other scientific institutions have been contacted to provide support investigations on the optical design of the mask faceplate.

STATUS

This project has several subtasks which are being coordinated to provide timely information to the Mask Development Office. A National Research Council Working Group met and identified potential visual problems requiring investigation. The preliminary investigations are scheduled to be completed prior to March 1977.

RESEARCH AND TECHNOLOGY WORK UNIT SUMMARY				1. AGENCY ACCESSION ^a	2. DATE OF SUMMARY ^a	REPORT CONTROL SYMBOL	
				DA OE 6734	76 10 01	DD-DR&E(AR)636	
3. DATE PREV SUMMARY	4. KIND OF SUMMARY	5. SUMMARY SECY ^a	6. WORK SECURITY ^a	7. REGRADING ^a	8A. DISSEM INSTR ^a	8B. SPECIFIC DATA- CONTRACTOR ACCESS	9. LEVEL OF SUM
76 03 01	D. CHANGE	U (NO CH)	U		NL	<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO	A. WORK UNIT
10. NO./CODES ^a		PROGRAM ELEMENT		PROJECT NUMBER		TASK AREA NUMBER	
a. PRIMARY		6.11.01.A		3A161101A9TC		00	
b. 6.11.01.A						288	
c. 6.11.01.A							
11. TITLE (Precede with Security Classification Code) ^a (U) Development of Measurement Techniques for the Medical Assessment of Visually Coupled System (VCS) Components							
12. SCIENTIFIC AND TECHNOLOGICAL AREAS ^a 004000 Components; 001400 Aircraft Flight Instrumentation (Helicopter); 007500 Human Factors Engineering; 007400 Bioengineering							
13. START DATE			14. ESTIMATED COMPLETION DATE			15. FUNDING AGENCY	
7509			7709			DA	
17. CONTRACT/GRANT				18. RESOURCES ESTIMATE		16. PERFORMANCE METHOD	
A. DATES/EFFECTIVE:				PRECEDING		C. In-House	
B. NUMBER ^a N/A				FISCAL YEAR		D. FUNDS (In thousands)	
C. TYPE:				76 & 77		1.6	
E. KIND OF AWARD:				CURRENT		50	
F. CUM. AMT.				77		3.6	
19. RESPONSIBLE DOD ORGANIZATION				20. PERFORMING ORGANIZATION			
NAME ^a US Army Aeromedical Research Lab				NAME ^a US Army Aeromedical Research Lab			
ADDRESS ^a Fort Rucker, AL 36362				Bio-Optics Division			
RESPONSIBLE INDIVIDUAL				PRINCIPAL INVESTIGATOR (Furnish SSAN if U.S. Academic Institution)			
NAME: BAILEY, Robert W., COL, Cdr				NAME ^a WILEY, Roger W., MAJ			
TELEPHONE: (205) 255-5107				TELEPHONE: (205) 255-6415/6808			
21. GENERAL USE				ASSOCIATE INVESTIGATORS			
Foreign Intelligence Considered				NAME: VERONA, R.W., CPT			
				NAME: HOLLY, F.F., CPT			
22. KEYWORDS (Precede EACH with Security Classification Code)							
(U) Visually Coupled System, (U) Helmet Mounted Sight, (U) Helmet Mounted Display							
23. TECHNICAL OBJECTIVE, ^a 24. APPROACH, 25. PROGRESS (Furnish individual paragraphs identified by number. Precede text of each with Security Classification Code.)							
23. (U) To develop measurement techniques for the medical assessment of Visually Coupled System (VCS) components.							
24. (U) The first phase will be concerned primarily with the Helmet Mounted Sight (HMS) component of the VCS. The approach during this phase will be to conduct laboratory and flight tests of the basic aiming and tracking performance of the head. Projected areas of investigation include the determination of the effect of custom fitted versus standard helmets. The second phase of this effort will be concerned with an investigation of helmet mounted display image quality. The major force of this investigation will be aimed at determining the ramifications of using monochromatic video displays and their effects on display image quality as perceived by the human observer. It is possible to inadvertently compromise an aviator's safety and physiological performance when designing and fabricating a VCS. This is because of the intimate and delicate interface which exists between the man and the machine in a VCS.							
25. (U) The equipment and fabrication materials necessary to conduct the laboratory portion of the aiming/tracking study have been procured and are being integrated into the experimental apparatus. The aircraft to be used for the airborne portion of the study has been obtained. Further modifications to the visionics system will be required so that it can be used to gather head aiming/tracking data. In several instances essential fabrication materials and equipment ordered for this project did not meet the vendors advertised specifications, had to be returned, and ordered from another vendor. These incidents have caused delays in the program's schedule. The AAH-PM, Cobra PM, and Frankford Arsenal have asked specific questions about the medical aspects of proposed or production VCS components. Minor alterations to the experimental plans will enable timely answers to the majority of their questions. These alterations to the experimental plan have resulted in further delay in the program schedule.							

GENERAL DETAIL SHEET

TITLE: Development of Measurement Techniques for the Medical Assessment of Visually Coupled System (VCS) Components

OBJECTIVE:

To determine man's capabilities and limitations of using his head motions in aim/tracking tasks.

BACKGROUND, METHODOLOGY, STATUS:

Statements concerning the above for this area of research can be found on the following pages numbered 89 through 90.

RECOMMENDATIONS:

It is recommended that research in this area be funded on a continuing basis.

HELMET MOUNTED SIGHT

OBJECTIVE

To determine man's capabilities and limitations of using his head motions in aiming/tracking tasks.

BACKGROUND

The hardware development agencies have encountered a dilemma in specifying values for the aiming/tracking accuracies that can be expected for a HMS. The question that must be answered before helmet mounted sight (HMS) accuracy can be specified and the man-machine performance predicted is how well can man use his neck and shoulder muscles to affect head aiming and head tracking. These data must be obtained in environments and scenarios typically encountered by crewmembers when operationally required to perform tracking and aiming tasks.

Well controlled experiments have not been conducted to determine man's capability for using his head as a tracking/control device in a vibration environment. Some experiments have been conducted by HMS manufacturers to determine the static aiming and tracking capability of aviators, but these data do not contain the effects of the entire man-machine system. Also, quantitative data justifying the proposed requirements that custom fit helmets, rather than standard helmets, be used in HMS applications have not been collected. A portion of the assets and test schedule will be devoted to gathering this data in a cooperative effort with the Bioengineering and Evaluation Division.

METHODOLOGY

The first phase of the study will be used to gather pilot aiming/tracking performance data in a vibration environment. The Multi-Axis Helicopter Vibration Simulator (MAHVS) will be programmed to simulate a specific flight profile and the audio information presented to the subject will provide a detailed scenario which corresponds in time to the flight profile. Both audible and visual cues will be presented to the subject indicating the start and stop points in his aiming/tracking tasks. During this period, the subject will be instructed to superimpose the reticle of his aiming/tracking system on the target. As the target moves in a quasi-random manner the subject must use his head to maintain alignment between the reticle and the target. Eight such aiming/tracking tasks will be presented to the subject during his 90-minute flight. Varying degrees of vibration will be experienced by the subject during each task. Base line data will be gathered during a static flight, i.e., no vibration. Each experimental condition will be administered in a static and dynamic flight.

The second phase of the study will be more concerned with target parameters than the first phase. The target will be moving in a manner prescribed by the condition being tested (i.e. specific path, velocity, acceleration); the prescribed target movement will be presented in a random order. Each subject will receive several trials with each target motion using each reticle configuration.

STATUS

The equipment and fabrication materials necessary to conduct the laboratory portion of the aiming/tracking study have been procured and are being integrated into the experimental apparatus. The aircraft to be used for the airborne portion of the study has been obtained and off-the-shelf slewable day/night vision system has been installed. Further modifications to the visionics system will be required so that it can be used to gather head aiming/tracking data. In several instances essential fabrication materials and equipment ordered for this project did not meet the vendors advertised specifications, had to be returned, and ordered from another vendor. These incidents have caused delays in the program's schedule. Data collection is expected to begin in Jan 77 with final report to be completed during 3rd Quarter FY77.

RESEARCH AND TECHNOLOGY WORK UNIT SUMMARY				1 AGENCY ACCESSION ¹	2 DATE OF SUMMARY ²	3 REPORT CONTROL SYMBOL ³	
				DA OD 6739	76 10 01	DD-DR&E(AR)636	
4 DATE PREV SUMRY ⁴	5 KIND OF SUMMARY ⁵	6 SUMMARY ACTY ⁶	7 WORK SECURITY ⁷	8 REGRADING ⁸	9A DISB'N INSTR'N ^{9A}	9B SPECIFIC DATA CONTRACTOR ACCESS ^{9B}	9C LEVEL OF SUM A WORK UNIT ^{9C}
76 03 01	I. TERMINATION	U (NO CH)	U		NL	<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO	
10 NO / CODES ¹⁰	PROGRAM ELEMENT	PROJECT NUMBER	TASK AREA NUMBER	WORK UNIT NUMBER			
a. PRIMARY	6.11.02.A	3E161102BS07	00	021			
b. 10.11.02.A	6.27.58.A	3A762758A819	00	119			
c. 10.11.02.A	CARDS II4 (f)(m)						
11 TITLE (Precede with Security Classification Code) ¹¹							
(U) Research of Psychoacoustical Problems Medically Significant to Army Aviation							
12 SCIENTIFIC AND TECHNOLOGICAL AREAS ¹²							
1300 Aircraft; 021000 Radio Communications; 000200 Acoustics							
13 START DATE		14. ESTIMATED COMPLETION DATE		15 FUNDING AGENCY		16. PERFORMANCE METHOD	
76 10		CONT		DA		C. In-House	
17 CONTRACT / GRANT Not Applicable				18 RESOURCES ESTIMATE		19. PROFESSIONAL MAN YRS	
A. DATES/EFFECTIVE				PRECEDING			
B. NUMBER *				FISCAL YEAR		FUND (In thousands)	
C. TYPE				76 & 77		13.0	
D. KIND OF AWARD:				CURRENT		453	
E. CUM. AMT.				77		0.0	
19 RESPONSIBLE DOD ORGANIZATION				20 PERFORMING ORGANIZATION			
NAME * US Army Aeromedical Research Laboratory				NAME * US Army Aeromedical Research Lab.			
ADDRESS * Ft Rucker, AL 36362				ADDRESS * Bioacoustics Division Fort Rucker, AL 36362			
RESPONSIBLE INDIVIDUAL				PRINCIPAL INVESTIGATOR (Furnish SSAN if U.S. Academic Institution)			
NAME: Bailey, Robert W., COL, Cdr				NAME * Camp, Robert T., Jr.			
TELEPHONE: (205) 255-5107				TELEPHONE: (205) 255-4408			
21 GENERAL USE				SOCIAL SECURITY ACCOUNT NUMBER			
Foreign Intelligence Considered				ASSOCIATE INVESTIGATORS			
				NAME: Mozo, Ben T.			
				NAME: Patterson, James H., CPT, MSC			
22 KEYWORDS (Precede EACH with Security Classification Code) ²²							
(U) Aircraft; (U) Conversion Techniques; (U) Man-Machine Relations; (U) Human Volunteers; (U) Protective Equipment; (U) Recording Devices.							
23 TECHNICAL OBJECTIVE ²³ , 24 APPROACH, 25 PROGRESS (Furnish individual paragraphs identified by number. Precede text of each with Security Classification Code.)							
23. (U) To provide information about sound which has medical input to US Army aviation.							
24. (U) The approach will be twofold. One will entail the physical description of the critical sound stimuli found in US Army aviation. This will involve descriptions at the generators or sources as well as descriptions of subsequent changes that may be precipitated by various propogating media. The second approach will involve studying the effects of these sounds on human receivers. Both approaches will employ valid research practices.							
25. (U) 76 07 - 77 09. Progress in this area is reflected in the following reports: "Real-Ear Sound Attenuation Characteristics and Impact Resistance of DH-132 Helmets, Lot 1, Manufactured by Gentex Corporation (Contract No. DSA100-75-C-0111)," "Comparison of Sound Pressure Levels Produced by Two Types of Engines in the OH-58 Helicopter," "Real-Ear Sound Attenuation Characteristics and Impact (Bump) Tests Evaluation of the Proposed Final Modification of the Sierra P/N AVC Helmet," "Noise Levels in the AH-1Q Equipped with a Low Giare (Flat-Plate) Canopy," "Preliminary Medical Evaluation of the Acoustic Hazard from the Weaponer Rifle Simulator," "Real-Ear Sound Attenuation of Selected Communication Headsets Available Through the Federal Supply System," "The Effect of Behavioral Paradigm on Auditory Discrimination Learning: A Literature Review," and "Preliminary Medical Assessment of the Acoustic Hazard of a Prototype Mechanized Infantry Combat Vehicle. This project is being terminated in order to separate its diverse aspects into five new projects.							

GENERAL DETAIL SHEET

TITLE: Research of Psychoacoustical Problems Medically Significant to Army Aviation

OBJECTIVE:

To provide information about sound which has medical importance to US Army aviation.

BACKGROUND, METHODOLOGY, STATUS:

Statements concerning the above for this area of research can be found on the following pages numbered 93 through 114.

RECOMMENDATIONS:

It is recommended that research in this area be funded on a continuing basis.

EFFECTS OF DISTORTION IN MILITARY COMMUNICATION SYSTEMS

OBJECTIVE

The purpose of this investigation is to study the effects of the following three important variables:

- a. Type of microphone
- b. Environmental noise level
- c. Distortion on the intelligibility of military communication systems.

Objectively, an attempt will be made to show the theoretical limits communicating in noise with idealized systems, to estimate the relative efficiency of present systems and to make recommendations on methods to improve the present systems. The hypothesis of this project is that systems with low distortion are the most suitable for communicating in thick noise levels.

BACKGROUND

During the early development of telephone communication systems, Bell Laboratories did extensive basic research concerned with the investigation of speech intelligibility parameters. The results of this research have shown that the process of communicating with speech is complex. Volumes have been published on the analyses of speech. The complex analyses have not yielded simple basic constituents that a layman may easily synthesize for practical application. It was only through close coordination of scientists in the field of psychophysics and engineers who designed the communication systems that the Bell Telephone achieved its successful application of the results of their basic research. The present networks of the telephone cables which transmit reliable messages around the world is a manifestation of the success.

The development of radio and intercommunication systems in military and commercial aircraft has not had the same degree of success. It is difficult to state the precise reasons for the arrested progress of the military applications. This project is proposed as an attempt to probe some of the causes of the present inefficient systems.

The principal investigator has had training and research experience in the field of speech communication. From 1952 to 1957 he was associated with the Ohio State Research Foundation conducting research concerned with investigating parameters of speech communication in noise. The most significant contribution was the publication entitled, "Perception of

Multiple-Choice Intelligibility Items in the Presence of Simulated Propeller-Type Aircraft Noise." This was a long-term empirical study of multiple-choice words as a tool for expedient measurements in research applications. Close approximation of the functions was determined to be a system of Poisson equations.

Articulation indices have been computed by Bell Laboratories. Most of the basic research of the analysis of speech may be found in Speech and Hearing, 1929, by Harvey Fletcher.

METHODOLOGY

Three types of microphones will be used. An omnidirectional condenser microphone, a military type noise cancelling dynamic lip microphone, and an inertial contact transducer, to be placed on the head of the speakers, will serve as transducers for picking up speech of talkers. Each of these microphones will be fed into systems of low distortion and recorded.

Each talker will be fitted with the three microphones for simultaneous recording of lists of phonetically balanced (PB) words. A list of words will be spoken under four environmental conditions. The talkers will speak under a condition of quiet and three levels of ambient white noise. The sound pressure levels of the noise will be 100 dB, 110 dB and 120 dB (re 0.0002 dyne/cm²). Recordings of simultaneous pickups from each of the three microphones will be presented to listeners who will be instructed to write down the words. Samples of listeners will be divided into six groups. Each of three groups will listen to one of the three microphones with amplification conditions of frequency and amplitude distortion. The frequency distortion will be a filtered bandpass of 200 Hz - 6000 Hz. Scores of each group of listeners will be the measure of the intelligibility of the experimental conditions.

Type of Microphones: The three types of microphones chosen for the experiment are various types usually discussed in most controversies about selection of proper transducers for transmitting speech in noise. The omnidirectional condenser microphone is extremely linear throughout the speech frequencies. The noise cancelling dynamic microphone is a type presently used with military helmets. The contact microphone receives the vocal signal via bone conduction. It represents a type of transducer that is frequently suggested by laymen to replace the conventional lip microphone. The simultaneous recording of the same speech signal with the three types of microphones will serve to make a direct comparison of relative efficiencies of the three.

Environmental Noise Levels: The ambient sound pressure level of environments in which the speech is picked up by the microphone is a very important variable of the communication situation. A range of ambient

SPL quiet, 100 dB, 110 dB and 120 dB (re 0.002 dyne/cm²) is chosen because it is an approximation of the dynamic range of most aircraft noise. The variable will furnish valuable information about the relative performance of the three microphones in a wide dynamic range.

Frequency and Amplitude Distortion: Most aviation communication systems have characteristics that introduce amplitude and frequency distortion. The width of the passed band of frequencies is usually less than the width of the speech spectrum. Also, often the dynamic range of the speech signal is distorted by peak clipping. The 200 - 6000 Hz bandpass filtering and the 20 dB clipping are considered to be a conservative estimate of the two types of distortion.

An experiment of this design will provide the necessary supplement to the existing knowledge of the speech communication process of subsequent application to the military communication systems in Army aircraft.

STATUS

Investigation of the physical and psychophysical characteristics of contact microphones has been completed. The investigation included a comparison of intelligibility of a contact microphone and a noise cancelling microphone in a noise environment. Also included in the investigation are response characteristics of the contact microphone placed at the forehead and throat of three (3) subjects.

Measurements of sound pressure levels produced by the ARC-164 Radio system were completed during operating conditions while installed in an OH-58 helicopter. Analysis and report writing are in progress.

ACOUSTICAL ENVIRONMENT OF US ARMY AVIATION PERSONNEL

OBJECTIVE

The objectives of this work are to determine noise spectra of the various environments in which US Army aviation personnel are required to perform their duties. These data will be used not only as a basis for the design and supply of protective equipment, but also as a means for improvement of future equipment designs.

BACKGROUND

Due to the wide variety of acoustic problems in the US Army and the need for effective solutions, it is necessary to have a knowledge of the characteristics of the acoustic environments of Army personnel.

Octave-band analyses have been useful for damage risk criteria and noise survey problems. The human ear response, on the other hand, is more analogous to third-octave spectra information. Also, for certain engineering purposes it is required to obtain narrow-band analyses. Therefore, three types of analyses will be desirable for adequate descriptions and treatment of acoustic problems.

For the above-stated reasons, it is desirable that three types of analyses be applied to noise data. This complete investigation of the characteristics of various acoustic environments will furnish valuable information not only for damage risk criterion applications, but also engineering applications of noise abatement program.

METHODOLOGY

Samples of noise data will be recorded with a precision magnetic tape recorder with a 70 dB signal-to-noise ratio. The analyses of the recordings will be done in the laboratory with octave-band and third-octave band filters and real-time narrow-band instruments. Statistical descriptions of the mean sound pressure levels and standard deviations of the third-octave and octave-band data will be provided. For certain outdoor measurements, a precision fourteen-channel tape recorder will record data from multi-positions simultaneously.

STATUS

Internal noise sound pressure levels in a mechanized infantry combat vehicle were measured to assess potential acoustic hazards to human subjects participating in heat stress studies during development tests of this vehicle. This vehicle was under test at Yuma Proving Grounds,

Arizona. Sound pressure levels in this vehicle were found to be extremely high. Most hearing protectors are not adequate to permit an 8-hour exposure to the noise in this vehicle under most operational conditions. It was recommended that exposures of human subjects wearing hearing protectors be limited to short periods depending on which hearing protector was being used. These physical measurements were not noise surveys. These data were required for research purposes and for the assessment of the acoustic hazards in newly developed equipment for future use in studies relating to hearing loss in combat vehicle crewmen.

Data analysis has been continued on a joint research project between USAARL and Construction Engineering Research Laboratory (CERL), Champaign, Illinois, to evaluate helicopter flyby noise. This Laboratory (USAARL) had primary responsibility for the collection and analysis of psycho-physical data to determine the best predictors of annoyance for use by CERL in land use planning. In April 1974, subjective ratings and tape recordings of noise from a variety of Army helicopters were collected. During the last year, data reduction and analysis have been in progress. This quarter analysis of selected data using the Fast Fourier Transform (FFT) instrumentation resulted in a summary of the recorded flybys in one-third octave band levels. These data, along with subject ratings, were transferred to the USAARL Hybrid Computer System for further analysis. Nineteen commonly used predictors of annoyance have been computed from the tape recorded data and compared with the average subjective ratings. Of the predictors analyzed thus far, average dBA and average dBD provide best agreement with the subject data.

A medical evaluation of a new type of engine (C20B) mounted on an CH-58 helicopter has been completed and a report is presently in progress. In general, the sound pressure levels are not significantly increased over those produced by the A700 engine. With the SPH-4 helmet these levels are well below the damage risk levels specified in TB MED 251.

Investigation was made of the noise sound pressure levels in an AH-1Q Cobra helicopter which was modified to decrease the visual glint signature. This investigation revealed a significant increase in sound pressure levels over the measured frequency spectrum. The data from this investigation was reported to the US Army Aircraft Development Test Activity (PROV) and included in a briefing to MG William J. Maddox, Jr.

The sound level evaluation of the prototype helicopters from the two (2) UTTAS manufacturers has been completed.

Medical assessment of the acoustic hazard associated with the Weaponeer Rifle Simulator was initiated and completed. Tables of peak sound pressure levels and recommendations to limit peak pressures were included in Letter Report No. USAARL-LR-76-19-2-5.

Data were collected on the noise levels transmitted to the ears of pilots wearing the SPH-4 fitted with the Sperry helmet mounted sight. Preliminary analysis indicates a potential hazard from the increased noise level introduced by this device. Data analysis is still in progress.

Internal noise levels in a UH-1H aircraft were measured and data analyzed. A report is in progress.

HEARING PROTECTION DEVICES EVALUATION

OBJECTIVE

The objectives are to: a) maintain readily available data, recorded under ANSI Z24.22 (1957) standardized procedures, of the attenuation offered by standard helmets, earmuffs and earplugs used by Army aviation personnel; and b) estimate the protective properties of prototype equipment that will be considered for use by Army aviation personnel.

BACKGROUND

Since World War II, there has been an increase in the interest and effort to perfect devices for the protection of personnel from harmful high sound pressure levels. The effort has resulted in the development of earplugs, earmuffs and helmets designed for sound attenuation.

Although the present prototype ear protection devices seem to reflect an asymptote in the rise of efficiency realized in the 1950's and early 1960's, there is still a need to properly evaluate the attenuation characteristics of all prototypes and standard equipment worn by Army aviation personnel. The real-ear method of psychophysically estimating the effective attenuation at the human ear is the method presently preferred.

It is important to maintain available data about the attenuation characteristics of all standard and proposed equipment. These data are necessary for ascertaining noise levels in which personnel can safely operate. This information is invaluable to medical personnel who prescribe devices for the adequate protection against noise. Such information, therefore, is in constant demand by laboratories concerned with noise problems, Army agencies responsible for design of helmets, medical personnel and private manufacturers of Army aircraft.

METHODOLOGY

Psychophysical measurements of attenuation will be made. The procedure will be in line with the ANSI Z24.22 (1957) standards. In addition to this standard ANSI test, other methods are being investigated. The physical-ear attenuation method developed by this Laboratory uses noise spectra and Fast Fourier Transform instrumentation.

STATUS

Completed real-ear and physical-ear medical assessment of one reworked sample from Lot 9 of the American Safety SPH-4 Helmet (Contract Number DSA 100-72-C-0143). This sample was reassessed following failing attenuation results on four samples submitted from Lot 9. Real-ear attenuation values obtained with the reworked sample from Lot 9 were greater than the minimum acceptable attenuation values set forth in MN(A) at all frequencies except 75 Hz and 250 Hz. At these frequencies the attenuation values fell below the minimum MN criteria. Statistical evaluations against the MN criteria indicated that the differences were not significant at the .05 level of confidence. A possible cause of these low values is the lighter weight cloth in the earcup suspension system. It was recommended that the manufacturer submit additional reworked samples of both medium and extra large sizes.

Completed real-ear sound attenuation evaluation and medical assessment of the Koss Quiet Zone K-1200 Circumaural Hearing Protector. This device yielded moderately efficient attenuation characteristics.

Completed real-ear sound attenuation evaluations and medical assessment of the Sierra P/N 791 AVC Helmet. Four (4) helmets (H-17, H-18, H-19, and H-20) incorporating the latest modifications of this design were submitted, two (2) each in sizes medium and large. All four helmets yielded attenuation values lower than the minimum requirements at one (1) or more test frequencies. It was concluded that the current submission of the Sierra P/N 791 AVC Helmet fails to meet the minimum sound attenuation requirements. The helmet was also noted to be extremely uncomfortable after 30-45 minutes wear and frequently caused headache. It was recommended that this helmet not be accepted as a second standard AVC helmet.

Completed real-ear sound attenuation evaluation and medical assessment of experimental Gentex SPH-4 aviator helmet with dual visor system. Real-ear attenuation values obtained with this model of the SPH-4 helmet were greater than the minimum acceptable values at all required frequencies.

Completed real-ear sound attenuation and medical assessment of an experimental version of the Gentex DH-132 helmet. The modifications on this version consisted of alteration of the velcro adjustment strips and elimination of the chin strap. The real-ear attenuation values obtained with this version of the DH-132 helmet were greater than the minimum acceptable values at all required frequencies.

Completed real-ear sound attenuation and medical assessment of the Sellstrom "Tone Down" Model 400 circumaural hearing protector. This device yielded moderately efficient attenuation characteristics.

Completed real-ear attenuation and medical assessment of the David Clark "Straightaway" E-800 circumaural hearing protector. This device affords poor attenuation in the low frequencies.

Completed real-ear sound attenuation medical assessment of the Welsh "Sound-Off" Model 4520 circumaural hearing protector. This device affords fairly good attenuation yielding an Attenuation Efficiency Score (AES) of 70.55.

Completed real-ear sound attenuation and medical assessment of the Gentex SPH-4 aviator helmet mounted with an oxygen mask using two (2) different systems of connectors. Data is being transferred to Aviation Medicine Research Division for preparation of the technical report.

Began medical assessments of a combination of hearing protective devices in search of adequate hearing protection for personnel associated with the Mechanized Infantry Combat Vehicle (MICV). This project includes the following: a) the DH-132 modified by FMC for use in the MICV; this device with E-A-R earplugs; this device with V51-R earplugs; b) the Roanwell P/N 125460-640 headset; this device with E-A-R earplugs; this device with V51-R earplugs; and c) a standard DH-132 with E-A-R earplugs; this device with V51-R earplugs.

Completed medical assessment of Safety Direct "Silencio" (M-25) circumaural hearing protector. This device affords moderate protection.

Completed medical assessment on Gentex Experimental DH-132 Helmet (with sewn on chin strap with swivel). This device failed to meet attenuation criteria at 2 kHz.

Completed medical assessment of Amplivox Gunfender Earplugs. This device affords very poor attenuation.

Began medical assessment of Cosmocord Nonlinear Hearing Protectors. This project was expanded to a variety of configurations to include: a) Cosmocord active; b) Cosmocord passive; c) Cosmocord active with E-A-R earplugs; d) Cosmocord passive with E-A-R earplugs; e) Cosmocord active with V-51R earplugs; and f) Cosmocord passive with V51-R earplugs. Besides these attenuation samples, an intelligibility assessment was made and a physical-ear attenuation measure was made.

Completed medical assessment on David Clark 9AN/2, NSN 4240-00-759-3290. This device affords average protection.

Completed medical assessment of Quietline GN-900. This device affords average attenuation.

Continued medical assessment of personal helmets of Army Aviators in the helmet retrieval project. We are still reliant on Aviation Medicine Branch to provide subjects for this project.

Began medical assessment of David Clark E-805 circumaural hearing protection devices in combination with E-A-R universal earplugs.

ARMY AVIATION AUDIOMETRY PROGRAM

OBJECTIVE

The purpose of this program is to perform precision audiometric assessments of a large sample of Army aviation personnel. The results of these assessments will serve not only as valuable information about the status of hearing among Army aviation personnel, but also will serve as a basis for the ameliorization of the automatic audiometric assessments in US Army aviation. This will be accomplished by the establishment of a more reliable audiometer calibration program and the introduction of trained personnel with an MOS for operating audiometers.

BACKGROUND

A survey of audiograms of US Army aviation personnel has revealed that a large percentage of young Army aviation personnel have hearing losses. The reliability of these data must be tested with a program of rigidly controlled instrumentation and testing procedures that will yield dependable data about the magnitude of hearing losses among US Army aviation personnel. If the results of such assessments show a significant difference between the health records data and the experimental data, there will be a recommendation for an ameliorization of audiometer calibration and audiometry in the US Army.

METHODOLOGY

The first task will be to determine the proper audiometer for the making of precision audiograms. The audiometer may be chosen from several sources. Presently, the possibilities are the Rudmose ARJ-4, the Rudmose ARJ-5 or some of the new models of automatic audiometers developed by Grason-Stadler Company, Inc. After a suitable audiometer has been chosen, the assessment program will proceed. The next task will be a treatment of the data to determine whether or not the differences between the health records data and the experimental data are of significance. If the differences are significant, then recommendations will be made as to how an improvement of audiometry may be accomplished. The requirement for having trained personnel with an MOS for audiometry and requirement for improved audiometer maintenance and calibration will be the primary recommendations. The acoustical environments of audiometric testing facilities in the Army will be investigated.

STATUS

Refurbishing of audiometric assessment facilities has been completed. Some preliminary data collection has begun. A study of the audiograms of US Army control tower operators is continuing.

COMPARISON OF PHYSICAL-EAR METHOD FOR MEASURING SOUND ATTENUATION
WITH THE ANSI Z24.22-1957 AND ANSI S3.19-1974

OBJECTIVES

The purpose of this series of experiments is to establish a data base comparing the measured attenuation of a wide variety of types of hearing protectors in order to validate and standardize procedures for measuring the attenuation of hearing protectors. The primary objectives are: a) to determine the relationship between the attenuation measured by the Physical-Ear Attenuation Method (PEAM) developed by the US Army Aeromedical Research Laboratory (USAARL) and the attenuation measured by the two ANSI procedures; and b) to determine the relationship of the new ANSI S3.19-1974 and the old Z24.22-1957.

BACKGROUND

For the last 20 years the standard method for measuring the attenuation of hearing protectors has been to measure the pure tone free-field threshold of a group of listeners with the hearing protector and without the protector. The average difference in these two thresholds at each frequency is the so-called real-ear attenuation at threshold. This procedure was formalized into the ANSI Standard Z24.22-1957. This procedure has been used for thousands of assessments of hearing protectors, but has some features that present problems in large-scale evaluation of hearing protectors. It requires subjects with normal hearing at all audiometric frequencies. It requires many hours of assessment at a high cost in terms of subject time and facilities time. To circumvent these problems, USAARL has begun development of a Physical-Ear Attenuation Method which can be used for circumaural protector evaluation. This assessment does not require a threshold measurement by the subject. Therefore the problem of finding subjects with normal hearing is eliminated. It is at least an order of magnitude faster, reducing the amount of time required for assessment. Preliminary indications are that there is a good correlation between the PEAM and the ANSI Z24.22-1957 method. However, there are still unresolved differences in the amount of attenuation measured by these two methods which appear to be dependent on the device being evaluated. Proper resolution of these differences in procedure requires long-term repetitive comparison of the two methods with a variety of protectors.

Recently, ANSI has approved a new standard, namely, S2.19-1974, to replace the Z24.22-1957. This new standard incorporates substantial changes in the methods used under the old standard. The primary procedure is still a threshold measurement. However, the signal is a one-third-octave band of noise presented in a hard-walled room to produce

a quasi-nondirectional sound field. This standard was approved and issued without a single facility existing which has been shown to meet all requirements of the standard. There have been no large-scale cross-validation studies to clarify the differences between the old and new ANSI standards. However, due to the fact that both standards require subjects with normal hearing and are based on threshold determinations, the advantages of the PEAM over the old Z24.22-1957 method will also be advantages of PEAM over the S3.19-1974 method. For these reasons the current proposal is to begin establishing the data base comparing these three methods.

The new Standard S3.19-1974 also describes an alternate method for evaluating circumaural hearing protectors which employs an artificial head. This is a physical measurement procedure which does not involve human subjects. As part of S3.19-1974 this alternate method will be included in the comparison of the three methods: PEAM, Z24.11-1957 and S3.19-1974.

METHODOLOGY

Currently, the instrumentation and methodology exist to assess hearing protectors under the ANSI Z24.22-1957 method and the physical-ear method. The facility for implementing the ANSI S3.19-1974 method is being constructed. Once all three methods are available, assessment of a wide variety of hearing protective devices will be conducted on all three methods. This will require a series of samples at each of a variety of protectors assessed, e.g., SPH-4 helmets, DH-132 helmets, communication headsets, etc. Differences will be assessed with t-tests, and correlations will be computed. Any differences found to be statistically significant will be subject to examination by varying the assessment procedures to determine the cause of the differences. It is essential that a large data base on each of a variety of protectors is required to identify consistent trends within a given device and to clarify differences between devices.

In order to reduce costs, it is suggested that, whenever possible, quality control samples of helmets, muffs and headsets submitted to the US Government for evaluation be used as assessment materials for this project. This will save the US Government the expense of procuring the large number of devices required for establishing this data base while supporting the needs of the procuring agency for medical evaluation.

STATUS

The modification of an audiometric sound room to comply with the requirements of the S3.19-1974 standard is nearing completion. Calibrations are in progress to establish compliance with the requirements

of the new standard. A number of problems with the new standard have been discovered and are being examined for possible resolution.

As part of the preliminary data for comparing methods, completed real-ear (Z24.22-1957) and physical-ear attenuation assessment on the following lots of DH-132 helmets: DSA Contract Number DSA 100-75-C-0111, Lots 16, 21, 26, 32, 33, 34, 35, 36, 37, 41, 46, and 51; DSA Contract Number DSA 100-76-C-0529, Lots 1, 6, 11, and 17; and SPH-4 helmets, DSA 100-75-C-0480, Lot 16.

THE EFFECT OF EXPOSURE TO LOW-FREQUENCY NOISE ON THE THRESHOLD OF HEARING

OBJECTIVES

- a. To determine at what intensity levels low-frequency noise will cause permanent hearing loss.
- b. To determine the validity of specifying damage-risk criteria for low-frequency noise in terms of dBA levels rather than octave-band levels.
- c. To determine differences between the effects on hearing of exposure to high- and low-frequency noise.

BACKGROUND

While there have been many studies of the effects of noise on hearing, little has been done with noises having low-frequency spectra. The emphasis of the research to date has either been with wide bands of noise or octave bands of noise with center frequencies of 0.5 kHz and above. One of the primary reasons for this has been an apparent area of maximal sensitivity to noise in the 4.0- 6.0-kHz region of the frequency spectrum and investigators have directed much effort toward understanding this phenomenon. Another reason for the research emphasis with frequencies above 0.5 kHz is that the bulk of information carried in the acoustic signals of speech is believed to be in the frequency region of 1.0-4.0 kHz.

There are several reasons, however, why the effects of noise at the low frequencies (below 0.5 kHz) should be studied. One of these is our inability to design hearing protectors which provide large amounts of attenuation at low frequencies. It has been well documented that hearing protectors, such as helmets, which provide high levels of attenuation at high frequencies, do not provide comparable levels of attenuation at low frequencies (Camp, Mozo, Kuc, & Schott, 1972). It has also been found that many military vehicles, particularly vehicles found in the Armor Branch of the Army (e.g., Patterson, Mozo, & Camp, 1976) produce intense noise which is predominately low-frequency. A recent survey of hearing loss among Army personnel found that those in Armor had the highest incidence of permanent hearing loss (Walden, Prosek, & Worthington, 1975). The question therefore arises as to whether this higher incidence of hearing loss is due to exposure to high levels of low-frequency noise which are known to be present in Armor vehicles. Since data are unavailable concerning the effects of exposure to intense, low-frequency bands of noise, the question remains unanswered.

Another reason for investigating the effects of low-frequency noise on hearing is that currently, all damage-risk criteria are expressed in terms of dBA rather than unweighted octave-band levels.* The effect of A-weighting is to de-emphasize low-frequency sounds. For example, the A-weighting network of a sound-level meter decreases by 39 dB the octave-band level of a noise band having 31.5 Hz as its center frequency. The level of the octave-band centered at 63 Hz is decreased by 26 dB, at 125 Hz is decreased by 16 dB, at 250 Hz is decreased by 9 dB, and at 500 Hz is decreased by 3 dB (Peterson & Gross, 1972). What this means is that when an octave-band of noise centered at 31.5 Hz has an octave-band level of 120 dB, the dBA level of the band is 81 -- a considerable reduction. Obviously the assumption is that low-frequency sounds have little effect on hearing. This assumption needs to be validated. Since all noise levels dictated by damage-risk criteria are expressed in terms of dBA levels, it is possible that the use of the A-weighting network, rather than a flat, uncorrected network or an octave-band analysis may result in potentially hazardous levels of low-frequency noise being overlooked and damage to hearing being done inadvertently.

The investigation of low-frequency noise effects is also of interest on theoretical grounds. It is widely held that low-frequency sounds are neurally encoded differently by the cochlea than are high frequency sounds (e.g., Geldard, 1972). If this is true, it would not be unexpected to find differences in the ear's response (and effect on hearing) to exposures to high level low-frequency noises and high-frequency noises. Differences might not only arise because of differences in neural encoding but also because of differences in the mechanical stimulation of the basilar membrane of the cochlea.

*The level of a sound can be measured in several ways. It can be measured on one of several weighting networks incorporated in a sound-level meter. A weighting network is simply a filter which selectively attenuates the level of certain frequency components of the sound being measured. The linear network gives equal weighting to all frequencies of the sound. The A-weighting network gives less weight to the low-frequency components of a sound. To indicate that the level of a sound has been determined by using the A-weighting network, the levels are expressed in units of dBA. Another method of measuring the level of a sound is to use a set of filters which isolate specific frequency regions of the sound. Most commonly the filters are designed to isolate octave-bands of frequencies. The level of a sound can then be expressed in terms of the levels of the individual octave-bands.

Bekey (1960) found that sounds produce a physical displacement of the basilar membrane with each frequency maximally displacing specific areas along the membrane. High frequencies maximally displace the basal portion of the membrane, and the mechanical motion of the membrane is damped as the high-frequency wave travels along it. Low frequencies produce maximal displacement at the apical end of the membrane so that the entire membrane undergoes greater mechanical stimulation (i.e., the entire membrane undergoes greater movement). It is possible then, that intense low-frequency sounds would be more likely than intense high-frequency sounds to produce damage to the ear because of the greater mechanical stimulation. It would also seem that because of this, exposure to low-frequency noise would affect a wider frequency range than is found with exposure to high-frequency noise. There is some data which indicate that this may be true (Carder & Miller, 1971, 1972).

The following investigation will be directed toward these questions and issues.

METHODOLOGY

The subjects will be 21 chinchillas obtained from a commercial breeder or supplier. The animals will be housed and maintained in individual cages. The age range of the subjects will be 12 - 36 months.

The animals will be trained and tested in an IAC booth which provides suitable low levels of ambient noise. Initially a behavioral audiogram will be obtained on each subject. The subjects will be trained in a double-grille cage with a shock-avoidance procedure similar to that used by Miller (1970).

After the audiograms are obtained and it has been determined that the subjects have normal hearing, they will be randomly assigned to three groups of seven subjects and exposed to noise. Two groups of subjects will be exposed to an octave-band of noise centered at 63 Hz and one group will be exposed to an octave-band of noise centered at 1000 Hz. The exposure levels of the three groups are given in Table I. Each level of exposure given in Table I refers to the octave-band level of the noise. Each group will be exposed at the lowest level given, data recorded, allowed to recover in the quiet for a period of 3 weeks, and then be re-exposed at the next higher level unless permanent hearing loss is found at the preceding lower level.

TABLE I
EXPOSURE LEVELS FOR THREE GROUPS OF SUBJECTS
(Octave-Band Center Frequency)

GP I (63 Hz)	GP II (63 Hz)	GP III (1000 Hz)
75 dB	100 dB	75 dB
85 dB	110 dB	85 dB
95 dB	120 dB	95 dB

By using these levels we will be able to determine the effects on hearing threshold of exposure to intense low-frequency noise (63 Hz) and to determine the desirability of using the dBA weighting in specifying damage-risk criteria. For example, the A-weighted level for an octave-band of noise centered at 1000 Hz is equal to its octave-band level, i.e., there is no correction factor for this band of noise when converting from octave-band level to dBA level. However, the dBA level of an octave-band of noise centered at 63 Hz is 26 dB lower than the octave-band level of this noise. Therefore, when the octave-band level of the 63 Hz noise band is 100 dB and the octave-band level of the 1000 Hz noise band is 75 dB, both will have equal dBA levels of 75 dBA.

The current use of the A-weighted measurement of damage-risk determination would dictate that both of these noise bands are equally damaging even though there is a 25 dB difference in their octave-band level. The present design will permit evaluation of this by directly comparing those subjects exposed to the 1000-Hz band and those exposed to the higher level 63-Hz band.

The subjects will be exposed in an IAC booth whose walls have been covered with Masonite. This will provide a non-directional sound field for exposure. The subjects will be exposed to the noise for a total time of 72 hours. Research indicates that the asymptotic level of threshold shift will be obtained within 24 hours (Carder & Miller, 1971, 1972). To follow the growth of threshold shift, audiograms on the animals will be obtained at intervals of 1, 2, 4, 8, 12, 24, 48 and 72 hours during exposure.

After 72 hours the exposures will be terminated. The decay of threshold shift will be followed by obtaining audiograms from the subjects at intervals of 1, 4, 8, 12, 24, 48, 72, 96, 120, 144 and 168 hours after the termination of the exposure. The final level of recovery should be

reached by the end of this seven day period. The animals will be given a two-week rest period and then, barring the occurrence of permanent threshold shifts, they will be re-exposed to the next higher level of noise. For those subjects exposed to the low-frequency noise band the tone frequencies will be 0.06-, 0.09-, 0.125-, 0.5-, 1.0- and 4.0-kHz. For those subjects exposed to the high-frequency noise band, the tone frequencies will be 0.5-, 1.0-, 1.4-, 2.0- and 4.0-kHz. Following the final 3-day exposure and 2-week recovery period at the highest intensities, the subjects will be re-exposed to the highest intensity levels on the same cycle until a permanent threshold shift occurs in two of the groups or until a permanent shift of 30 dB occurs in one group.

It is assumed on the basis of previous research (Carder & Miller, 1971, 1972) that complete recovery from threshold shifts reflects the absence of damage to the auditory system. Therefore, permanent threshold shifts obtained in the high-level exposure conditions will be assumed to be solely a function of the high-level exposure and not influenced by any insidious damage caused by the previous lower-level exposures. However, to control for that possibility, another independent group of animals, without prior exposure experience, will be run in the high-level condition. The amount of PTS of this group(s) and the other high-level group(s) which have received both low- and high-level exposures will be compared to determine any differential effects.

The maximum asymptotic values of TTS observed for the exposure conditions in Table I will be analyzed with a two factor analysis of variance (exposure band X exposure level) with repeated measures on the exposure level factor. Two analyses will be performed: one based on equivalent linear weighted exposures. These analyses are shown schematically in Table II.

TABLE II

EXPOSURE LEVEL	.063		1.0		EXPOSURE LEVEL	.063		1.0	
	75	GP II	GP III	GP I		GP III			
EXPOSURE dBA	85	GP II	GP III	GP I	GP III				
	95	GP II	GP III	GP I	GP III				

The PTS data will be analysed using t-tests for the equality of mean PTS in GP I vs GP III and for GP II vs GP III. These analyses will evaluate the effect of exposure level and the equivalence of high and low frequency exposure hazards.

STATUS

The equipment fabrication of this newly approved precis is nearly complete, as are the necessary sound field measurements and equipment calibration. Nineteen chinchillas were purchased and delivered. Instrumentation for audiometric assessment of chinchillas hearing levels using a shock-avoidance paradigm has been completed. Twelve (12) animals have been trained to respond to tone signals and their quiet free field thresholds have been determined. The threshold for this group of chinchillas is in good agreement with published norms for this animal. Preparations are being made to begin noise exposures on this group of animals.

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RESEARCH AND TECHNOLOGY WORK UNIT SUMMARY				1 AGENCY ACCESSION ¹	2 DATE OF SUMMARY ²	3 REPORT CONTROL SYMBOL ³	
				DA OD 6738	76 10 01	DD-DR&E(AR)636	
4 DATE PREV SUMMARY	5 KIND OF SUMMARY	6 SUMMARY CTY	7 WORK SECURITY	8 REGRADING ⁸	9A DISB'N INSTR'N	9B SPECIFIC DATA CONTRACTOR ACCESS	9C LEVEL OF SUM A WORK UNIT
76 03 01	D. Change	U (NO CH)	U		NL	<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO	
10 NO / CODES ¹⁰	PROGRAM ELEMENT	PROJECT NUMBER	TASK AREA NUMBER	WORK UNIT NUMBER			
A. PRIMARY	6.27.73.A	3E762773A819	00	009			
B. / / / / / / / / / /	6.27.58.A	3A762758A819	00	118			
C. / / / / / / / / / /	CARDS 114 (f) (m)						
11 TITLE (Precede with Security Classification Code) ¹¹							
(U) Research Psychology Applied to Medically Significant Problems in Army Aviation							
12 SCIENTIFIC AND TECHNOLOGICAL AREAS ¹²							
001300 Aircraft; 009400 Man-Machine Relations; 013400 Psychology							
13 START DATE		14 ESTIMATED COMPLETION DATE		15 FUNDING AGENCY		16 PERFORMANCE METHOD	
65 02		Cont.		DA		C. In-House	
17 CONTRACT GRANT				18 RESOURCES ESTIMATE		19 PROFESSIONAL MAN YRS	
A. DATES/EFFECTIVE				B. PRECEDING		C. FUNDS (In thousands)	
B. NUMBER ¹⁷ Not Applicable				FISCAL YEAR		76 & 77	
C. TYPE				77		7.6	
D. KIND OF AWARD:				77		271	
E. AMOUNT				77		271	
F. CUM. AMT.				77		271	
19 RESPONSIBLE DOD ORGANIZATION				20 PERFORMING ORGANIZATION			
NAME ¹⁹ US Army Aeromedical Research Laboratory				NAME ²⁰ US Army Aeromedical Research Laboratory			
ADDRESS ¹⁹ Fort Rucker, Alabama 36362				ADDRESS ²⁰ Aviation Psychology Division Fort Rucker, Alabama 36362			
RESPONSIBLE INDIVIDUAL				PRINCIPAL INVESTIGATOR (Furnish DDAR if U.S. Academic Institution)			
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Foreign Intelligence Considered				NAME: Armstrong, R. N.			
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23 TECHNICAL OBJECTIVE ²³ , 24 APPROACH, 25 PROGRESS (Furnish individual paragraphs identified by number precede text of each with Security Classification Code)							
23. (U) To provide US Army aviation information that is medically important about the human factors in the aircraft man-machine system with special emphasis on the performance of this human factor and the variables that influence it.							
24. (U) The approach will involve the application of current research techniques applicable to the objective as well as developing new techniques as required.							
25. (U) 7507 - 7609. Progress under this work unit for the previous 15 months include the following: publication of 8 USAARL Laboratory Reports, 6 presentations at scientific meetings and technical input to several aviation related working groups. These groups included the Staying Power Symposium, ASH, COBRA, CEP, HELL FIRE, UTIAS, XM-1 tank, Night Vision Goggles, HELMS, Helicopter Cockpit Controls and Instrument Displays, and DOD Topical Review. Research findings were presented to the Advisory Group for Aerospace Research and Development (AGARD), entitled: Helicopter flight performance with the AN/PVS-5; Aviator performance: biochemical, physiological and psychological assessment of pilots during extended helicopter flight; and Comparison of visual performance of monocular and binocular aviators during VFR helicopter flight. A research paper was also presented to IF Society Conference, "Aviator performance during day and night terrain flight." Four research papers have been accepted for presentation; one at AMEDD Psychology Conference in Nov 76, and three at NATO/AGARD Aerospace Medical Panel Specialists' Meeting in April 77. The 8 USAARL reports published were: "No. 76-2, Buettner cueing concept for helicopter flight control;" "No. 76-3, Perceived velocity and altitude judgment during rotary wing aircraft flight;" "No. 76-5, Object visibility patterns in low level flight;" "No. 76-10, Aviator performance measurement during low altitude rotary wing flight with the AN/PVS-5 night vision goggles;" "No. 76-17, Marijuana and human performance: An annotated bibliography (1970-1975);" "No. 76-18, Pilot opinion of flight displays and monitoring gauges in the UH-1 helicopter;" "No. 76-26, Versatile Manova: Design and documentation;" and "No. 76-27, In-flight performance with night vision goggles during reduced illumination.							

GENERAL DETAIL SHEET

TITLE: Research Psychology Applied to Medically Significant Problems in Army Aviation

OBJECTIVE:

To provide US Army aviation information that is medically important about the human factors in the aircraft man-machine system, with special emphasis on the performance of this human factor and the variables that influence it.

BACKGROUND, METHODOLOGY, STATUS:

Statements concerning the above for this area of research can be found on the following pages numbered 117 through 145.

RECOMMENDATIONS:

It is recommended that research in this area be funded on a continuing basis.

VISUAL PERFORMANCE DURING NIGHT NOE AND LOW LEVEL FLIGHT

OBJECTIVE

The objective of this investigation is to gain information concerning the areas of the windscreen most often utilized by aviators while performing night NOE and low level flight.

BACKGROUND

In contrast to day NOE flight where the aviator is constantly flooded with many perceptual cues, night NOE work places the aviator in an environment where normal cues are degraded or deteriorated to such an extent that they possibly lose their normal value. For example, it has been demonstrated through classic laboratory research that as luminance levels deteriorate, it becomes increasingly difficult for the human eye to perceive detail, delineate texture or retain good depth perception. These cues are of extreme importance for NOE-low level flight and a deterioration in efficient aviator performance may well be evident as such cues are more difficult to perceive. This work will seek to determine if changes in visual scanning techniques result as a function of decreased luminance levels. If performance is maintained at a satisfactory level for NOE flight with less visual information and visual scanning patterns are similar for both day and night operations, this information will be of value in determining just what the critical perceptual cues are for optimally performing this type of flight profile.

METHODOLOGY

This study will utilize six Army aviators. Visual performance will be measured using a corneal reflection technique in conjunction with a video recording system. The windscreen will be divided into eight sectors and there will also be marked two chin bubble sectors, two side door sectors and one inside cockpit sector. The six aviators will fly both low level and NOE runs and will be required to make two flights. (NOE flights will be in a riverbed negating the navigation task.) The video data will be analyzed with regard to time spent in each sector, transitions in and out of each sector and percentage of time spent in each sector.

STATUS

Investigation of formerly proposed techniques, including LLL TV and video recordings have been assessed and determined to be inadequate. Further modifications to the equipment have been accomplished. The present approach will include the utilization of the Eye Mark Recorder, LOCAM Motion Picture cameras, high speed film and an ultra-violet light source to illuminate the cockpit area. Preliminary still photography has been accomplished to assess feasibility of this approach.

AVIATOR PERFORMANCE DURING NIGHT NOE AND LOW LEVEL FLIGHT WITH AN/PVS-5 NIGHT VISION GOGGLES (40 DEGREES, 60 DEGREES AND 40 DEGREES BIFOCAL)

OBJECTIVE

The purpose of this investigation is to assess differences in aviator performance (flight and physiological) during NOE and low level flight utilizing various configurations of the AN/PVS-5 night vision goggles and the unaided eye.

BACKGROUND

The increased utilization of helicopters in night tactical operations and the particular flight profiles required for their projected mission effectiveness have necessitated the development of night vision aids for rotary wing aircrews. One device of this type is the AN/PVS-5 Night Vision Goggles developed by the US Army Night Vision Laboratory. This system allows the aviator to operate the aircraft at night with natural illumination. Although various agencies have utilized the goggles during night flight operations, little quantifiable data is available with regard to the relative impact of 40° FOV, 40° FOV bifocal and 60° FOV when worn by aircrews for various flight profiles. Of particular interest is their effect on aviator performance during NOE flight. This investigation will obtain and assess performance data from aviators wearing the NVG's and performing NOE and low level flight. An attempt will be made to determine what differences in performance are present among the three goggles' configurations and the unaided eye.

METHODOLOGY

The subjects for this study will be six rotary wing aviators with extensive NOE flight experience. Each aviator will be required to fly five consecutive low level and NOE flights. (NOE flights will be in a riverbed, thus negating the navigation task.) The first flight will be flown with the unaided eye. This run will be followed by three flights utilizing each of the three configurations of goggles (40° FOV, 60° FOV, 40° FOV bifocal). The last flight will again be performed with the unaided eye. Aviator and aircraft performance measures will be continuously recorded for all flights through the use of the Helicopter In-flight Monitoring System (HIMS). Physiological measurements such as heart rate and EKG will also be recorded and a urinalysis of pre- and post-flight specimens will be conducted.

STATUS

The results of this investigation have been presented in USAARL Report No. 76-10, entitled "Aviator Performance Measurement during Low Altitude Rotary Wing Flight with the AN/PVS-5 Night Vision Goggles," dated December 1975.

HOVERING PERFORMANCE OF AVIATORS DURING EXTENDED HELICOPTER FLIGHT

OBJECTIVE

The purpose of this research is to determine the fatigue effects introduced by extended flight performance, on the precision hovering performance of Army aviators. This investigation will determine at what point during the flight the fatigue effects become apparent and will also describe the effect on the man-machine system performance.

BACKGROUND

The effect of aviator fatigue on mission performance has long been a concern of the local flight commander. At the present time the Army is striving to develop a firm policy on crew rest and flight limitations. Previous research and experience has recognized that long hours of wakefulness and flight time degrades the skill level of the aviator. This skill degradation in turn impacts the potential utilization of aviator resources and substantially increases the risk of aircraft accidents. The current report will be developed from data obtained during a large scale research investigation which examined a broad range of flight profiles. The hover maneuvers, which will be examined in this report, are particularly suitable for an investigation of the effects of fatigue on aviator performance. They are commonly required at some point in all missions, and the hover maneuver requires the aviator to maintain precise control of the aircraft along all translational axes. Previous research has indicated that precision skill is often affected by fatigue long before the more general mission required skills. Since the control of the aircraft is always the primary task of any rotary wing aviator, it is anticipated that the performance of precision hover maneuvers will demonstrate extensive fatigue effects.

METHODOLOGY

Six recent graduates of the Army Rotary Wing Flight School will serve as subjects for an extensive investigation of extended flight performance. During the flight testing portion of this investigation, subjects will perform a standard set of 33 maneuvers each hour. Flight testing will be accomplished for 13 hours per day over a four and one-half day period for each subject. Subjects will have a controlled diet with no stimulants and be allowed approximately four hours of sleep per night. The performance of each subject on a selected maneuver will be assessed six times per day. The hover maneuvers examined in this report consist of a three foot precision hover, and a ten foot, twenty-five foot and a fifty foot precision hover. Each hover will be maintained and recorded for one minute. Multivariate statistical techniques will be used to designate the primary performance dimensions and to describe significant changes in the man-helicopter system performance.

STATUS

The reduction of the available measures into an independent set of performance measures has been accomplished for data from the three foot hover. At present, the analysis of performance changes and the description of fatigue effects on performance is being completed and drafted in a technical report form. During this same period, the program for reduction and analysis of performance variables for the remaining three hover maneuvers is being developed and standardized.

AVIATOR INCLINED LANDING PERFORMANCE DURING EXTENDED HELICOPTER FLIGHT

OBJECTIVE

The objective of this research is to determine the fatigue effects introduced by extended rotary wing flight performance on the ability of aviators to perform inclined landings. This investigation will determine at what point during the extended flights the effects of fatigue become apparent and will also describe the effect on the man-machine system performance.

BACKGROUND

The effect of aviator fatigue on mission performance has long been a concern of the local flight commander. At the present time the Army is striving to develop a firm policy on the realistic standardization of crew rest and flight limitations. Previous research and experience has demonstrated that long hours of wakefulness and flight time degrade the skill level of an aviator. This progressive but variable degradation of skill creates a major impact on the potential utilization of aviator resources and substantially increases the risk of aircraft accidents. The current work will be developed from a portion of the data obtained during a large scale research investigation which examined a broad range of mission related flight maneuvers. The inclined landing of a rotary wing aircraft is unique among the many varied maneuvers which can be accomplished in a helicopter. Because of the critical attention shifting demands of the inclined landing maneuver, its frequent practice both in training and in tactical operations, and the potentially hazardous consequences of its unsuccessful accomplishment, this maneuver provides an outstanding operational indicator of the effect of fatigue on aviator performance. In addition, the acquisition and analysis of this data provides an essential quantity of information to the developing in-house data base regarding aviator performance.

METHODOLOGY

Six recent graduates of the Army Rotary Wing Flight School will serve as subjects for an extensive investigation of extended flight performance. During the flight testing portion of this investigation, the subjects will perform a standard set of thirty-three maneuvers each hour. Flight testing for each subject will be accomplished for thirteen hours per day over a four and one half day period. Subjects will have a controlled diet with no stimulants and be allowed approximately four hours of sleep per night. The performance of each subject will be assessed six times per day. The inclined landings examined in this report consist of two landings, one with the right skid up and one with left skid up, in a standard area with a slope differential of approximately five degrees.

STATUS

The data for these inclined landing maneuvers has been acquired and identified. At this time, the reduction of available measures into a set of independent performance measures has been initiated. Analysis of the data will be accomplished after the preliminary data reduction process has been completed.

AVIATOR PERFORMANCE DURING HOVER WITH A STABILITY AUGMENTATION SYSTEM

OBJECTIVE

The purpose of this research is to determine the quality and improvement of hover performance which results from stability augmentation of one or more helicopter axes.

BACKGROUND

In the helicopter medical evacuation mission and other Army aviation missions, there exists the requirement to perform hover maneuvers. This maneuver requires the aviator to precisely control his aircraft along and about all three axes. With regard to medical evacuation missions by hoist extraction, reasonable tolerances must be maintained to preclude adversely affecting the patient. Previous investigations have indicated that the precise simultaneous control of the helicopter along these axes is difficult even for the most experienced pilots. In view of this difficulty it is anticipated that integration of a three axes stabilization system will markedly improve the man-helicopter hover performance.

METHODOLOGY

The subjects for this investigation will be 20 experienced Army aviators. After adequate familiarization with the stability augmentation system, they will be required to perform a series of thirty-foot precision hovers, each hover being maintained for 120 seconds. Each subject will fly the USAARL research aircraft under the six conditions of either single or dual axes stabilization and under one condition of stabilization of the pitch, roll, and yaw axes. The Helicopter In-Flight Monitoring System will be used to acquire data from each of the test flights which will be conducted at the High Falls stagefield.

STATUS

The stability augmentation system has been installed in the research aircraft and flight tested.

AVIATOR PERFORMANCE DURING DAY AND NIGHT TERRAIN FLIGHT

OBJECTIVE

The objective of this investigation is to determine what effects on aviator performance during terrain flight are introduced by the application of the night vision goggles (NVG's) as a primary viewing device. Performance of aviators during low level (LL) and Nap-of-the-earth (NOE) flight profiles using NVG's will be compared to similar profiles flown during the day and night using only the aided eye.

BACKGROUND

Previous experience with Army aviation has emphasized the tactical requirement for around-the-clock operations. A primary requirement in achieving 24-hour capability is the development of the aviator's ability to perform terrain flight profiles during both day and night operations. One device developed to aid in the accomplishment of this requirement is the night vision goggles (NVG's) (AN/PVS-5). The night vision goggles were originally developed for ground use but are now considered to be an interim solution to aid the pilot's night vision. Currently, little information is available which describes the effect of night vision goggles on aviator performance during the mission essential terrain flight profiles. The investigation will assess the influence of night vision goggles on aviator performance and improve the in-house data base being developed as a result of an ongoing research program designed to evaluate the effects of night vision goggles on rotary wing aviator performance.

METHODOLOGY

Performance data obtained from two earlier investigations of terrain flight, one using the night vision goggles, and one using the unaided eye during the day and night, will be utilized for this investigation. Appropriate flight profiles will be identified and standardized across the two studies. Multivariate analysis techniques will be used to test for significant differences between NVG's flights and flights using the unaided eye for both LL and NOE flight profiles. In addition, the analysis will designate those measures of man-helicopter system performance that demonstrated changes between visual conditions.

STATUS

Data selection, processing and analysis have been completed. At the current time the technical report draft is being prepared for publication.

GEOGRAPHIC FEATURE VISIBILITY IN LOW LEVEL FLIGHT

OBJECTIVE

To provide preliminary definition of the relative orientation and time in view of geographic features during low level flight.

BACKGROUND

Masking by vegetation and terrain during low level and nap-of-the-earth flight greatly restricts visibility to features used for geographic orientation. The time in view of features and their relative orientation when in view is determined largely by vegetation and terrain characteristics, but has not been quantified. As a result, the characteristics needed in systems for navigation at low level have not been well defined in regard to the orientation and duration that potential navigation features are in view. Preliminary analysis has suggested that little information for navigation is likely to exist directly ahead of the aircraft.

METHODOLOGY

Existing extreme wide angle low level motion picture imagery obtained in the Fort Rucker vicinity will be used to define quantitatively the relative orientation of features potentially usable for geographic orientation, and to define the time these features are in view. The azimuth and elevation angles at feature appearance and disappearance will be recorded, as well as intermediate orientations if in view for an extended period of time. Angular orientation of linear features such as roads will also be defined at crossing. The data will be summarized with regard to relative expectations of lines of sight which exist for various types of features at various orientations and durations.

STATUS

Data analysis on this work has been completed. The results of this effort have been published in USAARL Report No. 76-5, entitled "Object Visibility Patterns in Low Level Flight, dated September 1975.

VISUAL PERFORMANCE DURING DAY TERRAIN FLIGHT

OBJECTIVE

The objective of this work is to gain information concerning visual performance during terrain flight.

BACKGROUND

When executing terrain flight profiles in an Army helicopter, the aviator traverses through a constantly changing perceptual environment. Unlike normal flight profiles, NOE work is conducted at very low altitudes and variable airspeeds with the primary objective being concealment of the aircraft enroute to an assigned mission objective. The necessity of avoiding obstacles, assuring adequate height above all potentially hazardous terrain features, navigating to an objective while maintaining concealment as well as performing normal flight duties, places a formidable workload on the aviator. Much of the information necessary to perform these various functions is processed through the visual modality. Indeed, this sensory modality could be considered the most critical for helicopter flight. However, to date, little research has been accomplished to determine where a pilot looks with his eyes during flight. Recent work by this laboratory has monitored visual performance of aviators while flying standard maneuvers. This work will provide similar information for terrain flight.

METHODOLOGY

Subjects will be six Army aviators. Visual performance will be measured using an Eye Mark Recorder linked to a film camera. The windscreen will be divided into eight sections. There will also be two chin bubble sectors, two side door sectors and one inside cockpit sector. All pilots will perform two NOE-low level flights, each approximately twelve minutes in duration. All film will be scored in the laboratory. Time measurements in each sector will be obtained, as well as the number of transitions into and out of each sector. A percentage of time spent in each sector will also be computed.

STATUS

A precis to perform this research has been accepted. Preliminary design and instrumentation is complete and data during operational flight is presently being obtained.

AVIATOR OCULOMOTOR PERFORMANCE IN SIMUHIMS

OBJECTIVE

The objective of this research is to enlarge the present data base of aviator oculomotor performance information during simulated IFR flight and to link this perceptual data with aviator control and aircraft response parameters.

BACKGROUND

The helicopter is an integral part of the tactical structure and is continuing to receive expanded missions. Although audio and tactile stimuli are utilized, the aviator still relies in large measure on visual information for aircraft control. This information, under visual flight rules (VFR) is obtained from sources within the cockpit as well as viewing outside the aircraft. However, when flying under instrument meteorological conditions (IMC) or restricted visibility such as night, more if not all cues required for appropriate aircraft control and management must be obtained from the aircraft instrument panel.

In the past, and also persistent in future helicopter design, is the concept that fixed wing instrument and instrument arrangements provide the rotary wing aviator with adequate visual information transfer. However, in light of pilot opinion, accident reports and limited objective data, it would appear that this concept should be challenged. This investigation will permit data collection with regard to visual cues necessary for IFR helicopter maneuvers, thus, providing a partial data base useful for optimal panel design.

METHODOLOGY

Visual and psychomotor performance will be measured in the USAARL Helicopter Simulator during basic IFR helicopter maneuvers. These data will be compared to similar data obtained in the 2B24 Helicopter Simulator and UH-1 helicopter. In addition to expanding the objective data base, this study will provide the above mentioned comparisons.

STATUS

Preliminary design and equipment acquisition and integration has been accomplished. Data collection will commence during 2nd Quarter, FY 77.

COMPARISON OF OCULOMOTOR PERFORMANCE OF MONOCULAR AND BINOCULAR AVIATORS DURING VFR HELICOPTER FLIGHT

OBJECTIVE

The objective of this investigation is to gain data concerning oculomotor performance during visual meteorological conditions (VMC) while executing a number of maneuvers in a UH-1 helicopter. For purposes of comparison, data will be acquired for one monocular aviator and six binocular aviators.

BACKGROUND

There is little question that helicopters have become an integral part of the U. S. Army's tactical structure. Also, there is little question that mission accomplishment and safe flight of the helicopter is dependent in large measure on external visual information received by aircrew personnel. Evidence that minimum adequate visual information is currently afforded Army aviators is substantiated by the very fact they can, and do, fly the machines. However, little is known with regard to what areas of the windscreen aviators most often use, how long they dwell in these areas, what dynamic response patterns they utilize to transition from area to area, where and what they view external to the aircraft, or how these parameters change as a function of variables, such as aircraft flown, maneuvers flown, level of training, or physiological state. Knowledge concerning these parameters is perhaps a first step in gaining information concerning what visual cues are critical in helicopter flight control.

Though the visual sensory modality is considered, almost without exception, to be highly critical to helicopter flying, few research studies have been conducted measuring where the pilot looks during actual rotary wing flight.

Additionally, there may be information relative to visual flight rules to be gained from studying monocular visual performance during helicopter flight. Perhaps the major binocular cue which a monocular aviator loses is that of retinal disparity which perhaps can be useful to a distance of between 490 - 700 yards. This, however, does not appear necessary for the conduct of adequate flight control, a fact attested to by a number of successful one-eyed helicopter pilots. However, there is little information available as to whether or not these monocular pilots tend to gain their flight control cues from the same areas which appear to be visually "rich" for binocular aviators.

METHODOLOGY

Visual performance of all subjects will be measured via a modified NAC Eye Mark Recorder used in conjunction with either a video recording

system or 16mm motion picture camera. All recording will be done in real time.

Each subject will perform a standardized set of eleven maneuvers common to helicopter operations. These are as follows: (1) lift off to stabilized hover; (2) forward hover; (3) rearward hover; (4) hover turn left - 90°; (5) hover sideward - left; (6) hover sideward - right; (7) hover turn left - 360°; (8) hover turn right - 360°; (9) hover turn right - 90°; (10) Normal take off and normal approach to a hover - left traffic pattern; and (11) normal take off and normal approach to touchdown - right traffic pattern.

All data will be recorded and scored to determine time spent in each area of the windscreen, as well as percentages of flight time for each visual cue will be obtained. Comparisons between monocular and binocular visual performance will be made.

STATUS

Data has been acquired and analyzed. Initial comparisons indicate that the monocular visual performance generally resembled that of binocular aviators with regard to the areas of the windscreen used but varied with regard to the total time spent in these areas and the average dwell time. A manuscript is under preparation and a final report should be published in the near future.

VISUAL WORKLOAD OF THE COPILOT/NAVIGATOR DURING TERRAIN FLIGHT

OBJECTIVE

The objective of the proposed research project is to examine the existing visual workload of the navigator/copilot and navigation performance of the aircrew during terrain flight. The project will be divided into three phases.

Phase I will examine the visual workload of the navigator/copilot. Phase II will incorporate information obtained in Phase I and will examine experimental navigation devices. Phase III will also incorporate information obtained in Phases I and II and examine NOE navigation at night with and without the use of the AN/PVS-5 night vision goggles.

BACKGROUND

The emphasis on aviator workload has been of primary concern to the U.S. Army aviation community since the incorporation of low altitude terrain flight techniques into the helicopter tactics repertory. Navigation has been a particularly acute problem at low altitudes due to the relative perceptual speeds at which the terrain is traversed and the subsequent short periods of time that navigational cues remain in the visual field.

The division of duties between the primary aircrew currently requires that the navigator/copilot perform duties which entail among other things: monitoring the map and navigation instruments as well as the terrain in an attempt to locate the significant navigational cues needed for maintaining the correct flight path; monitoring the helicopter engine instruments and other flight instruments; tuning the radios; orally providing navigational information to the pilot that will allow him to maintain the appropriate flight path; and helping the pilot locate and avoid potentially hazardous terrain obstacles. Thus, the navigator/copilot also encounters a large visual workload during low altitude flight.

METHODOLOGY

Visual performance will be measured via a modified NAC Eye Mark recorder used in conjunction with a LO-CAM high speed camera. Each subject will be fitted with the NAC recorder in the laboratory and checked for accuracy. The subject will then be taken to the aircraft for hook-up with the LO-CAM camera. Stability of the Eye NAC recorder will be checked after the mission to insure that the device has not shifted, thus introducing error into the measurements. The scoring methodology to be utilized in the analysis of the eye movement data can be found in previous USAARL reports.

Altitude, airspeed and geographical location and other flight performance measures will be recorded via HIMS. Visual free time will be determined through performance of a nonflight related task (reading task of random words). Nap-of-the-earth flight will be required and successful location of the checkpoints will be noted along with the other flight performance measures.

STATUS

Data on Phase I has been collected and partially analyzed. The project is currently in the data reduction/analysis phase.

PILOT VISUAL PERFORMANCE DURING SIMULATED INSTRUMENT FLIGHT

OBJECTIVE

This is the first of a series of studies designed to obtain base line data of pilot visual performance during helicopter flight. This project concentrates on visual performance during instrument flight in a helicopter simulator.

BACKGROUND

The helicopter has become an integral part of the tactical structure and is continuing to receive expanding missions. Mission accomplishment in a safe and efficient manner is dependent in large measure on visual information. This information under visual flight rules (VFR) can be gained from sources within the cockpit as well as viewing the outside world. On the other hand, when flying under instrument meteorological conditions (IMC), all cues required for appropriate aircraft control and management must be gained from inside the cockpit. This study will provide data with regard to the critical visual cues used during simulated instrument flight. Such data is vital for optimal design and information transfer in the helicopter environment.

METHODOLOGY

Ten rotary wing aviators of varying experience will participate in simulated aerial flights in the 2B24 Synthetic Flight Trainer. Visual performance will be recorded via a modified NAC Eye Mark Recorder in conjunction with a 16mm motion picture camera with time code capability.

STATUS

Visual flight data has been reduced to the thirteen areas subjects visually utilized to accomplish an instrument flight profile. This data has been statistically reviewed to determine if experience, flight condition, or instrument arrangement affect visual performance.

AVIATOR VISUAL PERFORMANCE IN JUH-1H HELICOPTER UNDER VISUAL FLIGHT RULES (VFR)

OBJECTIVE

The objective of this project is to provide information concerning visual performance/workload during helicopter flight under visual flight rules (VFR).

BACKGROUND

Evolving from the Army's modern air mobility concept, the helicopter has become a strategic element of the tactical structure. The pilot's ability to manipulate his aircraft in the tactical setting is directly related to the inputs or cues he receives from the flight environment. Of the perceptual inputs required to fly the aircraft, visual cues are considered vital. Visual data obtained during the conduct of basic VFR helicopter maneuvers, will be compared with similar data obtained in the 2B24 helicopter simulator and IFR helicopter flights. These performance data and their subsequent comparisons will provide an objective data base which will be useful in understanding present pilot techniques and demonstrating potential cockpit panel design deficiencies.

METHODOLOGY

Subjects will consist of ten Army aviators of varying experience levels. Visual performance during each of the actual JUH-1 flights will be recorded via a modified NAC Eye Mark recorder in conjunction with a 16mm motion picture camera with time code capability. A technique for assessing visual free time will be applied during the testing sequence. This technique will require the subjects to read from a free time monosyllable word chart during periods of low visual activity.

STATUS

Ten hours of visual performance during VFR helicopter flight have been recorded and data is currently being reduced for statistical analysis.

PERCEIVED VELOCITY AS A FUNCTION OF ALTITUDE AND VISUAL ENVIRONMENT

OBJECTIVE

The investigation of aviator ability to estimate aircraft velocity as a function of altitude under normal daylight and low light level night conditions.

BACKGROUND

The perception of velocity is believed by some to be a linear function of altitude; however, there does not appear to be any empirical evidence in this regard. Velocity perception has become increasingly important with the new tactical profiles and night vision devices.

METHODOLOGY

Eight subjects will be flown at 12 altitude/aircraft speed combinations (4 altitudes, 3 aircraft speeds) under each of 4 visual conditions: unaided eye in daylight and both the aided and unaided eye in night light (simulated and equivalent to quarter to half moon). Visual aids are 2 pairs of night vision goggles, one with a 60° field of view, the other with a 40° field of view.

The subjects will estimate aircraft speed and altitude, utilizing normal visual cues, for each of the above conditions.

The experiment design consists of a counterbalanced Latin-square with subjects randomly assigned to visual conditions and altitude/aircraft speed combinations.

Criterion measure will be the difference between aviator estimates and the actual altitude/aircraft speed measured by the radar altimeter and a helicopter in flight monitoring system.

Analysis of variance will be used to examine the data with respect to altitudes, aircraft speed and visual conditions.

STATUS

A report on the results of this investigation has been completed and published as USAARL Report No. 76-3, entitled "Perceived Velocity and Altitude Judgments during Rotary Wing Aircraft Flight," dated September 1975.

AEROMEDICAL EXPLORATION OF HELICOPTER FLIGHT CONTROL CUEING CONCEPT FOR CONTACT TRAINING

OBJECTIVE

To gain a full understanding of a cueing concept that has been developed to assist students in developing helicopter contact flying skills, and to explore the potential application of the concept in resolving aeromedical problems in helicopter flight operations and training.

BACKGROUND

A senior flight instructor has developed a cueing technique that appears to assist in acquisition of higher than usual skills in contact flying. This cueing is highly similar to the attitude cues used in instrument flight, and students trained with the technique in contact training seem to do quite well in instrument training. The technique seems likely to have potential for resolving some of the disorientation and control problems that exist when attempting to fly helicopters using imaging devices.

METHODOLOGY

A thorough indoctrination was conducted in the application of the cueing technique in student flight training, with emphasis on essential aspects, advantages, and drawbacks. A tape recording is being obtained of classroom and flight training and discussions, and film recordings illustrating the application of the cue in flight are being obtained. A non-rigorous assessment will be made of the effect of the technique on learning of contact and instrument flying skills, and of the potential of applying the technique with a minimum of time and effort. After a full understanding of the cueing technique and its potential is obtained, the potential of the technique for resolving various aeromedical problems in current and future Army helicopter systems will be assessed. More definitive research on applications of the concept will be defined should they be considered appropriate.

STATUS

The results of this research have been presented in USAARL Report No. 76-2, entitled "Buettner Cueing Concept for Helicopter Flight Control," dated August 1975.

OPERATIONAL MEASURES OF PILOT PERFORMANCE DURING AUTOROTATIONS

OBJECTIVE

The objective of this study is to investigate pilot and aircraft performance as related to autorotational maneuvers.

BACKGROUND

Currently, autorotation is the only in-flight escape system available to the helicopter pilot. For this reason, research into mechanisms which affect this maneuver is very important. Preliminary investigations into accident data records show that a significant number of problematic landings associated with this maneuver could be attributed to human factor errors, leaving the question of what factors are associated with such pilot performance.

METHODOLOGY

This study is being conducted in two phases. Phase I involves a review of autorotational accidents. Information derived from these reports will provide cost figures and should yield information as to variables common to various types of aircraft, weather conditions, time of day which may be contributory factors to these accidents.

Phase II will involve measuring both pilot and aircraft performance during autorotation. Initial variables to be studied relative to performance during autorotation will include environmental conditions and individual differences.

STATUS

Autorotational accidents for FY 70-72 have been analyzed. A technical report detailing these accidents has been written (USAARL Report No. 74-2 entitled "Army Autorotational Accidents FY 70-72"). Necessary equipment for measuring autorotational performance has been developed, and a precis has been approved to perform the research. Further work in this area is postponed pending tactics instructor pilot qualification of responsible investigator/aviator.

TEMPERATURE EFFECTS ON ACCIDENT RATES

OBJECTIVE

To determine the effect of cockpit ambient temperatures on accident rates in Army aviation.

BACKGROUND

Data currently do not exist on the effect of temperatures on accident rates in Army aviation. The lack of such data has resulted in cockpit environmental conditioning requirements in new aircraft developments being subjectively determined. Comfort of the crew is generally regarded as too costly in terms of the weight/power penalties involved for cooling; the design concern is the temperature that can be tolerated without serious performance consequences. Laboratory data do not translate easily into the serious consequence tolerance limits that are needed, other than physiological collapse limits. Data are available indicating a substantial increase in industrial accidents during high temperatures in comparison to moderate temperatures. It is reasonable to expect that this temperature-accident relationship may also exist for Army aviation accidents. If so, it would seem to be the most valid basis for determining cockpit environmental conditioning requirements.

METHODOLOGY

The accident record ADP files of USAAVS (US Army Agency for Aviation Safety) will be searched and sorted by relevant data items on their accident reporting form. These items will include temperature, aircraft type, mission profile, humidity related items, geographic, density altitudes, and possibly others. Statistical techniques will be used to separate temperature-humidity effects from other co-varying factors to the extent the data permits. It is anticipated that accident rates, per se, may not be directly obtainable as a function of temperature, but that comparisons of the relative numbers of accidents at various temperatures should be possible. A comparison of temperature distributions for accidents in relation to average temperature distributions should also be possible. An attempt will be made to determine accident rates as a function of temperature directly if adequate data for this purpose can be obtained.

STATUS

After a thorough review of accident and temperature data acquired from USAAVS and USAF Weather Squadron at Cairns AAF, it was determined that insufficient information was available to warrant further, more detailed analysis; therefore, this project has been terminated pending availability of more precise data.

FLIGHT TIME AND CREW REST REQUIREMENTS FOR
INITIAL ENTRY ROTARY WING (IERW) TRAINING AND SELECTED COMBAT MISSIONS

OBJECTIVE

The objective of this study is to provide data in the form of subjective estimates of the appropriate flight time and crew rest requirements for the different phases of IERW training and selected combat missions.

BACKGROUND

Studies of flight time/crew rest related to rotary wing flight are few in number and inconclusive in their results. The amount of crew rest necessary is directly related to the degree of fatigue encountered during crew duty time. In a recent NATO AGARD report, "for the 50 accidents on which a full report was available it was concluded that in some 20 percent, aviator fatigue was a major cause of the accident." USAAAVS data indicate that for the FY 1969-73 period, fatigue was cited as a factor in six percent of the rotary wing accidents and four percent of the fixed wing accidents. The question remains, how many other Army aircraft accidents were in part due to fatigue but were attributed to other factors such as: (1) failure to use accepted procedures, (2) selected wrong courses of action, (3) inadvertent operation self-induced, (4) poor crew coordination, (5) inadequate coordination or timing, (6) misjudged speed or distance, (7) delay in taking necessary action, (8) distraction, (9) channelized attention, (10) task oversaturation, (11) inattention, and (12) confusion of controls and others.

U.S. Army Aviation Regulation AR 95-1 indicates that flight time limitations and crew rest requirements are established by local commanders. AR 95-1 provides the commanders with very few guidelines as to what might be appropriate. The proposed project will provide additional information concerning flight time and crew rest during IERW training and selected combat missions.

METHODOLOGY

Subjects will consist of IP's and student pilots. The flight time/crew rest questionnaire was developed in two forms--one dealing specifically with IERW training, the other with combat missions. Both versions contain: (1) biographical information, (2) questions relating to flight time/crew rest limits for various periods of time across each training phase or combat mission, (3) rank ordering of phases or missions in terms of fatigue, (4) applicable factors contributing to fatigue for each phase or mission, and (5) a general comments section in which subjects could address any problems related to the project in detail.

STATUS

The data has been collected and analyzed and initial drafts of the methodology and results section have been completed. The project is currently in the interpretation and write-up phase.

DRUGS IN AVIATION MEDICINE: AN INVESTIGATION OF THE EFFECTS OF ORAL CONTRACEPTIVES ON PERFORMANCE

OBJECTIVE

The objective of this investigation is to measure changes indicative of mood and psychomotor performance, if any, associated with oral contraceptive therapy.

BACKGROUND

The assignment of women to aviation occupations in the military promises to rapidly augment the number of women active in the field. This innovation may bring many benefits such as increasing the size of the pool from which qualified aviators can be drawn. However, it will require certain adjustments relating to aviation medicine, such as the management of aviators who are using oral contraceptive medication. Women in military aviation are in the 18 to 50 year age group which corresponds closely to the childbearing years of 13 to 44. Contraceptive practice patterns among women aviators will probably be similar to those of women of similar age in the general population. In the United States, the use of oral contraceptives is reported in 22% of women currently married and 23% of the age specific population. Common usage of any drug warrants investigation of the side effects of its use, especially where speculation has suggested that the particular generic group might affect performance and thus could influence safety.

METHODOLOGY

Participating personnel for the study will be 47 women volunteers from the Fort Rucker, AL area. Subjects will be placed in one of four groups according to their contraceptive practices: those using no oral contraceptives throughout the study; those using oral contraceptives throughout the study; those entering the study not taking oral contraceptives who volunteered to take them for the last month of the study; and those entering using oral contraceptives who will volunteer to discontinue such usage for the last month of the study. The last two groups will function as their own controls. Psychomotor performance will be evaluated through the use of the following tasks: Minnesota Rate of Manipulation - Placing and Turning; Purdue Pegboard - Dominant Hand, Nondominant Hand and Both Hands; Groove Type Steadiness; Visual and Auditory Reaction Times; Rotary Pursuit Tracking and Rotary Pursuit Tracking with Visual Digit Span.

Additionally, a mood checklist scale measuring anger, happiness, fear, depression, lethargy and psychological well-being will be administered at each testing session. Subjects will be tested twice monthly--mid-cycle and premenstrually/menstrually on the psychomotor tasks and mood scale.

STATUS

Data has been collected, analyzed and interpreted. An initial draft of the study has been completed and final revisions are being made.

VISUAL PERFORMANCE DURING NIGHT HELICOPTER FLIGHT

OBJECTIVE

The primary objective of this project is to obtain data of pilot's visual performance/workload during night helicopter flight.

BACKGROUND

Evolving from the Army's modern air mobility concept, the helicopter has become a strategic element of the tactical structure. Although audio and tactical stimuli are utilized, the pilot still relies in large measure on visual information to maintain aircraft stability and safe flight. This information, under visual flight rules (VFR), is obtained from sources within the cockpit as well as outside the aircraft. However, when flying under instrument meteorological conditions (IMC) or restricted visibility such as night, more if not all cues required for appropriate aircraft control and management must be gained from the information provided on the aircraft instrument panel.

The purpose of this project is to provide information relative to the visual performance and workload of pilots during helicopter flight under night conditions.

METHODOLOGY

Ten Army aviators of varying experience will participate in helicopter flights under night conditions. Visual performance will be measured with a modified NAC Eye Mark recorder used in conjunction with a LO-CAM high speed camera. Visual free time will be measured with a free time monosyllable chart. Altitude will vary from ground hover to cruise flight at five thousand feet.

STATUS

This project is in the equipment design stage. Preliminary tests have been completed with video recordings and 35 mm still pictures. From these tests, 16 mm film with ultraviolet lights from the cockpit has been determined to be the best procedure.

IN-FLIGHT PERFORMANCE WITH NIGHT VISION GOGGLES DURING REDUCED ILLUMINATION

OBJECTIVE

The purpose of this research is to investigate changes in man-helicopter system performance resulting from reduced illumination levels presented to the aviator while wearing AN/PVS-5 night vision goggles. This investigation will also examine changes in man-helicopter system performance resulting from a reduction in the illumination level presented to the unaided eye.

BACKGROUND

At the present time the Army is striving to attain around-the-clock operational capability for its tactical forces. The objective is to achieve a near-daytime capability at night and during inclement weather. One device which has been developed as an aid in achieving this goal is the night vision goggles (NVG's) (AN/PVS-5). Recognizing the major impact that the NVG's could have on Army aircraft systems, this laboratory has developed an ongoing program to investigate performance characteristics of aviators while using the night vision goggles. To date, several research studies have been completed and over 100 hours of flight experience have been obtained with the night vision goggles. Based on this experience, it became apparent that there was an immediate need to systematically investigate the role of illumination as it affects the aviator's ability to fly with night vision goggles. This requirement is based on the fact that below certain illuminance levels, night vision goggles produce a signal-to-noise ratio that substantially degrades the pilot's ability to fly certain maneuvers. These marginal illuminance levels impact Army aviation in several ways. First, they represent a major safety concern for the aviator because they limit his flying capability. Inadvertent entry into marginal levels may provide the aviator with unusually hazardous flight conditions. The identification of illuminance levels necessary for adequate performance is also necessary for both the tactical and the training environment. If the commander knows the light level at which he can expect full NVG's capability, he can then approximate the percentage of time they can be employed for any given reason, location, and time of night.

METHODOLOGY

Subjects for this investigation will be six experienced Army rotary wing pilots. Subjects will perform twenty-four precision stationary hovers at three feet while wearing the night vision goggles and twenty-four hovers while in a simulated unaided eye condition. With each of the viewing devices, the subject will be exposed to six standard illuminance level conditions. Data will be acquired with the Helicopter In-Flight Monitoring System (HIMS) and analyzed using multivariate statistical analyses methods.

STATUS

Data have been obtained and analyzed. A report on this research investigation entitled, "In-Flight Performance with Night Vision Goggles During Reduced Illumination" (USAARL Report No. 76-27) has been published.

AVIATOR PERFORMANCE DURING HOVER USING RADAR ALTITUDE AND AUDITORY AUGMENTATION AIDS

OBJECTIVE

The purpose of this investigation is to determine the improvement in hover performance of Army aviators that is provided by the introduction of altitude maintenance information. Aviator hover performance using a radar altitude visual display and auditory display is to be compared with hover performance obtained using current flight instruments.

BACKGROUND

In the helicopter medical evacuation mission and other Army aviation missions, there exists the requirement to perform hover maneuvers. This maneuver requires the aviator to control his aircraft along and about all three axes. This control must often be established within a narrow tolerance band if the mission is to be efficiently accomplished. With regard to medical evacuation missions by hoist extraction, reasonable tolerances must be maintained to preclude adversely affecting the patient. Previous investigations have indicated that the precise simultaneous control of the helicopter along the three axes is difficult even for the most experienced pilots. It is anticipated that unburdening the aviator by stabilizing one axis may improve the overall quality of precision hover performance.

METHODOLOGY

Approximately 20 experienced Army aviators will be used as subjects for this investigation. These pilots will be required to perform a thirty-foot precision hover for 120 seconds. Each subject will be tested under conditions of normal flight instruments, flight instruments plus information from the radar altimeter, and flight instruments plus information from the auditory altimeter display. All subjects will fly the USAARL test aircraft for each of these maneuvers with the test location being at the High Falls stagefield. The Helicopter In-Flight Monitoring System will be utilized to acquire data on the man-helicopter system performance.

STATUS

At the present time further progress in this investigation requires the completion of other current projects and the subsequent allocation of personnel and equipment resources. Preliminary flight checks of the equipment and experimental design have been conducted and the required test program has been drafted.

GENERAL DETAIL SHEET

TITLE: Evaluation of Mini-Huds

OBJECTIVE:

To provide information as to whether or not numeric and/or analog LED displays focused at infinity can be effectively utilized as displays during flight with night vision goggles.

BACKGROUND, METHODOLOGY, STATUS:

Statements concerning the above for this area of research can be found on the following page numbered 148.

RECOMMENDATIONS:

This research effort will be complete during First Quarter, FY 77.

EVALUATION OF MINI-HUDS

OBJECTIVE

The objective of this investigation is to evaluate the potential for utilization of LED numeric displays to provide critical aircraft status information to pilots during flight with night vision goggles.

BACKGROUND

As a function of battle field threat conditions, tactical helicopter operations will require NOE flight. As such, aviators will be required to maintain a maximum of head-out-time to avoid obstacles and maintain concealment. Consequently, finding time available to come into the cockpit and adjust to near vision for flight and aircraft status information is a problem. This problem is further compounded when wearing night vision goggles because they require a manual refocus in order to achieve near vision when coming into the cockpit. This, of course, not only increases the required time to come in but also means removing one or both hands from the controls. Because of these time considerations, the aviator must often go without the information he desires at the time he desires it; he must ask the copilot to provide it or risk obstacle collision by coming inside. A potential solution for alleviating this problem resides in mounting LED numeric displays focused at infinity on the glare shield. Such displays have the potential for quickly relaying certain parameters of key interest to the pilot at a low dollar cost.

METHODOLOGY

The proposed approach in evaluating this concept will involve flying the displays. The method will be to design and integrate the displays into a helicopter. The parameters to be displayed will be in part determined by the accessibility and electrical output form of the current instrument. Once the displays are installed and integrated, a number of aviators will use them while flying various flight profiles with and without night vision goggles. Opinions will be obtained from these aviators concerning the relative merit of providing information in this form.

STATUS

System components have been obtained and integration of these components to provide the candidate system is nearly complete. Preliminary flight testing has begun.

RESEARCH AND TECHNOLOGY WORK UNIT SUMMARY				1 AGENCY ACCESSION*	2 DATE OF SUMMARY*	REPORT CONTROL SYMBOL	
				DA OB 6901	76 10 01	DD-DR&E(AR)636	
3 DATE PREV SUMMARY	4 KIND OF SUMMARY	5 SUMMARY SCTY*	6 WORK SECURITY*	7 REGRADING*	8A DES'N INSTR'N	8B SPECIFIC DATA- CONTRACTOR ACCESS	9 LEVEL OF SUM A WORK UNIT
	A. New	U	U		ML	<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO	
10 NO. CODES*		PROGRAM ELEMENT	PROJECT NUMBER	TASK AREA NUMBER	WORK UNIT NUMBER		
a. PRIMARY		6.27.73.A	3E62773A819	00	012		
b. CONTRIBUTING							
c. Key/Info/Info/		CARDS TT4(F) (M)					
11 TITLE (Precede with Security Classification Code)* (U) Evaluation of Scan Converters for Airborne Application							
12 SCIENTIFIC AND TECHNOLOGICAL AREAS* 009400 Man-Machine Relations; 011900 Optical Detection; 005700 Electronics & Electrical Engineering							
13 START DATE		14 ESTIMATED COMPLETION DATE		15 FUNDING AGENCY		16 PERFORMANCE METHOD	
76 01		76 12		DA		C. In-House	
17 CONTRACT GRANT				18 RESOURCES ESTIMATE		19 PROFESSIONAL MAN YRS	
a. DATES/EFFECTIVE				PRECEDING		b. FUNDS (In thousands)	
b. NUMBER* Not Applicable				FISCAL YEAR		c. AMOUNT:	
c. TYPE				76&77		.6	
d. KIND OF AWARD:				77		.2	
e. AMOUNT:						3	
f. CUM. AMT.							
19 RESPONSIBLE DOD ORGANIZATION				20 PERFORMING ORGANIZATION			
NAME* US Army Aeromedical Research Laboratory				NAME* US Army Aeromedical Research Laboratory			
ADDRESS* Fort Rucker, AL 36362				ADDRESS* Aviation Psychology Division Fort Rucker, AL 36362			
RESPONSIBLE INDIVIDUAL				PRINCIPAL INVESTIGATOR (Furnish SSAN if U.S. Academic Institution)			
NAME: Bailey, Robert W., COL, Cdr				NAME* Hofmann, M. A., Ph.D.			
TELEPHONE: (205) 255-5107				TELEPHONE: (205) 255-3211			
21 GENERAL USE				SOCIAL SECURITY ACCOUNT NUMBER			
Foreign Intelligence Considered				ASSOCIATE INVESTIGATORS			
				NAME: Wright, R. H., Ph.D.			
				NAME: Sanders, M. G., CPT			
22 KEYWORDS (Precede EACH with Security Classification Code) (U) Video Cameras, (U) CRT, (U) Psychology, (U) Optics, (U) Target Acquisition							
23 TECHNICAL OBJECTIVE, 24 APPROACH, 25 PROGRESS (Furnish individual paragraphs identified by number. Precede text of each with Security Classification Code.)							
23. (U) To evaluate the potential of imagery scan converter processing techniques for application to a target acquisition task.							
24. (U) The approach will be to integrate the necessary visual and electrical components to provide low cost target acquisition prototype device and determine the feasibility of this type of device for field application.							
25. (U) Necessary components have been procured and a prototype device has been developed. A field evaluation of this system is in progress.							

GENERAL DETAIL SHEET

TITLE: Evaluation of Scan Converters for Airborne Application

OBJECTIVE:

To evaluate the potential of imagery scan converter processing techniques for application to a target acquisition task.

BACKGROUND, METHODOLOGY, STATUS:

Statements concerning the above for this area of research can be found on the following page numbered 151.

RECOMMENDATIONS:

This research effort will be complete during First Quarter FY 77.

EVALUATION OF SCAN CONVERTERS FOR AIRBORNE APPLICATION

OBJECTIVE

The objective of this investigation is to obtain data relative to the advantages and/or disadvantages of TV imagery scan converters as compared to an unaided visual system.

BACKGROUND

Based on current tactical doctrine there exists the requirement for certain Army aircraft to execute "pop-up" type maneuvers for the purpose of gaining information. Such maneuvers have associated with them threats which increase as a function of exposure time. Therefore, time reduction in gaining required information will lead to a decrease in vulnerability and subsequent aircraft losses. A potential solution for reducing this time as well as enhancing the behavior associated with the information gathering task is the utilization of scan converters for obtaining and storing visual information.

METHODOLOGY

The approach in evaluating the device will be to conduct a target acquisition task. The method to be employed will involve ground detection of various military vehicles. These vehicles will be employed in both dynamic and static conditions. Measures will be gained as to total time and exposure time required for acquisition and identification of vehicles with and without the aid of scan converters. The ranges to be employed have not yet been determined, but will be dependent upon field of view and area of responsibility. These parameters will be decided on the basis of preliminary work.

STATUS

Equipment has been obtained and integrated into the candidate systems to be evaluated. Preliminary data collection in the field has begun.

RESEARCH AND TECHNOLOGY WORK UNIT SUMMARY				1 AGENCY ACCESSION ^o	2 DATE OF SUMMARY ^o	3 REPORT CONTROL SYMBOL DD-DR&E(AR)636		
4 DATE PREV SUMMARY	4 KIND OF SUMMARY	5 SUMMARY SCT ^o	6 WORK SECURITY ^o	7 REGRADING ^o	8A DES'N INSTR ⁿ	8B SPECIFIC DATA - CONTRACTOR ACCESS		9 LEVEL OF SUM A WORK UNIT
	A. New	U	U		NL	<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO		
10 NO / CODES ^o	PROGRAM ELEMENT	PROJECT NUMBER		TASK AREA NUMBER	WORK UNIT NUMBER			
4. PRIMARY	6.27.73.A	3E62773A819		00	013			
5. CONTRIBUTING	CARDS 114 (f) (m)							
11 TITLE (Precede with Security Classification Code) ^o (U) Evaluation of Low Cost Navigation System								
12 SCIENTIFIC AND TECHNOLOGICAL AREAS ^o 001300 Aircraft; 019300 Passive Sensors, Trackers & References; 019700 Computers and related programming; 009400 Man-Machine Relations								
13 START DATE			14 ESTIMATED COMPLETION DATE		15 FUNDING AGENCY		16 PERFORMANCE METHOD	
76 01			76 12		DA		C. In-House	
17 CONTRACT GRANT				18 RESOURCES ESTIMATE		19 PROFESSIONAL MAN YRS		20 FUNDS (in thousands)
A. DATES/EFFECTIVE				B. PREVIOUS		.8		65
B. NUMBER ^o				FISCAL YEAR		CURRENT		
C. TYPE Not Applicable				77		.2		3
E. KIND OF AWARD:				F. CUM. AMT.				
19 RESPONSIBLE DOD ORGANIZATION				20 PERFORMING ORGANIZATION				
NAME ^o US Army Aeromedical Research Laboratory				NAME ^o US Army Aeromedical Research Laboratory				
ADDRESS ^o Fort Rucker, AL 36362				ADDRESS ^o Aviation Psychology Division Fort Rucker, AL 36362				
RESPONSIBLE INDIVIDUAL				PRINCIPAL INVESTIGATOR (Pursuant to AR 15-6, Academic Institution)				
NAME: Bailey, Robert W., COL, Cdr				NAME ^o Hofmann, M. A., Ph.D.				
TELEPHONE: (205) 255-5107				TELEPHONE: (205) 255-3211				
21 GENERAL USE				SOCIAL SECURITY ACCOUNT NUMBER				
Foreign Intelligence Considered				ASSOCIATE INVESTIGATORS				
				NAME: Kimball, K. A., Ph.D.				
				NAME: Armstrong, R. N.				
22 KEYWORDS (Precede EACH with Security Classification Code) (U) Recording Devices, (U) Aircraft, (U) Navigation, (U) Electronics Engineering, (U), Psychology,								
23 TECHNICAL OBJECTIVE, 24 APPROACH, 25 PROGRESS (Pursuant to individual paragraphs identified by number. Precede text of each with Security Classification Code)								
23. (U) To evaluate the potential for application of low cost sensors and data processors as navigation aids during NOE and tactical instrument flight missions.								
24. (U) The approach in evaluating these devices will be to conduct in-flight testing. Flights will be conducted at NOE and low level to determine the accuracy and navigation aid this system affords.								
25. (U) Various components necessary for fabricating a bread board prototype of the candidate system has been acquired, integrated and bench tested. Data collection in-flight will soon commence.								

GENERAL DETAIL SHEET

TITLE: Evaluation of Low Cost Navigation System

OBJECTIVE:

To evaluate the potential for application of low cost sensors and data processors as navigation aids during NOE and tactical instrument flight missions.

BACKGROUND, METHODOLOGY, STATUS:

Statements concerning the above for this area of research can be found on the following page numbered 154

RECOMMENDATIONS:

This research effort will be complete during First Quarter FY 77.

EVALUATION OF LOW COST NAVIGATION SYSTEM

OBJECTIVE

The objective of this effort is to evaluate the utility of a low cost prototype navigation system for low level and terrain flight application.

BACKGROUND

Navigation is extremely difficult during low level flight. The lack of altitude in this type of flight prevents the aviator from viewing large areas of terrain and presents him with a fast moving perceptual world. During night flight accurate navigation becomes even more difficult because of the degraded visual environment. A potential solution for unburdening the Army copilot/navigator and/or improving navigation performance exists in combining low air speed sensors with low cost aircraft orientation sensors. Such a system might prove to be a valuable aid and should be low in cost.

METHODOLOGY

The approach in evaluating this device would be to conduct in-flight testing. The method will be to design and integrate the system into a helicopter. Flights will then be conducted at NOE and low level to determine the accuracy and aid which the system affords. Accuracy will be measured by comparing the system with highly accurate ranging information supplied by a radio ranging system. Subjective opinion of the aid that the system affords will be gained by questionnaires given to the aviators that utilize the system. Additionally, time and accuracy measures will be obtained for preselected NOE courses.

STATUS

System components have been obtained and integration of these components to provide the candidate system is nearly complete. Preliminary flight testing has begun.

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