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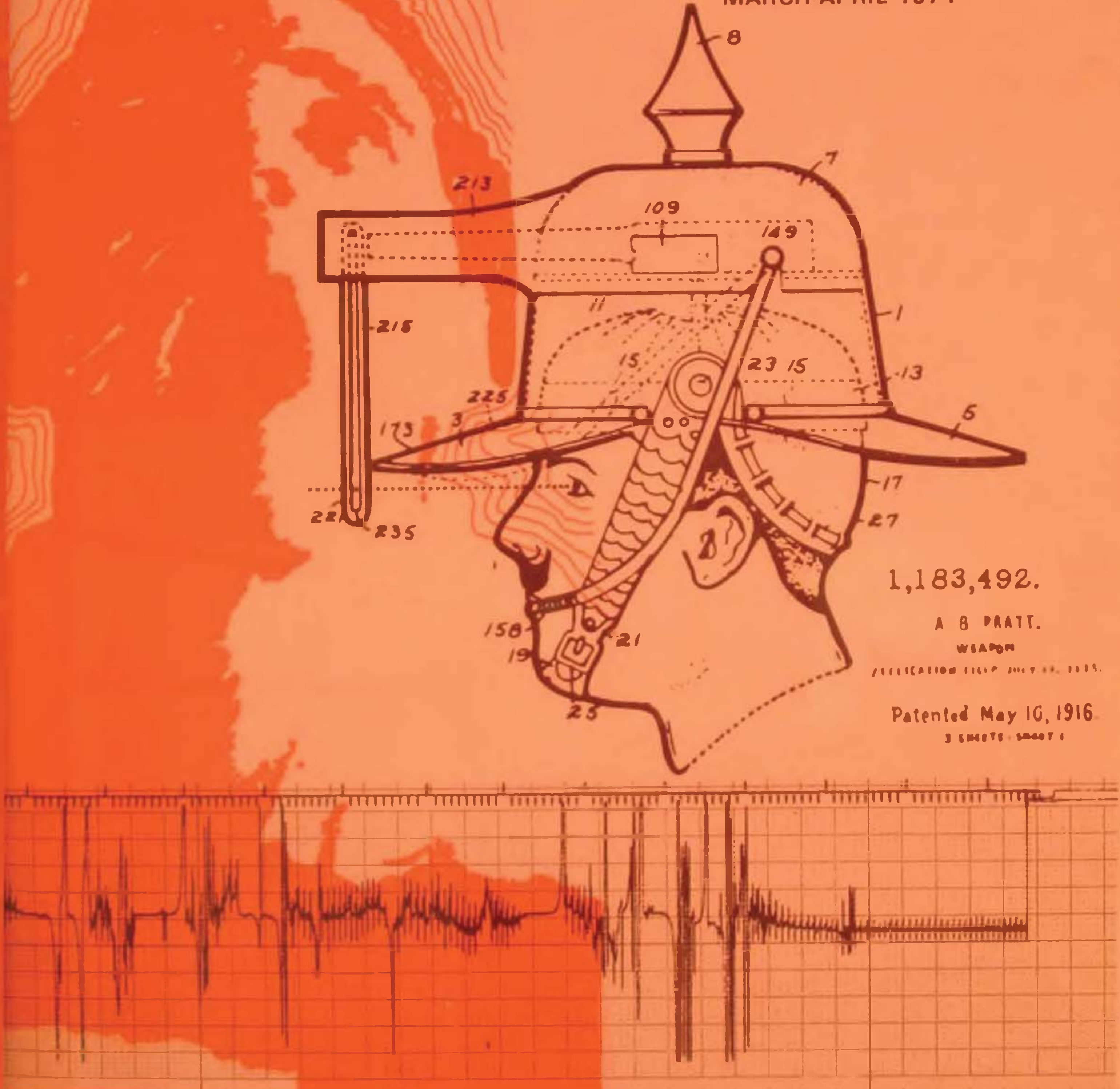

UNITED STATES AIR FORCE

AIR UNIVERSITY

REVIEW

AIR UNIVERSITY review

THE PROFESSIONAL JOURNAL OF THE UNITED STATES AIR FORCE

USAF Aeromedical Research

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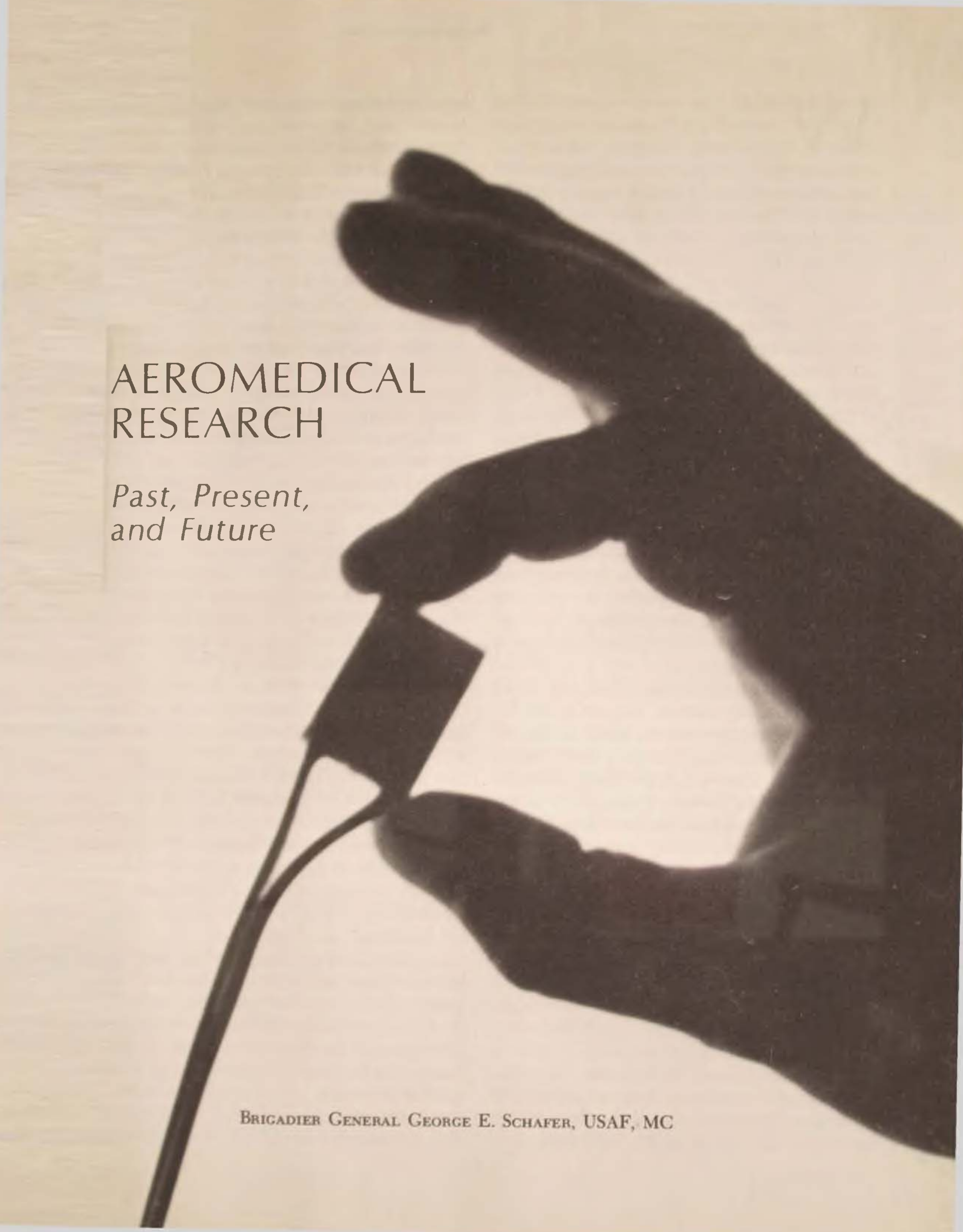
the cover

Several of the many facets of aeromedical research are presented in this issue of the *Review* and are reflected on our cover. Brigadier General George E. Schafer, USAF, MC, Commander, Aerospace Medical Division, Air Force Systems Command, first gives an overview of aeromedical progress in the Air Force. Then three research areas are considered in depth: "Visually Coupled Systems," reflected in the 1916 patent drawing, and "The Man/Machine Interface" and "Aeromedical Consultation Service," suggested by our artist's interpretive motifs.

AEROMEDICAL RESEARCH

Past, Present, and Future



Brigadier General George E. Schafer, USAF, MC

WHEN the term "medical research" is used, one tends naturally to think of medical research in the classic sense involving health care and searching for better ways to soothe man's ills. The Air Force does some of this type of research in several of its medical facilities across the country. However, "aerospace biotechnology" is the term used to describe that research designed to meet specific Air Force needs, and it is conducted almost exclusively by the Aerospace Medical Division of the Air Force Systems Command.

These efforts in aerospace biotechnology are oriented toward the care and protection of man as a key element in every aerospace military operation. Such research is aimed at determining and defining man's performance and his ability to function in an Air Force system in an operational environment. The knowledge gained can be applied toward enhancing his ability to perform as well as toward systems design and operations plans that take full advantage of his optimum ability.

Aerospace biotechnology research, then, considers human disease only when it affects Air Force operations, such as the effect disease may have on a pilot's ability to operate an aircraft or perform a certain mission. Another area of aeromedical research that considers human disease is directed toward establishing criteria for selection, retention, and care of aircrew members in order to develop and maintain the most viable and effective Air Force possible.

During the past twelve years, thousands of aircrew members have been referred to the Aeromedical Consultation Service of the USAF School of Aerospace Medicine for evaluation of clinical conditions that put their flight status in jeopardy. The data gained from these individuals, together with the data available from over 750,000 electrocardiographic records in the school's USAF Central Electrocardiographic Library, have served as a valuable research data base. In addition, approximately 46 percent of the individuals referred have been returned to flying status, including 71 with minor heart maladies. Considering the high cost of training today, the return of these aircrew members to flight status represents a substantial dollar savings to the Air Force. This work is the subject of another article in this issue by Colonel Malcolm C. Lancaster and Colonel William H. King of the Clinical Sciences Division, USAF School of Aerospace Medicine.

Aerospace medicine as a specialty is only about 24 years old, but research in aviation medicine and the study of problems concerning the care of the flyer began during World War I. An aeromedical laboratory was established at Mineola, Long Island, in 1917 when it was discovered that 60 percent of the aircraft accidents were caused by pilots who were not physically qualified to fly. This organization grew into what is now the USAF School of Aerospace Medicine at Brooks AFB, Texas, a part of the Aerospace Medical Division (AMD).

In the early thirties a young physician, Captain Harry Armstrong, was given a budget of $500 to do aeromedical research at Wright-Patterson AFB, Ohio. A part of this money was used to build the first human centrifuge that the Air Force had. Armstrong went on to achieve general officer rank and become Surgeon General of the Air Force. His laboratory is now the 6570th Aerospace Medical Research Laboratory, also a part of the Aerospace Medical Division.

Because of work done in the early days by both these organizations, we now enjoy many creature comforts on commercial airlines, and we have many effective life-support systems in military aircraft that we take more or less for granted. In fact, so great have been the accomplishments in aerospace medicine in the last half century, it is easy to assume all has been done and little is left to learn by continuing aeromedical research.

Nothing could be further from the truth. Military man is a key element in any military operation, and new technology, new systems, and new requirements pose changing and continually increasing demands on the military man. While new technology makes possible conceptual breakthroughs and provides new and different forms of weaponry, the man operating and maintaining the equipment remains essentially unchanged. Though he is unchanged, the environments in which he must function are becoming more severe, his tasks more complex, and his responsibilities more awesome.

We tend to expect man to utilize untapped reservoirs of strength, skill, and experience that are not programmable to enhance his ability to survive and perform effectively in increasingly demanding and hostile environments. The tacit assumption that these untapped reservoirs are limitless is invalid. Maximum effectiveness of current and future systems can only be achieved when we have a clear understanding of the actual *limits* which constrain man's performance, adaptability, and survivability. Biotechnology research is aimed at establishing just such a clear understanding of man's capabilities and limitations.

Technological advances in aircraft structures and power plants have placed the military pilot in an aircraft capable of creating and withstanding gravitational forces that were unheard of a decade ago. In order to enable pilots to survive and operate effectively under these stresses, AMD has inaugurated a two-phase approach to the problem. First, we are trying to determine what slight modifications to current equipment and what instructions to the pilots will enable them to tolerate these increased G forces and function under them. We are passing this information on to the Tactical Air Command as it is developed. Second, we are looking at long-range solutions to the high G problem, perhaps by repositioning the pilot in the cockpit. Such a solution, of course, will require considerable research from the point of view of mission accomplishment.

The theme of yet another article in this issue deals with the man/machine interface; it is written by Colonel Neville P. Clarke, Director of Research and Development for the Aerospace Medical Division.

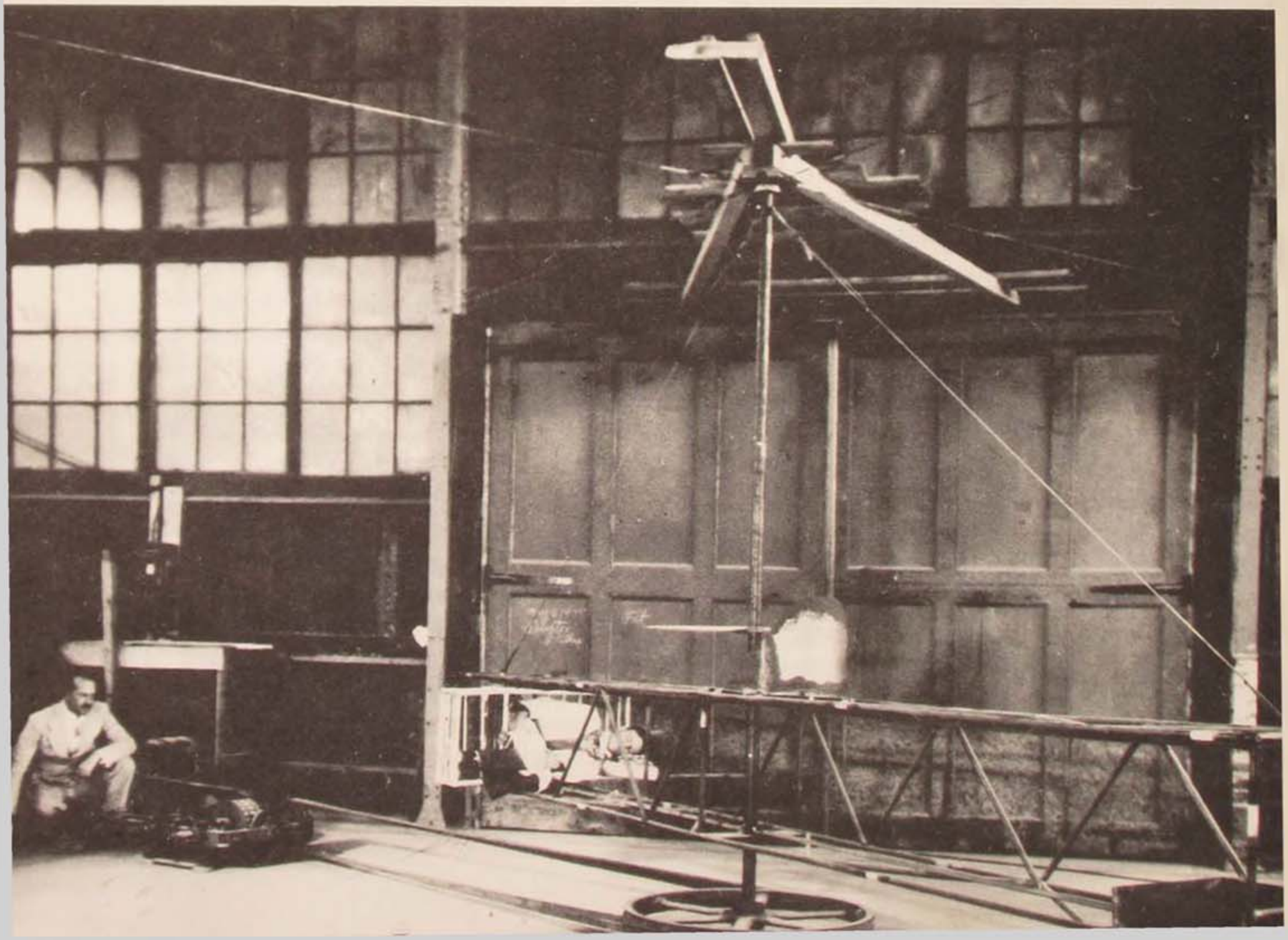
Often research performed in one area will reveal potential uses that, with additional research and development efforts, may result in the utilization of a new-found capability. One such instance is work being done by the Human Engineering Division of the Aerospace Medical Research Laboratory at Wright-Patterson. These are the people who conceived the idea of firing laterally out of an aircraft and developed a gunsight that would permit it. It was their work that culminated in the gunship that was so successful in Southeast Asia. Some of the things they discovered during this work appear to have application in improving the precision of weapons delivery. They include the use of flares, target image enhancement, and visually coupled systems. The latter show great promise for delivering a weapon onto any target that can be seen. They also show possibilities for application to a variety of other tasks for both military and civilian use. This work is the subject of another article in this issue, entitled "Visually Coupled Systems," coauthored by Lieutenant Colonel Joseph A. Birt, Chief, Human Performance Division, Aerospace Medical Division, and Thomas A. Furness III, a supervisory research engineer of the Aerospace Medical Research Laboratory.

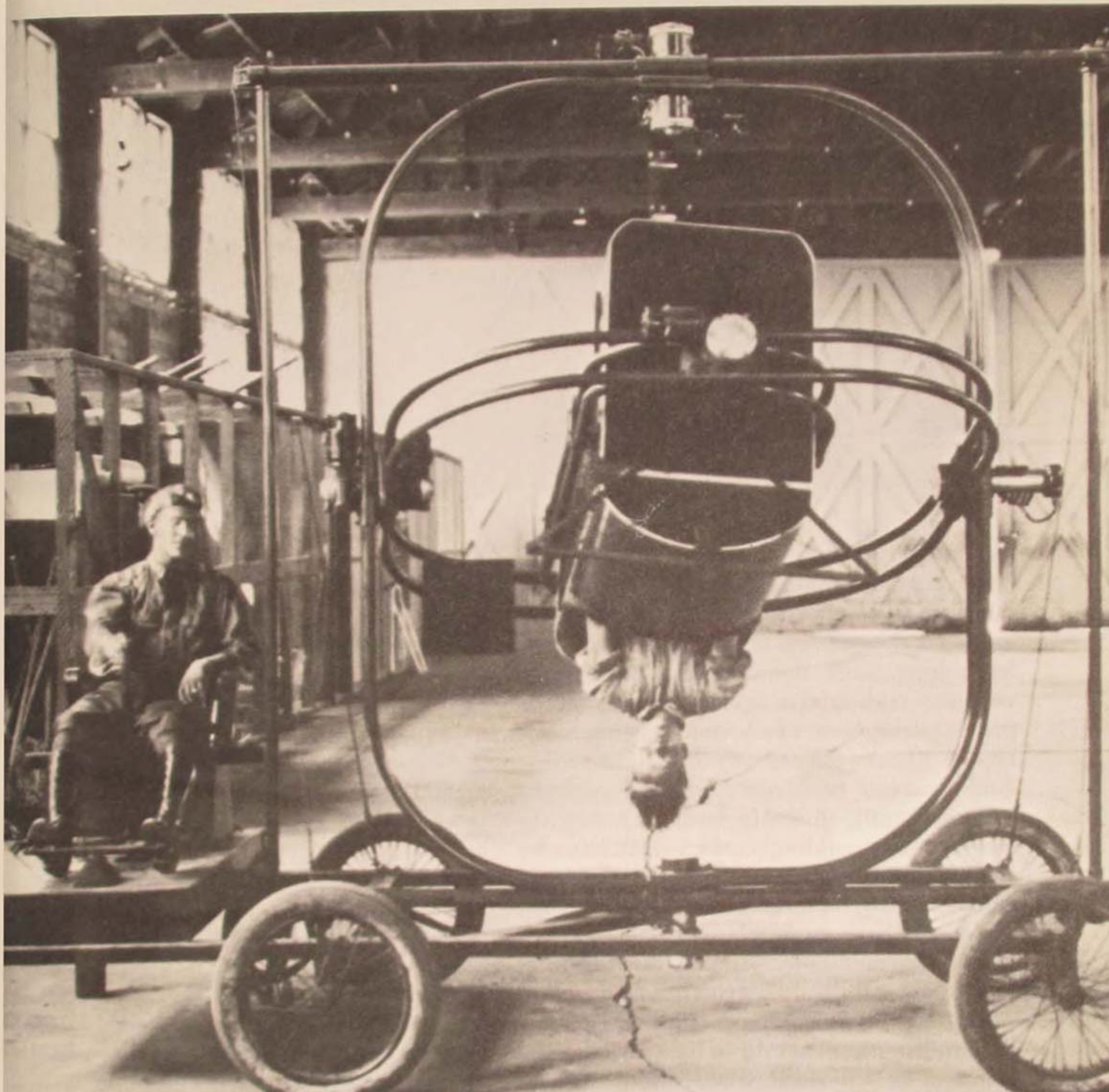
Because of the vast collection of data and its expertise in a variety of areas, AMD is constantly involved in "fire fighting." Never a week passes that some problem doesn't surface and AMD is asked to assist in finding a solution. Over the years, these problems

Continued on page 8

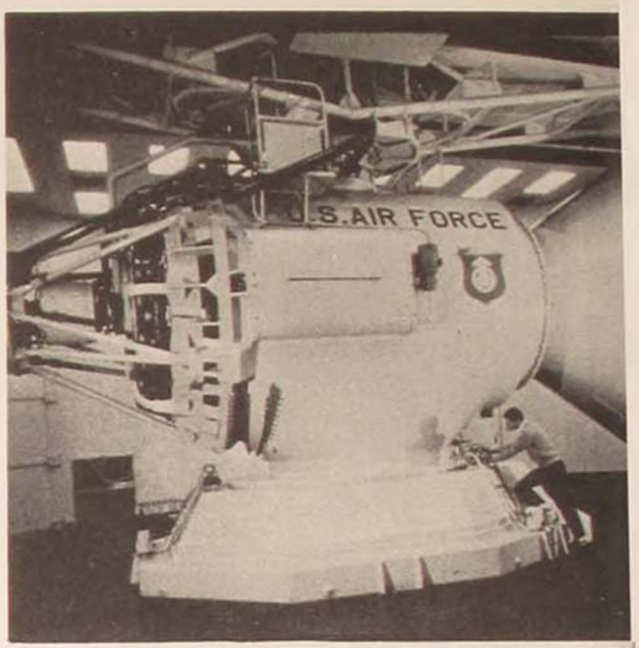
Early Aeromedical Research

In the clapboard frame structure housing the Medical Research Laboratory at Mineola, Long Island, New York, as seen in 1918, studies began that helped flyers adapt to the new medium of air. . . . During the thirties, Captain Harry Armstrong (bottom), in charge of aviation medicine at Wright-Patterson AFB, Ohio, built the first human centrifuge to test the effects of gravity on flyers. . . . At Brooks Field, Texas, the "Ruggles Orientator" acquainted students with the sensation of flying.





A volunteer for a centrifuge experiment gets fitted with sensors to provide telemetric monitoring of vital signs. . . . The Dynamic Environmental Simulator of the 6570th Aerospace Research Laboratory at Wright-Patterson recreates combinations of acceleration, vibration, temperature, barometric pressure, and acoustic environmental stresses as they occur in today's aircraft. High G centrifuge tests have improved the pilot's ability to withstand 9G for 45 seconds without blacking out.



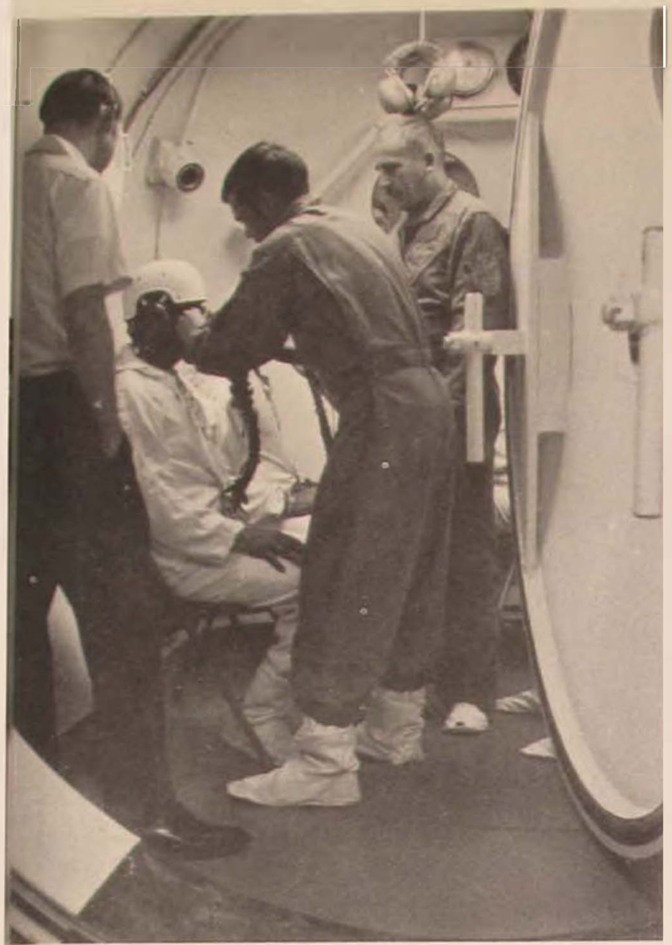
have ranged from back injuries sustained during pilot ejection to problems with escape oxygen systems used in underground silos; from long-range development of aircraft cockpits and safety devices to retrofit of present equipment to alleviate existing problems.

Many such problems come to us from sources outside the Air Force. During its short history, AMD has been involved in some way with almost every federal agency as well as with commercial corporations and Allied air forces on problems associated with aerospace medicine. Among its teaching programs, AMD, through the USAF School of Aerospace Medicine, provides the Residency Program in Aerospace Medicine. Through its Wilford Hall USAF Medical Center, it provides residencies and fellowships in 21 other medical specialties. In fact, the Aerospace Medical Division trains approximately 65 percent of the residents trained by the Air Force in USAF medical facilities.

Because of the equipment and expertise that we have, we are called upon to lend support to the civilian community in certain areas. One such area is in the field of hyperbaric medicine.

Although our hyperbaric chambers exist primarily as research and teaching facilities, we also treat aircrew members who happen to have an air embolism or an occasional case of the bends. We also treat cases of the bends and air embolism in skin divers referred to us from the surrounding area.

The use of a hyperbaric chamber in medicine is not new. The first recorded attempt was made in England in 1662 by a gentleman named Henshaw. There have been numerous attempts to use hyperbaric chambers to treat many types of diseases and with a variety of claims of success, some of which were exaggerated. As was pointed out



A skindiver is among the many cases of decompression sickness treated in the hyper/hypobaric chamber at USAF School of Aerospace Medicine.

by Dr. Julius H. Jacobson II, at the 1st International Congress on Hyperbaric Oxygenation in Amsterdam in 1963, "If this form of therapy is to achieve a worthwhile and lasting place in the medical world, it can only do so on a firm basis of accurate physiological data on the effects of both pressure and oxygen obtained in experiments as well as controlled clinical medicine will permit." In recent years it has been discovered that oxygen therapy can be used in the treatment of gas gangrene, which is a general term applied to various conditions of acute infection with gas-forming organisms growing only without oxygen.

Prior to the use of hyperbaric oxygenation in the early sixties, gangrene was treated with massive doses of antibiotics and surgical debridement and/or amputation. Even with these drastic measures, the fatality rate was over 50 percent. Hyperbaric oxygenation inhibits the production of alpha toxin, and the circulating toxin may be neutralized. Prompt application of hyperbaric therapy saves tissue by making it easier for the surgeon to determine the tissue that must be removed when amputation is required. It is generally lower on the limb, making the fitting and functioning of a prosthesis easier.

Normal treatment requires between three and six dives to 66 feet below sea level for 90 minutes with 100 percent oxygen. During the past 8 years, 60 cases of gas gangrene have been treated by compression therapy teams at the USAF School of Aerospace Medicine. Those cases that received early diagnosis were treated successfully.

It is difficult to say what biotechnology research will be performed in the future, but as we make technological advances in weapon systems, man, the key to such systems, will no doubt find his environment changing and perhaps exposing him to new stresses.

It is difficult to predict the specific future of biotechnology research or treatments in aerospace medicine, but judging from the past and from today's problems engendered by technological advances, biotechnology research will play an important role in fitting man into weapon systems and military operations.

Each breakthrough in technological advancement brings with it associated problems. We can never attain full benefit of our technological advancements until we can make them compatible for man. To achieve that benefit is the aim of the Aerospace Medical Division.

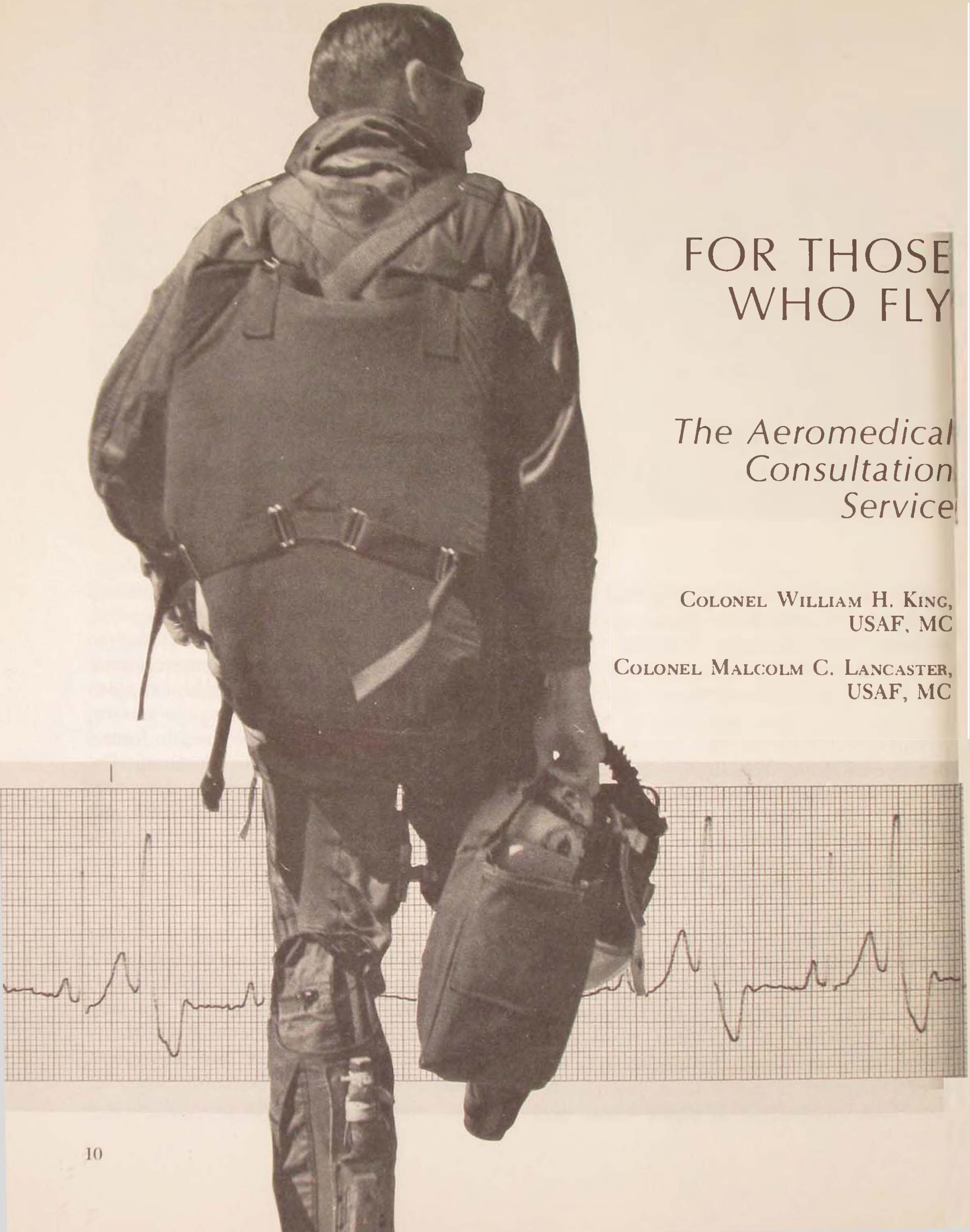
Hq Aerospace Medical Division, AFSC

FOR THOSE WHO FLY

The Aeromedical Consultation Service

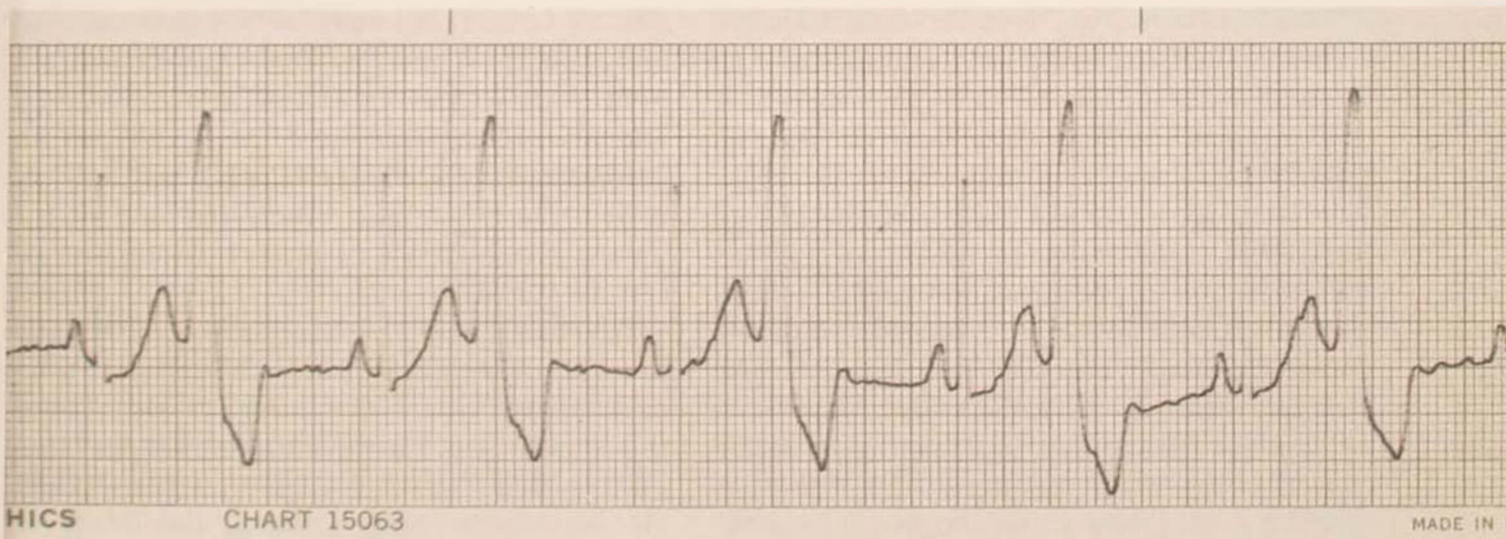
Colonel William H. King, USAF, MC

Colonel Malcolm C. Lancaster, USAF, MC



ONE of the unique functions of the USAF School of Aerospace Medicine (SAM) at Brooks AFB, Texas, is that of conducting a medical evaluation service reserved exclusively for flying personnel. While staff members of SAM's Clinical Sciences Division participate in the school's educational programs and conduct a varied program of aeromedical research, their primary job is patient care. They feel that the world's finest patients are those who report to Building 100 on the SAM campus each morning to begin their evaluations. From the airman at the reception desk to the highly trained medical specialists who participate in the examination, the prevailing philosophy is to regard each patient as singularly important and each case as challenging.

Most patients are active-duty pilots and navigators who have TDY orders to this small base on the outskirts of San Antonio, Texas, because of a specific medical problem. It may have been detected during an annual physical examination by a base flight surgeon or become manifest in some illness, symptom, or dramatic event. Occasionally, small groups of aircrew members are evaluated not because of any health problem but because of their selection for a special flying or aerospace program that requires the highest possible level of physical and mental reliability. The NASA astronauts were examined here. So, for many years, were the candidates for the Air Force's Aerospace Research Pilots School and SAC's U-2 and SR-71 operations. Several times each year a few youthful cadets from the Air Force



Academy may report for evaluation. The patient roster occasionally includes airmen from the U.S. Army or Navy or flying personnel from the armed forces of Allied countries.

Over 11,000 evaluations have been performed at USAFSAM since the service was established in 1955. It has been termed the Aeromedical Consultation Service, the Aerospace Medical Consultant Service, and (by one patient) the "Aircrew IRAN Center." The mission has not varied. It is to evaluate difficult, borderline, or obscure medical problems, to evaluate the flyer assigned to special operations, and to provide assistance to unit flight surgeons, command surgeons, the Surgeon General, and the chief medical officers of the Air Force Reserve and Air National Guard, in maintaining a high degree of medical fitness among flying personnel. This assistance is provided by daily telephone conversations and correspondence with these offices. There are also frequent responses to inquiries from other federal agencies (NASA and FAA) and the aeromedical communities of many foreign countries.

Primarily, however, the service provides a backup capability to flight surgeons' offices throughout the Air Force that offer direct medical support to flying personnel. Where a problem is identified that requires a SAM evaluation, either by regulation or in the judgment of the base flight surgeon, a request is submitted for review to the surgeon of the respective major air command. When this is approved, USAFSAM sets an appointment date and returns a letter of instruction and reporting information to the referral base. The flight surgeon collects the individual's medical records, X rays, and any other medical data that may be of interest for forwarding to USAFSAM. A letter of evaluation is also requested from the individual's flying supervisor regarding his experience, aptitude, and motivation as an aircrew member.

The patient finds that his preparations for evaluation precede his arrival at Brooks by three days. During this time he is asked to follow a special high-carbohydrate diet and keep a careful record of his food intake, for correlation with laboratory tests to be conducted at SAM. He arranges his schedule to arrive at Brooks the evening prior to his appointment, where he finds a comfortable room reserved at the base BOQ. The evaluation is not conducted in a hospital setting, and, except for unusual procedures requiring overnight observation, the patient is free during nonduty hours to visit historic San Antonio. The use of alcohol or any drug, except as prescribed by his flight surgeon, is forbidden throughout the course of examination. On the evening prior to the first day of evaluation the patient begins a 12-hour fast, which is essential to standardization of the laboratory data to be collected the next morning.

Thus prepared, the patient begins the first day of his evaluation at 0730 hours, at which time he checks in to the scheduling center and receives an itemized list of procedures or examinations that have been arranged for him. A staff flight surgeon has previously reviewed the patient's medical records and added any special procedure that may have relevance to his case, in addition to the studies considered routine at USAFSAM. The "routine" goes quite beyond what the patient may have experienced during annual physical examinations at base level. Regardless of the primary cause for referral, each patient follows a checklist that effectively screens for unsuspected disease in each major organ system of the body.

The first couple of hours are required for preliminary studies in the laboratory and X-ray department. Blood samples are drawn to provide a basis for evaluating proper function or disorder of several systems. Specimens are processed, utilizing the latest in automated equipment, under the supervision of a physician specialized in laboratory medicine. Some of the better-known determinations involve measurements of the fractions of lipids or fats carried in the serum portion of the blood. When elevated, these substances are considered to be significant risk factors in the development of heart disease. Each patient undergoes a two-hour screening test for diabetes. Liver and kidney function and the status of the patient's blood cells are indicated by other tests. The results are transmitted to the flight surgeon on the same day, and further evaluation is undertaken if necessary.

The problem of diet and weight control receives specific attention of the consultation service. Each patient has a body composition study, which quantifies the degree of obesity, if any, and sets a realistic target or "ideal body weight" that the patient is encouraged to achieve. Dietary counseling by a qualified flight nurse is provided to patients who are overweight or who have other medical problems requiring dietary adjustment.

X-ray views are obtained of the chest, abdomen, and paranasal sinuses. Kidney stones are occasionally discovered, and inflammation of the sinuses (of which the patient is often unaware) is found in a surprisingly large number of patients.

At mid-morning the patient is seen by the flight surgeon assigned to his case. His medical history is reviewed in detail, and a complete physical examination is performed. The flight surgeon also reviews the purpose of the visit to the Consultation Service and gives the patient an in-briefing concerning the remainder of the evaluation. This consists of visits to various specialists, who examine the eyes, ears, nose, and throat and specialized procedures, such as those pertaining to the heart, lungs (cardiopulmonary system), and brain (central nervous system).

All patients undergo a thorough evaluation of their cardiac status, usually on the second morning of the examination. A resting electrocardiogram (ECG) is performed on all candidates and compared with those on file in the USAF Central ECG Library. This ECG provides a record of the electrical activity of the heart with measurements in millivolts and milliseconds. Records are obtained from 12 standard leads, or pairs of electrodes, attached to the patient's chest, arms, and legs. A special three-dimensional vectorcardiogram is then obtained, which adds pertinent information to the standard ECG tracing. The vectorcardiogram portrays the net electrical activity of the heart at any instant in time on an oscilloscopic screen, with one complete cardiac cycle being captured in a photograph taken by the attending technician. This photographic reconnaissance is performed from three different viewpoints, with enlargements to permit study of certain aspects of the activity in more detail.

After these studies are reviewed by a physician specialized in cardiology, the patient is given clearance to perform further tests, during which ECG data are recorded during and after strenuous exercise. The first of these procedures is called the Master's test, named after the physician who standardized the procedure, in which the patient climbs up and down a short flight of stairs a certain number of times prescribed for his age. As aircrew members usually are in average or above-average physical condition, the "double" Master's formula (utilizing the maximum number of steps) is usually employed. Afterwards, electrocardiograms are recorded during eight minutes of the recovery period, while the patient rests on an examining table. This tracing is also reviewed by a physician, and the patient is given a "go" or "no go" for a maximal exercise test on the SAM treadmill. The treadmill requires that the patient engage in a brisk walk on a moving belt traveling at a standard speed of 3.3 miles per hour. Also, as he walks, the treadmill becomes an increasingly difficult uphill climb, as the angle of incline is raised one percent each minute up to a maximum of 24 degrees. During this time the patient is completely instrumented for the simultaneous recording of three electrocardiographic leads. An attending technician carefully monitors his pulse and blood pressure. The cardiologist is always in attendance and directly observes the patient's ECG record on an oscilloscope; the ECG data are simultaneously fed onto a computer tape for later analysis, and a paper print-out of the tracing is obtained.

When the patient indicates that he has reached a maximum level of exertion, a sample of expired air is collected in a plastic bag; this is used to calculate an efficiency report on the utilization of oxygen by his heart and lungs. The range of performance on the treadmill varies widely, of course, with most aircrew members in the 12- to 15-minute range and those in exceptionally good physical condition performing for longer periods of time. USAFSAM has accumulated wide experience with exercise electrocardiography over the years. This procedure has proved to be the most reliable and sensitive ECG method for the early detection of heart disease in the flying population.

A final bit of ECG recording is conducted over a period of several hours while the patient goes about other activities or portions of the examination. One pair of electrodes is attached to his chest, and the recorder is carried in a little black box on a shoulder strap. He maintains a log of his activities during this time and is supposed to make note of any event that might affect his heart rate.

The electroencephalogram (EEG) or brain wave is a new experience for most SAM patients. A number of small plastic electrodes are glued to the scalp in precisely determined locations. The patient then reclines in an oversized chair and relaxes while a technician pores over a complex console of controls that govern the recording of electrical activity from the brain according to established procedures. Differences in electrical activity are recorded between two points in successive pairs, comparing right to left, front to back, etc. The magnitude of the electrical activity varies markedly from that recorded on the electrocardiogram, as EEG signals are in the microvolt range. The EEG is a valuable tool in evaluating cases of head injury, for example; the majority of cases seen for this purpose at SAM are the result of automobile rather than aircraft accidents, incidentally. For all aircrew members, however, the study is considered a valuable piece of base-line information in the event that a patient should, in his future life, develop some central nervous system problem through disease or injury. All EEG's are retained on file at USAFSAM for possible future reference. The EEG also records sections during which pertinent types of stresses are applied, not exercise in this case but brightly flashing lights that pulse the brain-wave system or a few minutes' exposure to mild hypoxia, as might be encountered in the flying environment.

If these studies do not provide all of the information required, the patient may find himself being tested in more exotic surroundings, such as simulated flight in an altitude chamber or during exposure to $+G_z$ forces on the SAM human centrifuge. Either is readily available at SAM and is equipped for biomedical monitoring, e.g., recording of pulse rate, blood pressure, and electrocardiogram. These procedures may seek to duplicate any in-flight circumstance that might have a bearing on the individual case.

But most frequently the cause of a patient's referral to USAFSAM is not related to a dramatic in-flight illness. The evaluation, however, may seek to prevent the occurrence of such an event. The most common cause of death and disability in the American adult male population is heart disease or, more specifically, coronary artery disease resulting in an acute myocardial infarction or heart attack. Aircrew members are not immune to the hazards of this disease and share most of the risk factors found in the civilian population. Unfortunately, there have been several cases in which flying careers have been prematurely curtailed by heart disease. The Air Force effort in the early detection of coronary artery disease has obvious implications with regard to the safety of flight operations as well as to the health of the individual. Thus, cardiac problems are the leading cause of referral of patients to USAFSAM.

The key to the early detection program is the electrocardiogram recorded on each aircrew member upon entry into flying training and then annually at age 35 and thereafter. Copies of each electrocardiogram are forwarded to the USAF Central ECG Library, located at USAFSAM, for careful review. If any evidence of change from one year to the next is noted by the reviewing cardiologist, further evaluation may be suggested at the patient's home base, or referral to SAM may be recommended.

Other conditions are also referred to SAM in accordance with Hq USAF policy set forth in a manual of physical standards. For example, any aircrew member who experi-

During recording of a vectorcardiogram, with the patient enclosed in an electrostatic "cage," the attending technician obtains photographic images of the heart's electrical activity from three different views. . . . A veteran B-52 pilot gets his heart rate, blood pressure, and electrocardiogram monitored while exercising on the treadmill.

ences an unexplained loss of consciousness or significant head injury requires evaluation at the Aeromedical Consultation Service prior to consideration of return to flying status. To take advantage of the expertise centralized at USAFSAM, certain organic conditions of the eye, such as glaucoma (an increase in the intraocular pressure), or of the vestibular apparatus (the body's gyros) are referred to the school. Consultation is also available for an aircrew member experiencing any significant emotional problem. In all these areas his case will be examined by specialists who are also well versed in the Air Force mission and the relevance of his condition to it.

At the conclusion of the evaluation, the patient is given a complete debriefing by the flight surgeon, who has gathered together the results of all procedures and consultations. A detailed report is completed promptly and forwarded to the Surgeon General or other designated reviewing authority, in the event that any administrative action is required. Recommendations for medical treatment, follow-up, or correction of defects are spelled out for the patient and reviewed with his base flight surgeon, by phone, on the day the patient leaves Brooks. The early diagnosis of disease and the prevention of any serious consequences are the goals in each case.

Conduct of the Consultation Service also interrelates with USAFSAM aeromedical research programs and results in a number of by-products of value to the Air Force and to medicine in general. The electrocardiographic library is thought to be the largest in the world, with over 700,000 tracings currently on file. It has added new pages to medical knowledge in the increased appreciation of certain findings in the normal population and the significance of findings developed on serial recordings. There is continual feedback and interchange of ideas with the Aircrew Standards Division of the Surgeon General's Office in an effort to refine the physical standards for flying duty in order to permit the greatest utilization of trained manpower consistent with flying safety.

Improved knowledge has resulted in significant increases in the number of flying personnel returned to flying duty since the establishment of the Consultation Service. For example, certain conduction defects in the heart's electrical circuitry were once thought to be indicative of coronary artery disease. Over 100 patients studied at USAFSAM during the past five years have disproved this hypothesis, and the majority of these individuals have been returned to active flying duty.

These and other medical conditions of distinct interest to the Air Force form the basis for a small number of clinical study groups in which patients are followed over a period of several years, with annual evaluations by the Consultation Service, in order to maintain the individual on flying status and learn more about the significance of the condition. In addition to the conduction defects, patients with heart murmurs indicative of mild aortic valvular disease, those with a history of certain irregularities of the heart beat, and patients with history of vertigo and blood loss from the upper gastrointestinal tract are among those currently being followed.

The Consultation Service provides a setting for utilization of the latest medical techniques in seeking the early diagnosis of disease. The SAM clinical laboratory actively engages in research concerning the significance of biochemical findings in their relationships to disease. For example, the widely used glucose tolerance test for the detection of diabetes is under study. The significance of minute amounts of certain metals such as copper, zinc, chromium, and magnesium, which are found in the blood, is being evaluated. The technical problems of accurate determinations are being overcome, and the possible relationship to diseases of the cardiovascular system is currently under study. In addition to the ECG Library and the EEG files, USAFSAM maintains repositories of information on the Air Force's hearing conservation program and a repository of data on individuals who require medical waiver for continuation of flying duties. Over 6500 aircrew members are currently listed in the waiver file. A complete print-out of these data is distributed quarterly to the Surgeon General's Office and to the surgeon's office of each major air com-

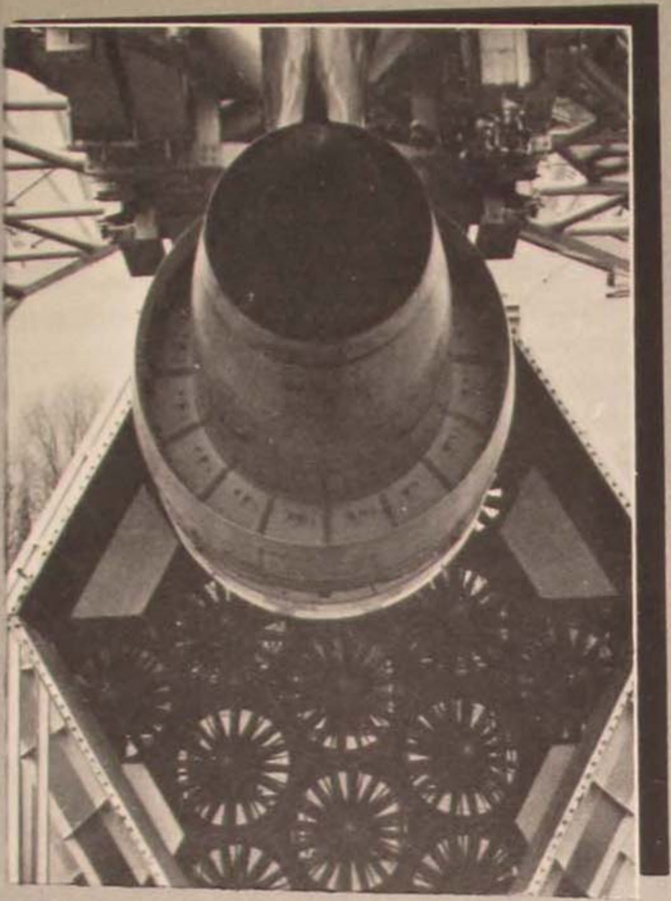
A patient is checked out on operation of the portable ECG monitor he will wear for as long as eight hours during normal activities. . . . An electroencephalogram records variations in the brain wave while the patient experiences mild hypoxia.

mand. SAM has also been designated as the Air Force center for the storage and analysis of medical data pertaining to repatriated prisoners of war from Vietnam.

Utilizing the staff and facilities of the Clinical Sciences Division, the Air Force has conducted specific research projects in support of Air Force mission requirements. For example, the safety of antimalarial drugs was verified in a clinical study at USAFSAM prior to their use in Southeast Asia. Certain types of drugs used in the treatment of high blood pressure were studied at the school and are now being utilized by over 300 individuals, who are able to continue on flying status whereas they might otherwise have been grounded. The SAM experience in telemetry of biological data was directly applied in NASA missions. The knowledge and experience on the staff have contributed to the design of new protective equipment for flying personnel. Current studies seek to evaluate impact resistance of various types of spectacle lenses and to eliminate distortion from windscreens proposed for advanced aircraft, and even to build better dental appliances for flying personnel.

The efforts of the Consultation Service result in considerable savings to the taxpayers when a medical problem in an aircrew member may be satisfactorily resolved. The staff recognizes that its patient population represents enormous investments in training costs and valuable experience. Their greatest satisfaction is in helping another patient return to years of continued aircrew duty.

Clinical Sciences Division, USAFSAM



THE MAN-MACHINE INTERFACE

COLONEL NEVILLE P. CLARKE, USAF, VC

THE PLACE at which man and a weapon system interact, the man/machine interface, is influenced by four principal variables: the mission to be accomplished; the operating environment, both natural and systems-produced; the characteristics of the machine; and the performance of the human operator in the operational situation. This circle of variables comprises a complex relationship involving plans, environmental quality, hardware technology, and human tolerance. Hardware technology is usually defined at the mission/machine interface; however, consideration must also be given to man's capability and how he will be required to perform within the proposed mission envelope.

The severity of the natural or induced environment within the system limits man's ability to perform and creates problems with regard to safe exposure limits for aircrewmen. In addition, the effect of systems operation on the environment is of increasing concern with regard to environmental quality. All these variables meet and interact inextricably at the man/machine interface. Performance of the man/machine complex governs the overall performance of the system and the ability to accomplish the mission for which the system was designed.

Within Air Force Systems Command are two organizations principally responsible for research and development associated with performance at the man/machine interface: Air Force Human Resources Laboratory (AFHRL) and Aerospace Medical Division (AMD). The missions of both organizations are broader than support for system development per se. From different aspects, both organizations consider human problems along a continuum that bears on the performance area at the man/machine interface. It is at this performance interface that the mission areas of the AFHRL and AMD come into juxtaposition and form a mutually supportive and complementary relationship with regard to system development problems. AFHRL's mission includes developing criteria for selection of the entire Air Force population, not just those individuals concerned with operating systems. The criteria are concerned with developing methodologies, procedures, and hardware for enhancing the training of Air Force personnel in all areas of specialization. They are also concerned with system manpower problems and are ultimately involved in the definition of the overall force structure of the Air Force.

The Aerospace Medical Division mission area is also quite broad. It entails medical selection and care of specialized flying personnel. It deals with human engineering, which includes the development of methods for optimizing man's performance at the man/machine interface by providing engineering design criteria, man/machine geometry considerations, and methods that make optimum use of man's native performance capabilities.

We are also concerned with providing safety criteria for Air Force personnel operating in hazardous environments, such as high-altitude flight, crash landing or escape, and exposure to lasers. AMD is also concerned with developing criteria for preserving the quality of the environment in the areas of radiation, chemical hazards, and noise. Early development of appropriate criteria for these environments not only assures the safety of our operational personnel and preservation of the surrounding environment, but it also precludes the imposition of arbitrarily conservative standards on our present operations and on future systems development. This, in turn, reduces the cost of development and operation of current and new systems.

The AMD and AFHRL missions come together in the area of providing criteria for enhancing man's ability to perform at the man/machine interface. The AMD effort emphasizes applying human engineering and performance design criteria at this interface while AFHRL is involved with assuring that the personnel with appropriate skill levels are available and can be effectively utilized at the man/machine interface. AMD is involved, for example, with target location, weapon aiming, multicrew systems, operation of man as an effective part of high-acceleration weapon systems, and with defining the relationship between man and the machine in the employment of remotely piloted vehicles. AFHRL is concerned, for example, with providing proper skill levels, cost-effective training simulators, and mechanisms for assuring job satisfaction in the operation of complex airborne and land-based Air Force systems.

AMD's mission in biotechnology, while often directed at specific systems development questions, frequently provides new information and capability that can be generalized to applications supporting entire classes of systems.

Our R&D efforts cover the spectrum from basic research through test and development. I shall describe the kinds of work done in biotechnology to support the development and operation of each of the system classes. The biotechnology effort is divided into five major technical segments, four of which support development and operation of these classes of systems. The fifth, dealing with specialized medical problems of the flyer, is less directly related to the man/machine development issues and is thus presented in more detail elsewhere in this issue.

The four major technical areas of the biotechnology program are operational atmospheres, radiation, mechanical force, and human performance. They are closely related to systems operation and development, since they are involved with such things as altitude and temperature, acceleration and vibration, nuclear and laser radiation, control displays, dynamic geometry, etc. All these areas of concern could be of importance for such aerospace systems as fighters, bombers, missiles, airlift, reconnaissance/surveillance, command control and communications. However, individual classes of systems require biotechnology emphasis on selected areas. Let's take a look, then, at a few specific examples for each class of system and consider some of our work in support of each.

fighters

High-altitude effects continue to be of concern with regard to the Aerospace Defense Command mission and in some air-superiority missions. In the acceleration area, new materials and power plant technology provide an opportunity for operations at sustained high-level acceleration. Providing commensurate capability to utilize the aircrewmen in these environments is a significant effort in the Aerospace Medical Division.

New evaluations of the physiological effects of acceleration have led to a three-pronged attack on the problem by AMD. First, we take a close look at man's ability to withstand high-acceleration forces, using all available equipment and procedures. Second, this information is passed on to tactical fighter pilots from the Fighter Weapons School through rides in the human centrifuge at the USAF School of Aerospace Medicine. The third prong of the attack is aimed at further increasing man's ability to withstand acceleration by repositioning him during increased acceleration to change the G-force vector. In this area, we are actively engaged with the Flight Dynamics Laboratory in exploring the utility of a tilt-back seat for future fighter aircraft designs.

As the performance capability of fighter aircraft continues to improve, there remains a concern for providing adequate escape capability over the entire flight envelope. Joint efforts with the Flight Dynamics Laboratory are continuing in the controls and displays area to improve man's performance. It has recently become more important to achieve better cockpit layout which takes into consideration the capability and limitations of man to perform dynamically during various stressful conditions such as acceleration. This has introduced the idea of developing a dynamic geometry for the fighter crew station.

bombers

In the radiation area, the biotechnology program is defining, on a quantitative level, the ability of aircrews to continue to perform their assigned function following exposure to nuclear radiation. New modeling concepts are being employed so that man and his performance limitations following radiation may be treated as one of the several subsystems in determining overall systems vulnerability to various nuclear threats. In addition to ionizing radiation effects, we are concerned with the problem of flash blindness during night missions.

As a part of the overall effort in developing an improved windscreen segment for the B-1 aircraft, the Aerospace Medical Division is supporting the Materials Laboratory in evaluating a new ferroelectric ceramic material that can become opaque at the onset of a nuclear flash and thereby provide protection to the cockpit.

Turbulence-induced vibration remains another area of concern and is of increasing importance with longer flight time and higher speed during low-level flight. Noise problems are also of concern with new as well as existing bomber systems, particularly as regards increasing emphasis on environmental quality.

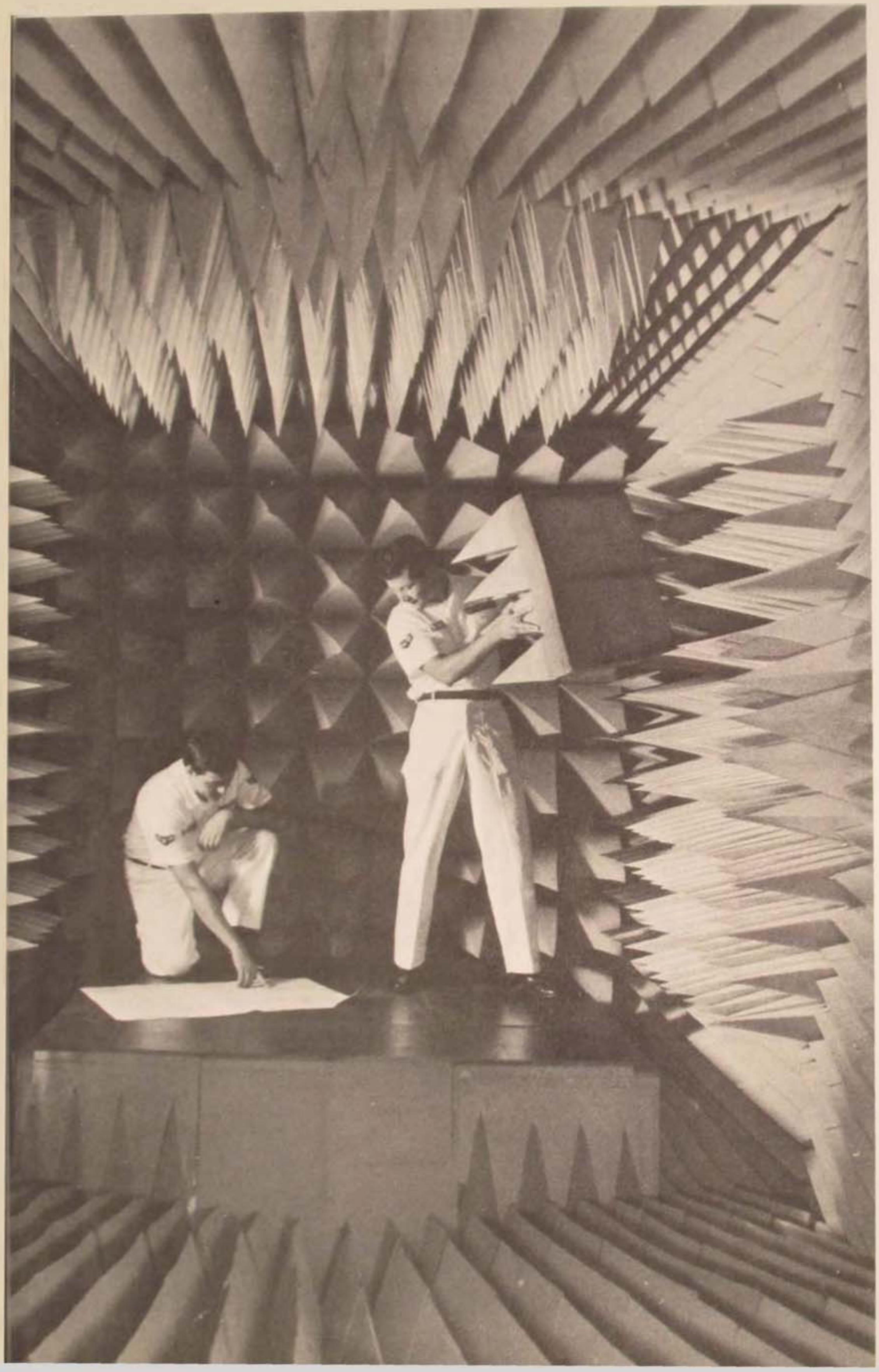
The Aerospace Medical Division has been working for some time in programs jointly sponsored by the other services and the Federal Aviation Administration to develop improved methods for assessing the environmental impact of noise produced by aeronautical systems during all phases of their operation. New computerized techniques have been developed to predict the effect of aeronautical operations on surrounding communities as a function of both the physical characteristics of the noise environment and the projected psychological impact. The noise exposure forecast produced by this analysis can be plotted, the contours representing various levels for acceptable industrial, residential, and community activities. (See map on page 24.)

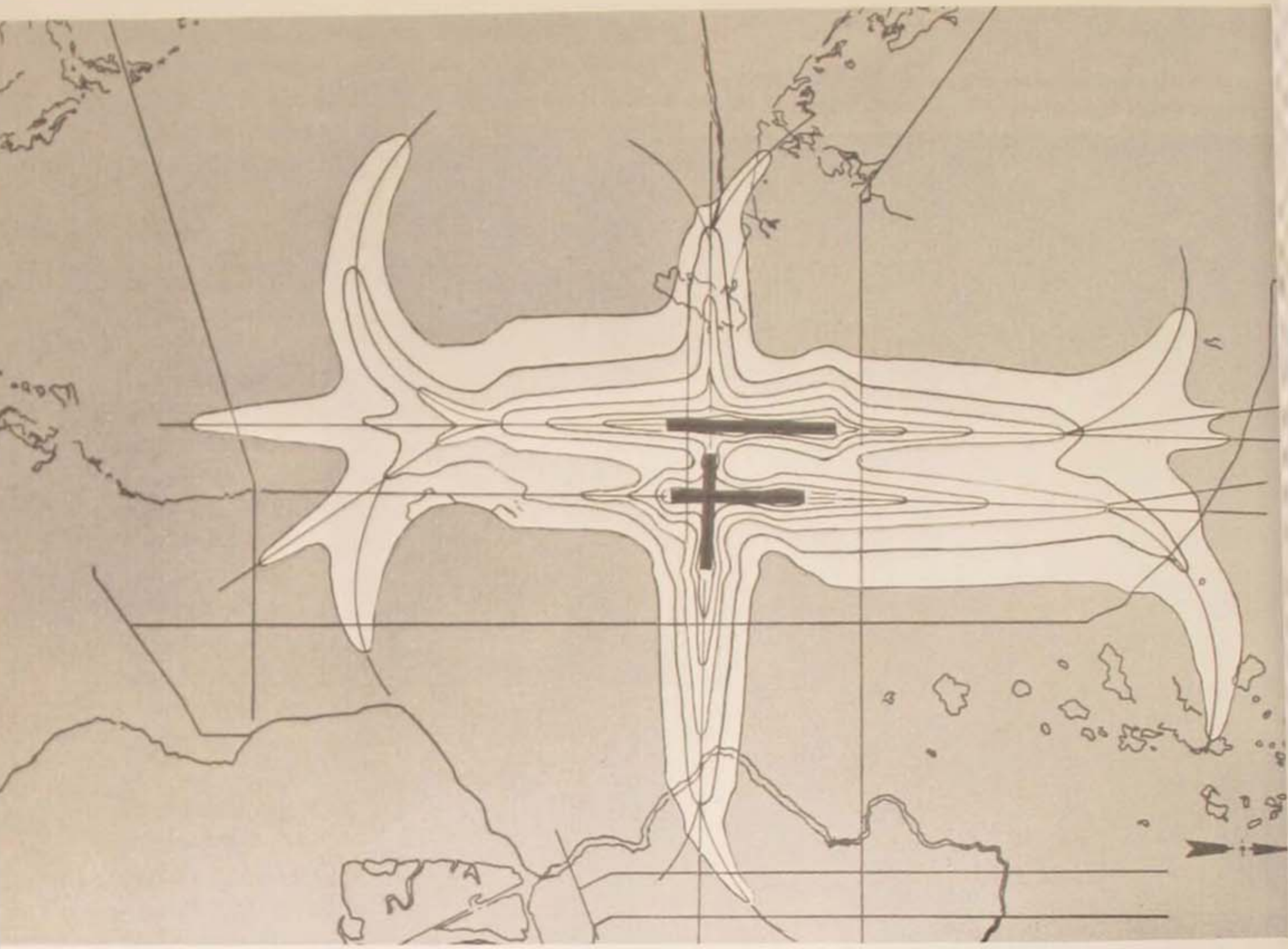
Remotely piloted vehicle operators are trained to fly simulated missions with computer-generated images.

missiles

There are two general classes of biotechnology problems associated with missiles. First, with regard to the large intercontinental ballistic missiles, the biotechnology effort is directed toward assuring that the potential problems produced by the noise and by-products of rocket fuels do not produce hazards either for Air Force operational crews or for the surrounding environment. By realistic assessment of the potential hazards associated with these operations, we are able to provide the Air Force with realistic —as opposed to potentially overly conservative—launch constraints. This maximizes the flexibility in accomplishing the Air Force mission while at the same time assuring that

In the echolessness of the anechoic chamber, high-frequency radiation fields are created, to study their effects on crew members.





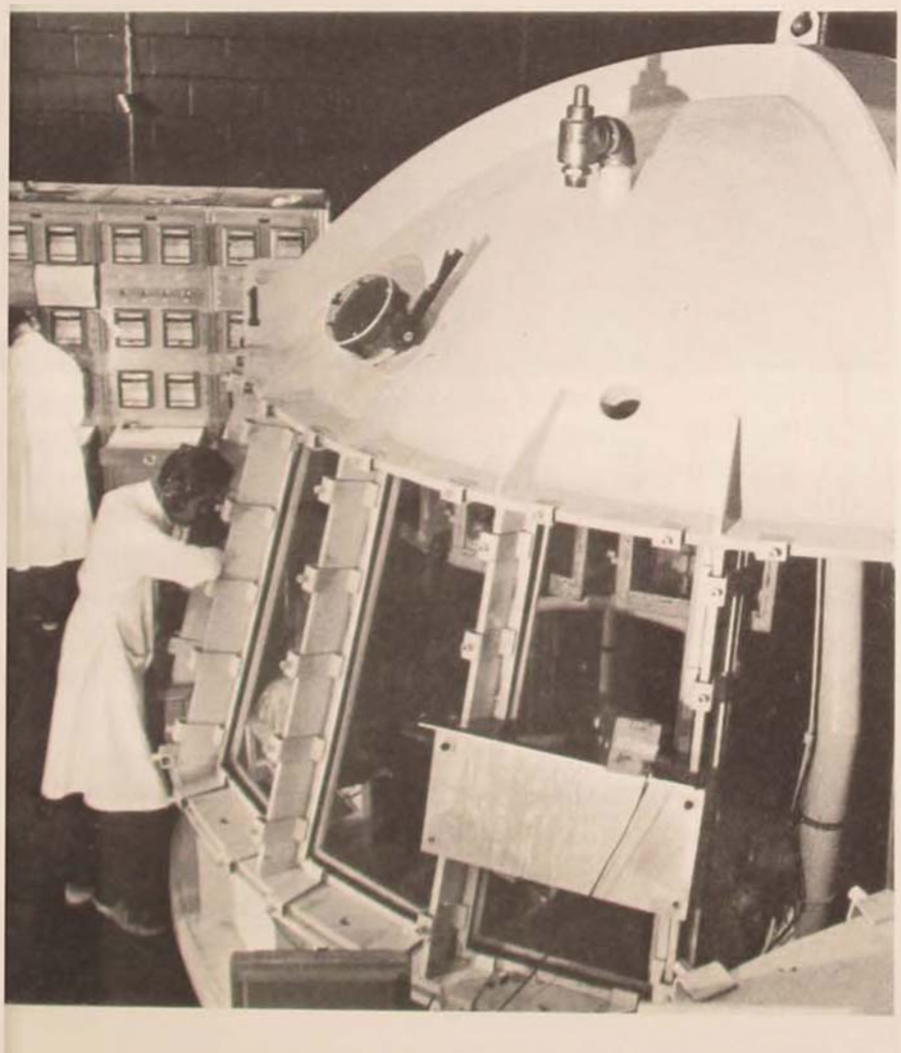
Predicted acceptable noise levels for industrial, residential, and community activities near an airport are plotted. . . . Air Force personnel measure the noise level to provide basic data for the computerized forecast.

no adverse effects will be produced. The Aerospace Medical Division has a major laboratory facility for the study of environmental quality effects. These are the Thomas Domes, which have the capability for producing controlled concentrations of various chemical substances of potential concern from the standpoint of environmental quality. These facilities are used to produce controlled exposures to chemicals of concern to the Air Force, to determine minimum thresholds beyond which operational exposures should not occur.

The other area of interest for missile development is where the biotechnology program is providing new capability for taking maximum advantage of the pilot's inherent visual capability for the aiming and guiding of air-to-air and air-to-ground missiles. The visually coupled system being developed for this purpose has the capability to aim automatically either a weapon or a sensor in the direction in which the pilot is looking and to provide him preprocessed sensory imagery that better portrays the target at which he is looking. This latter capability can, for instance, provide low-level-light TV images for targets during nighttime operations.

airlift

Many of the areas of concern that have been related to other aeronautical systems obviously also apply to a development and utilization of aeronautical systems for airlift operations. One of the more important biotechnology efforts supporting such operations is that directed toward determining



Eight Thomas Domes or toxic hazards altitude exposure chambers simulate the exotic atmospheric conditions encountered by advanced aircraft, missile, and space systems and enable continuous exposure studies lasting more than a year.

optimized work/rest cycles for aircrews. Crew utilization ratios in problems related to operational deployment of aircrews in the Military Airlift Command, as well as in the Tactical Air Command and in Pacific Air Forces, are of considerable concern to the operational commands. AMD has recently been involved in studies that led to the development of new computerized rules that can be used for computing crew utilization ratios in the C-5 aircraft as well as other operational systems. These new rules consider a wide diversity of factors that contribute to crew performance, ranging from organization and performance of preflight duties to consideration of the effects of a shift in time zones on crew fatigue and the like.

reconnaissance/surveillance

In manned systems that support this mission area, there is still concern about the effects of high altitude from the standpoint of providing a simple, comfortable capability

...ilt design of future high-performance aircraft ...es study of many possible solutions, including ...ilt-back seat, to help the pilot withstand stresses.

for emergency pressurization and temperature protection. Ground-based as well as airborne radar-surveillance systems generate electromagnetic energy at frequencies and powers that are of concern from the standpoint of environmental quality. Work currently under way within the Aerospace Medical Division is designed to produce an assessment of the environmental quality problems associated with operation of these devices and to provide appropriate criteria for land use planning. In the area of real-time reconnaissance and surveillance, application of visually coupled systems technology is providing major new improved capability in this area.

command control and communications

New systems such as the airborne warning and control system (AWACS) and the Advanced Airborne Command Post are being evaluated in terms of the possible crew hazards associated with the conglomerate of electronic equipment that will be aboard these new systems. Particular emphasis is being placed on assuring that ground maintenance crews are not exposed to excessive levels of radiation. The Aerospace Medical Division is placing most of its emphasis in this area on supporting the Electronic Systems Division's development of improved ways of presenting and processing complex information for decision-makers. Man/machine interface problems are paramount in both the ground-based and airborne command and control systems. Matching the computational capabilities of modern computer systems with the decision-making capacity of the responsible commander is an increasing challenge in the era of burgeoning electronics capability.

THE CONTRIBUTION of the Aerospace Medical Division to the solution of man/machine interface problems is very much dependent upon the continuing active interactions between our R&D activities and those of the other laboratories within Air Force Systems Command. The hardware approach developed by other laboratories to meet the mission goals of the Air Force defines, in large measure, the kinds of information about the crewmen that will be required from the Aerospace Medical Division. We have very active continuing joint efforts with literally every laboratory in the Systems Command. Much of the work done by AMD supports larger activities in the other laboratories. Similarly, much of our effort is directed towards providing short-range-focused answers to the product divisions in Systems Command as they develop major weapon systems. Our activities carry over into the operational arena, where we continue to provide advice and new technology as requested in the broad area of aerospace biotechnology. We believe that the effort currently under way and that planned for the future in aerospace biotechnology are providing new information that is crucial to the entire spectrum of Air Force operations. We believe that the cost of this program is relatively small in comparison to the significant benefits which it provides.

Aerospace Medical Division, AFSC

VISUALLY COUPLED SYSTEMS

Lieutenant Colonel Joseph A. Birt, USAF

Thomas A. Furness III

THE capability to "look and shoot" was but a fantasy in the days of the Flash Gordon and Buck Rogers comic strips. Soon today's Air Force pilot will be able to aim his weapons by a mere glance and fire along his line of sight by the simple push of a button. Systematic research and development of visual-coupling concepts, to improve man's relationship with his machine, are helping to bring a "look and shoot" capability closer to operational reality.

Recent combat experience has shown that many tactical, reconnaissance/strike, and air-superiority systems are operator-limited by both the task loading placed on the crew and the design of the interface between the operator and his machine. As long as tactical weapon systems are used in a high-threat environment, the flight profiles necessary for survivability will dictate that the operator perform all essential tasks effectively, accurately, and, most important, expeditiously. A well-designed interface lets him use his natural perceptual and motor capabilities optimally. Such limiting factors are especially critical in weapon delivery missions where visual target acquisition and weapon aiming are task requirements.

Since 1965, in an attempt to improve aircraft man-machine design, human-factors engineers of the Aerospace Medical Research Laboratory (AMRL) at Wright-Patterson AFB, Ohio, (a unit of Aerospace Medical Division) have been pioneering techniques to "visually couple" the operator to his weapon system.

Visually Coupled Systems Concepts

A visually coupled system is more correctly a special subsystem that integrates the natural visual and motor skills of an operator with the machine he is controlling. An operator visually searches for, finds, and tracks an object of interest. His line of sight is measured and used to aim sensors and/or weapons toward the object. Information related to his visual/motor task from sensors, weapons, or central data sources is fed back directly to his vision by special displays so as to enhance his task performance. In other words, he looks at the target, and the sensors/weapons automatically point at the target. Simultaneously with the display, he verifies where sensors/weapons are looking. He visually fine-tunes their aim, and he shoots at what he sees.

Two functions are performed: a line-of-sight sensing/control function and a display feedback function. Although each may be used separately, a fully visually coupled system includes both. Thus, it is a unique control/display subsystem in which man's line of sight is measured and used for control, and visual information is fed back directly to his eyes for his attention and use.

Currently a helmet-mounted sight is used to measure head position and line of sight. An early version of a helmet sight was used in an in-flight evaluation at Tyndall AFB in 1969. Various experimental sights have undergone flight tests. The U.S. Navy has produced a similar sight for operational use in F-4J and F-4B aircraft.

A helmet-mounted display is used to feed back information to the eye. An early bulky experimental display completely occluded outside vision to the right eye. Later versions permit a see-through capability, which allows simultaneous viewing of the display and the outside world scene. Many experimental display improvements are under study, but display flight-test experience is still limited. Research and development efforts are under way to reduce size, weight, and profile and to increase the performance of future visual coupling devices. Before looking at development progress toward operational reality, let's explain in general terms how such sights, displays, and visually coupled systems are now mechanized and discuss their potential capabilities.

A helmet-mounted sight, based on an electrooptical technique developed by Honeywell, was tested in the F-106 at Tyndall, 19

helmet sight components and capabilities

In the mid-sixties Honeywell selected, as one way to mechanize line-of-sight determination, an electrooptical technique for determining helmet position and the line of sight through a reticle. (Figure 1) Rotating parallel fanlike planes of infrared energy from the sight surveying units (mounted on canopy rails) scan two photo diodes on the side of the helmet. Timing signals from the scanners and diodes are processed by a digital computer (sight electronics unit) to determine line of sight. Such line-of-sight information can be used to point a variety of other subsystems.

A helmet-mounted sight facilitates wide off-boresight sensor or weapon aiming and speeds target acquisition. It permits continuous visual attention to the target outside the cockpit while sensors/weapons are slewed, and the hands are free from slewing control. The sight capitalizes on the ease and accuracy of the operator's natural eye/head tracking abilities. His natural outside-the-cockpit spatial orientation is used throughout target acquisition.

helmet display components and capabilities

In an experimental helmet-mounted display, video and symbolic signals are received from various alternative aircraft subsystems. Cathode-ray tube (CRT) imagery is projected directly to the eye of the operator in such a way that it appears to be focused upon a real-world background. A collimation lens performs the focus at infinity. The combiner reflects the imagery into the eye much as a dental mirror does; however, it permits the eye to see through to the real-

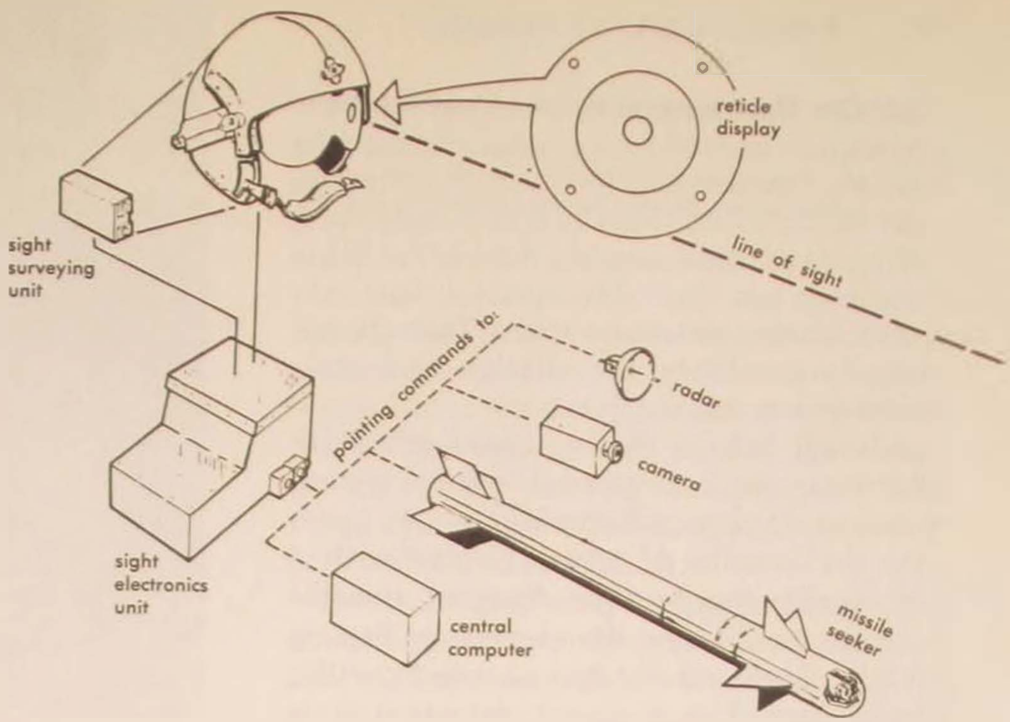


Figure 1. Components of the helmet-mounted sight interact with sensors, weapons, and central data sources. The system measures operator's line of sight to give pointing commands to interfacing sensors and weapons. It also feeds location information into central computers for the determination of target coordinates.

The first Air Force experimental helmet-mounted display, built by Hughes Aircraft, made use of a completely occluded monocular display.

The Army, too, tested the Honeywell head-position sensing system, for the Cheyenne program in 1968–69.

world scene simultaneously. Thus it essentially combines the display and real-world scenes for the eye.

A small helmet display could substitute effectively for a large conventional panel-mounted display and would give the operator the benefits of larger display with a high-quality image. The designer benefits from an overall subsystem weight and space savings. These advantages accrue from the simple fact that in target detection it is image size upon the retina of the eye which counts. A one-inch-diameter CRT display presented as a virtual image[1] and placed one inch in front of the eye results in approximately the same image size on the retina as a 21-inch CRT would mounted on a panel 21 inches away from the eye.[2] Miniature CRT technology can now provide sufficient resolution to make a high-quality helmet-mounted image display practical.

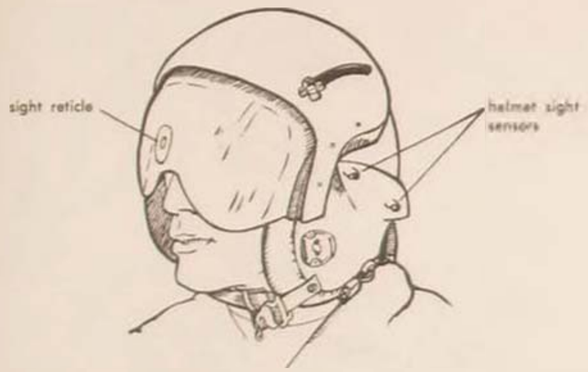
Even though most aircraft panels cannot accommodate large CRT's, it is important that the displayed imagery be large enough to be detected and identified by the eye. In other words, the image size detection capabilities of the sensor, the display, and the eye should be made as compatible as possible. Helmet-mounted displays offer designers a new way to achieve this compatibility. They offer the operator continuous head-up, captive-attention viewing. When the display is used alone, selected sensor imagery, flight control/display symbols, or other subsystem status information can be directly presented to the eye no matter where the operator is looking. However, comprehensive analyses and ground and in-flight evaluations of the operator's capability to use the information must be carried out if operator effectiveness is to be realized.

Second-generation sight had a reticle on a combiner extended in front of eye.

A 1970 improvement projects the reticle on a parabolic helmet visor, eliminating the visual obstruction of the combiner.

In the latest development, a lightweight helmet integrates visor, reticle projection, and head-position sensing diodes in one unit.

The more advanced sight will be based on one of three approaches being developed by industrial technology.



visually coupled systems components and capabilities

The helmet-mounted sight and display are combined as a system integrated with the operator's vision. Mechanization of the full system involves integration of the sight and display components into a lightweight helmet, development of a visor that automatically varies light transmission to ensure appropriate display brightness contrast, and improvements in the electronic and optic components.

When they are combined and matched with seekers, sensors, central data computers, and/or flight control subsystems, entirely new control/display capabilities can be provided to the user: a hemispheric head-up display that is compatible with the operator's outside-the-cockpit spatial orientation; sensor extensions of the operator's vision (e.g., it is possible to position sensors so the operator "looks" through aircraft structures); visual control of the aircraft and weapons; and visual communications between crew members and between aircraft.

Potential visual coupling applications with aircraft and remotely piloted vehicle fire control, flight control, reconnaissance, navigation, weapon delivery, and communications subsystems are many. In a night attack mission, for example, a low-light-level television scene can be displayed, superimposed on the real world, off-boresight, and through aircraft structure. Flight control and weapons data are provided in addition to the ground scene on the display.

Visually coupled systems can also be used to input line-of-sight angle information into central computers in order to update navigation; to identify a target location for restrike, reconnaissance, or damage assessment; and to communicate coordinate locations in real time with other aircraft or with command and control systems. By means of intracockpit visual communication, one operator can cue another operator on where to look for targets of interest. Similar nonverbal communication between forward air control and attack aircraft is conceivable.

Development Progress

Visually coupled system development is merely highlighted here to give a glimpse of progress. No attempt is made to be comprehensive but rather to give a feel for some of the choices and changes that led to the current objectives of the Air Force engineering development efforts. Until 1971 these efforts were mainly exploratory. Since March 1971, the Aerospace Medical Research Laboratory has pursued exploratory development of advanced concepts and engineering development of visual coupling devices. Progress to date indicates that these devices will soon be ready for Air Force operational use.

helmet-mounted sight development

Historically, it is not possible to trace the basic line-of-sight and display-feedback concepts to specific originators. Some credit for the sighting concept should go to behavioral scientists who in the late forties and early fifties were engrossed in systematic analyses of pilot eye movements to determine instrument scan and visual search patterns.[3] Initial applied sighting efforts in government and industry concerned the accuracy of head and eye tracking in the laboratory.[4] It was apparent that accuracy and effectiveness were functions of the head and/or eye position sensing techniques. Applications had to await practical sensing technologies. Head position tracking has received the most applied emphasis. Eye position tracking continues to be explored. It was also evident that the proof for any sighting technique would be in its accuracy and acceptability in flight.

The Army, Navy, Air Force, and industry have pursued complementary developments of helmet-mounted sights. Two especially noteworthy early approaches to line-of-sight sensing: a mechanical head-position sensing

Progress in Helmet-Mounted Display and Visually Coupled Systems

In this early experimental see-through display, the white circular element was so polarized that manual adjustments vary the transmission of ambient light and thus the brightness of the outside scene.

In the 1969 Honeywell helmet-mounted display, the "virtual image" of the cathode-ray tube (CRT) face plate projects onto a combiner or "granny glass" placed in the line of sight between eye and visor.

system by Sperry, Utah Division, and an electrooptical helmet-position sensing system by Minneapolis Honeywell were developed to the brassboard [5] stages for testing in the 1965 through 1967 time period.

Sperry's sight is a mechanically linked system where helmet position is determined in a manner similar to the working of drafting-board arms. A reticle in front of the operator's eye fixes the line of sight in reference to the helmet and its mechanical linkage. A magnetic attachment provides a quick disconnect capability.[6] Under Army contracts, Sperry's mechanical head-position tracker was evaluated in UH-1 and AH-1G helicopters, starting in 1967. Subsequent testing has led to a production contract to use the mechanical helmet-mounted sight as a backup target acquisition aid on certain Cobra helicopters. The Air Force pursued the mechanical sight approach in early AC-130 gunship aircraft.

In 1968 and 1969, the Army tested the Honeywell electrooptical head-position sensing system for the Cheyenne program. (The principles of such an electrooptical system were mentioned in the discussion of the helmet sight system.) This original Honeywell unit was a first-generation helmet-mounted sight (see first photo, page 32). In 1968 the Air Force sponsored a test of air-to-ground navigation/reconnaissance using a similar unit to pinpoint targets.[7] This test successfully used the sight for ground target coordinate determination in low-altitude, high-speed flight. However, helmet weight

In the first Air Force experimental visually coupled system, the CRT image is transmitted by the fiber optics from a rear-mounted CR tube across the helmet top onto a parabolic visor for presentation to the eye.

In the artist's concept, dotted lines represent transmissions of CRT image to optical elements for projection onto visor. The imagery in circle uses technology for predicting targets in the visual scene.

and center of gravity were problem areas.

The Air Force sponsored further development to reduce the size and bulk and to improve components. The resulting second-generation sight was then loaned to the Navy for a significant F-4B flight test at Point Mugu, California, in June 1969.[8] Navy test pilots concluded that it provided additional target acquisition capability under dynamic high G air-to-air combat conditions. As a result of that and later tests,[9] the Navy contracted through McDonnell Douglas, St. Louis, for a helmet sight capability, called Visual Target Acquisition System, to direct radar and missile target acquisition in certain F-4B and F-4J aircraft.

An improved second-generation sight was flight-tested at Tyndall AFB later in 1969 in F-101 and F-106 aircraft. (Photo on page 32) This important test quantitatively determined the accuracy of this sight under high maneuvering acceleration and wide off-boresight aiming conditions.[10]

In the early sights discussed so far, a reticle was projected onto a "granny glass" (combining glass) suspended directly in front of the eye. In a subsequent (1970) Air Force exploratory development, a substantial improvement was made by projecting the reticle directly upon a parabolic helmet visor, thus eliminating any visual obstructions by the suspended granny glass. An experimental version of the helmet-mounted sight with a visor reticle projection was included in flight tests in 1972 by the Air Force at Tyndall AFB and by the Navy in conjunction with its Visual Target Acquisition System testing. The Navy is currently retrofitting the visor reticle into its operational F-4J fleet.

Each helmet-sight version represents a development improvement to meet program and flight-test schedules. A current flight-testable sight has the photo diode sensors and visor-projected reticle in one lightweight unit attached to the helmet.

Air Force visual coupling research and development activities center around the Aerospace Medical Research Laboratory's Project 5973, "Development of Visual Coupling Aids." These development activities catalyze and complement the programs of the sister services and industrial agencies. The project's objectives are to provide the Air Force with design criteria and test information for current sight applications and for future advanced helmet sight, helmet display, and visual coupling equipment. Existing sights are ready for specific application evaluations. The project's technical objectives call for an interim helmet sight in 1974 and an advanced sight in 1976 (Table I).[11]

In the latest sight under development, the sighting mechanism is integrated into a lightweight helmet. This interim helmet unit will weigh less than the standard 55-ounce Air Force helmet (HGU-2A/P).

The advanced sight will include one of three new advanced approaches[12] to sensing head position and likewise will be integrated into a lightweight helmet. Flight-testing of advanced helmet-position sensing concepts in cooperation with the Navy is anticipated. An approach by Polhemus Navigation Sciences, Inc., employs controlled projection and sensing of a magnetic field. A Raytheon device uses light-emitting diodes on the helmet and cockpit-mounted photo diode detection surfaces. A Honeywell technique employs ultrasonic sound ranging and sensing.

Projected advanced sight improvements include enlarging from 1 cubic foot to 2 cubic feet the head-motion envelope (motion box) within which helmet position can be determined. Also sighting accuracy is to be improved, as is the effective coverage of line-of-sight azimuth and elevation angles. Improvements will further reduce helmet weight to 51 ounces and will reduce costs per unit while increasing its reliability. Helmet-mounted sight technology is being integrated with helmet display developments

Table I. Project 5973
Helmet-Mounted System Technical Objectives

Product	*Current Estimate*
Interim helmet-mounted sight	
Weight on head	Less than 55 oz
Angular coverage	±130° az/±75° elev
Motion box	1 cu ft
Accuracy	8 milliradians (CEP)
Total subsystem weight/space	44 lb/900 cu in
Mean time between failures	300 hr
Advanced helmet-mounted sight	
Weight on head	51 oz
Angular coverage	±135° az/±90° elev
Motion box	2 cu ft
Accuracy	4 milliradians (CEP)
Total subsystem weight/space	23 lb/600 cu in
Mean time between failures	500 hr

(described below) to form the Air Force's fully visually coupled system.

progress in display and visually coupled systems

The helmet-mounted display concept has a long history and more diverse development than the other sight concept. The idea of head-mounting a direct display to the eye emerged concurrent (in the late fifties and early sixties) with the concept of "head-up" windscreen displays in the Army-Navy Instrumentation Program (ANIP). In 1963 Hughes Aircraft Company built an experimental head-mounted display. Earlier efforts were deterred by CRT size and performance limitations as well as associated human-factors problems.

Throughout visually coupled systems development, designers have been concerned with effects of such human-factor aspects as added weight to the helmet; brightness contrast ratios between the display and the outside world scene; field of view (FOV);[13] exit pupil size;[14] display image quality; obstructions to peripheral vision; display use under vibration; perceptual compatibility and conflict between the display scene and the outside world scene; operator orientation when using a display; and display scaling, dynamics, and content format. These problem areas will be addressed in achieving current design objectives. Perceptual compatibility and display format also need to be looked at in the context of each specific application.

In 1967 and 1968 a joint Air Force/Navy effort flight-qualified a Hughes experimental helmet-mounted display. This display (see page 31) was monocular and occluded outside vision in one eye. An improved see-through model was developed in 1970 and included a manually adjustable, variable light-transmission feature to regulate ambient brightness experimentally. It had a 30° field of view. (The photos on pages 34–35 show several developmental helmet-mounted displays.)

There are currently three approaches to see-through display presentations. All involve projection of a "virtual image" of the CRT face plate to the observer's eye. In one method, used in a 1969 Honeywell display, the image is projected onto a combining glass, which is placed in the line of sight. It had only a 12.5° field of view. The granny glass caused some visual obstruction. Subsequently, this technique has been developed under Army contract to provide a 40° field of view.

When it became apparent that the projection of a sight reticle on a visor was going to be successful, the same technique for display projection was explored by the Air Force on contract with Honeywell. In 1972 they developed a flyable prototype with a rear-mounted CRT and fiber optics image transmission from the rear across the top of the helmet to front optical elements, which project it on the visor. Since this model included sight provisions, it was the first USAF experimental visually coupled system. In this approach, a special parabolic helmet visor is used as an optical element for presentation to the eye. Although the visual interference of the granny glass is eliminated, only a narrow 20° field of view is possible.[15]

The third advanced approach to display projection incorporates a holographic lens into a visor.[16] Theoretically a holographic display can achieve very wide fields of view, in excess of 60°. The technical feasibility of this approach is still under study.

Project 5973 has established technical objectives for advanced helmet-mounted displays and visually coupled systems to be achieved by 1977 (Table II). The advanced display and the fully visually coupled system (VCS) will be integrated into lightweight helmets. They will have resultant weights of 60 and 63 ounces, respectively. The field of view will be 20° if a parabolic visor is used. If holographic technology permits, a larger field-of-view capability will be incorporated. Efforts are under way to improve the quality of miniature CRT devices by increasing display brightness[17] while retaining their resolution. In order to see a display projected on the visor under all conditions of outside illumination, it will also be necessary to vary the light transmission characteristics of the visor itself. Research is under way to develop a visor that automatically varies its transmissivity with respect to ambient illumination, similar to variable-density sunglasses.

The Future of Visually Coupled Systems

Visually coupled systems are under Army consideration for night attack applications in the Cobra helicopter and as a technology for future advanced attack helicopters. The Navy is considering them for its AGILE and F-14 programs. The Air Force is investigating potential applications for air-to-air and air-to-ground target acquisition and weapons delivery, off-boresight weapon guidance, reconnaissance, navigation, and remotely piloted vehicle control. Currently, the Air Force is conducting or planning flight tests in conjunction with the AGM-65 Maverick, C-130 gunship, laser designation systems, and weapons guidance developments.

The immediate future will be determined by progress made in current development and test projects. Advanced technology will be transitioned into engineering development prototypes for testing. Interim helmet-mounted sights will be ready for Air Force application testing late in 1974, and advanced versions of sights, displays, and combined subsystems will be ready in 1977.

The Aerospace Medical Research Laboratory is already looking beyond the technology discussed here to future visual coupling concepts that can further improve operator performance. One such line-of-sight sensing concept will determine eye position rather than head position. A display patterned after the human eye is also under study. These concepts are briefly discussed:

• The Aerospace Medical Research

Table II. Project 5973
Visually Coupled System Technical Objectives

Product	*Current Estimate*
Advanced helmet-mounted display	
Weight on head	60 oz
Field of view	20°+
Exit pupil	16 mm
Resolution	800 TV lines
Brightness	150 ft lamberts*
Total subsystem weight/space	18 lb/450 cu in
Mean time between failures	400 hr
Visually coupled system	
Weight on head	63 oz
Angular coverage	±135° az/±90° elev
Motion box	2 cu ft
Accuracy	4 milliradians (CEP)
Field of view	20–60°
Exit pupil	16 mm
Resolution	800 TV lines
Brightness	150 ft lamberts
Mean time between failures	400–500 hr
Total subsystem weight/space	33 lb/750 cu in

*See note 17.

Laboratory is attempting to determine line of sight accurately from a small eye-movement sensor that could be located in the cockpit instrument panel. This remote oculometer determines line of sight from the reflection angle of a beam of infrared "light" projected onto the cornea of the eye. Currently, in the laboratory the eye can be tracked within a one-cubic-foot motion box with an accuracy of one degree. Should this technique prove to be practical, line-of-sight sensing and control could be possible without any encumbrance on the head.[18]

• A promising visually coupled system display technique employs dual-resolution fields of view, high resolution with a zoom capability in the center and low resolution in the periphery.[19] This concept, patterned after human vision, offers considerable potential in target search and identification as a means of coupling the operator with high-magnification sensors and high-power optics. Associated sensor slewing control techniques enable the operator to feel he has been moved closer to the target while using his natural visual search capabilities.

• Also several display-related technologies can be incorporated into visual coupling devices. For example, predictor displays can be readily exploited. Color display for improved infrared sensor target detection is also a possibility.[20]

In summary, the "look and shoot" capability is around the corner. Systematic R&D pursuit of visual coupling technology is opening many possible applications. Development of components has progressed sufficiently that operational applications are feasible. Although helmet sighting technology is further along than helmet display, full visually coupled systems capabilities should be available to the Air Force in 1977. Operator and system performance will be appreciably enhanced by the application of visual coupling devices.

Aerospace Medical Division, AFSC

Notes

1. A "virtual image" in this context refers to the fact that the image which is reflected from the combiner or visor actually "appears" to be in focus and located in the outside world on the line of sight.

2. T. A. Furness III, "The Application of Helmet-Mounted Displays to Airborne Reconnaissance and Weapon Delivery," in *Proceedings of First Symposium on Image Display and Recording*, AFAL-TR-69-241, vol. 1, U.S. Air Force Avionics Laboratory, Wright-Patterson AFB, Ohio, December 1969.

3. For early classical eye movement work see R. E. Jones, I. L. Milton, and P. M. Fitts, *Eye Fixations of Aircraft Pilots I. A Review of Prior Eye Movement Studies and a Description of a Technique for Recording the Frequency, Duration and Sequences of Eye Fixations during Instrument Flight*, Tech Report no. 5837 Air Materiel Command, Wright-Patterson AFB, Ohio, September 1949.

4. For example, see R. B. Lockard, and J. L. Fogard, (U) *The Eye as a Control Mechanism*, NOTS 1546, U.S. Naval Ordnance Test Station, China Lake, California, August 1956.

5. "Brassboard" stage refers to a flyable engineering model, which is beyond the stage of laboratory-workable "breadboard" models.

6. C. L. Keller, "Human Factors and Vipre Fire," Sperry Rand Corporation, *Sperry Engineering Review*, vol. 20, no. 2, 1967, pp. 17–23.

7. USAF Tactical Air Reconnaissance Center, (U) *TACREACT, Tactical Air Command Test 67-118*, TAC 7058-01054, Tactical Air Command/TARC, Shaw AFB, South Carolina, January 1968. (Report is CONFIDENTIAL.)

8. Department of the Navy, (U) *First Partial Report on Project 0/V63, Conduct an Operational Evaluation of the Helmet-Mounted Sight in an F-4 Aircraft as an Acquisition Aid during Air Combat Maneuvering*, Command Operational Test and Evaluation Force, Norfolk, Virginia, October 1969. (Report is CONFIDENTIAL.)

9. Department of the Navy, (U) *Conduct a Concurrent Technical and Operational Evaluation of the F-4 Dog Fight Optimization Systems, Final Report on Project C/V 20*, Command Operational Test and Evaluation Force, Norfolk, Virginia, April 1972. (Report is CONFIDENTIAL.)

10. F. H. Dietz, Major, USAF, and J. D. Wise, Captain, USAF, (U) *Final Report ADC/ADWC Project 69-19 Evaluation of the Helmet-Mounted Sight*, Air Defense Weapons Center, 4750th Test Squadron, Tyndall AFB, Florida, December 1971. (Report is CONFIDENTIAL.)

11. From a Command Assessment Review of Project 5973, Visual Coupling Aids, presented by Colonel Fredric F. Doppelt, Commander, AMRL, at Hq Air Force Systems Command, 3 July 1973. Presentation information is available from the 6570th AMRL/HER, Wright-Patterson AFB, Ohio.

12. For comprehensive treatment of these new head-position sensing techniques see J. Kuipers, "The SPASYN—a New Transducing Technique for Visually Coupled Control Systems"; W. J. Haywood, Jr., "A New Electro-Optical Technique for Measuring Pilot Line of Sight in Aircraft Coordinates"; and R. T. Sawamura, "The Ultrasonic Advanced Helmet-Mounted Sight"—all in J. A. Birt, Lieutenant Colonel, USAF, and H. L. Task, editors, *Proceedings of the Symposium on Visually Coupled Systems Development and Application*, AMD TR 73-1, Aerospace Medical Division, Brooks AFB, Texas, 1973.

13. "Field of view" in this context refers to the angle which the image supplied by the display subtends at the eye.

14. The display's "exit pupil" dimension is the diameter of the circular area within which the eye can move and still can see the displayed image. This dimension is measured at the entrance pupil of the eye. A large exit pupil is desirable in helmet-mounted displays so the image will not be lost under buffeting, turbulence, or high-acceleration conditions.

15. D. F. Kocian, Captain, USAF, and P. D. Pratt, "Development of a Helmet-Mounted Visor Display," in J. A. Birt, Lieutenant Colonel, USAF, and H. L. Task, editors, *Proceedings of the Symposium on Visually Coupled Systems Development and Application*, AMD TR 73-1, Aerospace Medical Division, Brooks AFB, Texas, September 1973.

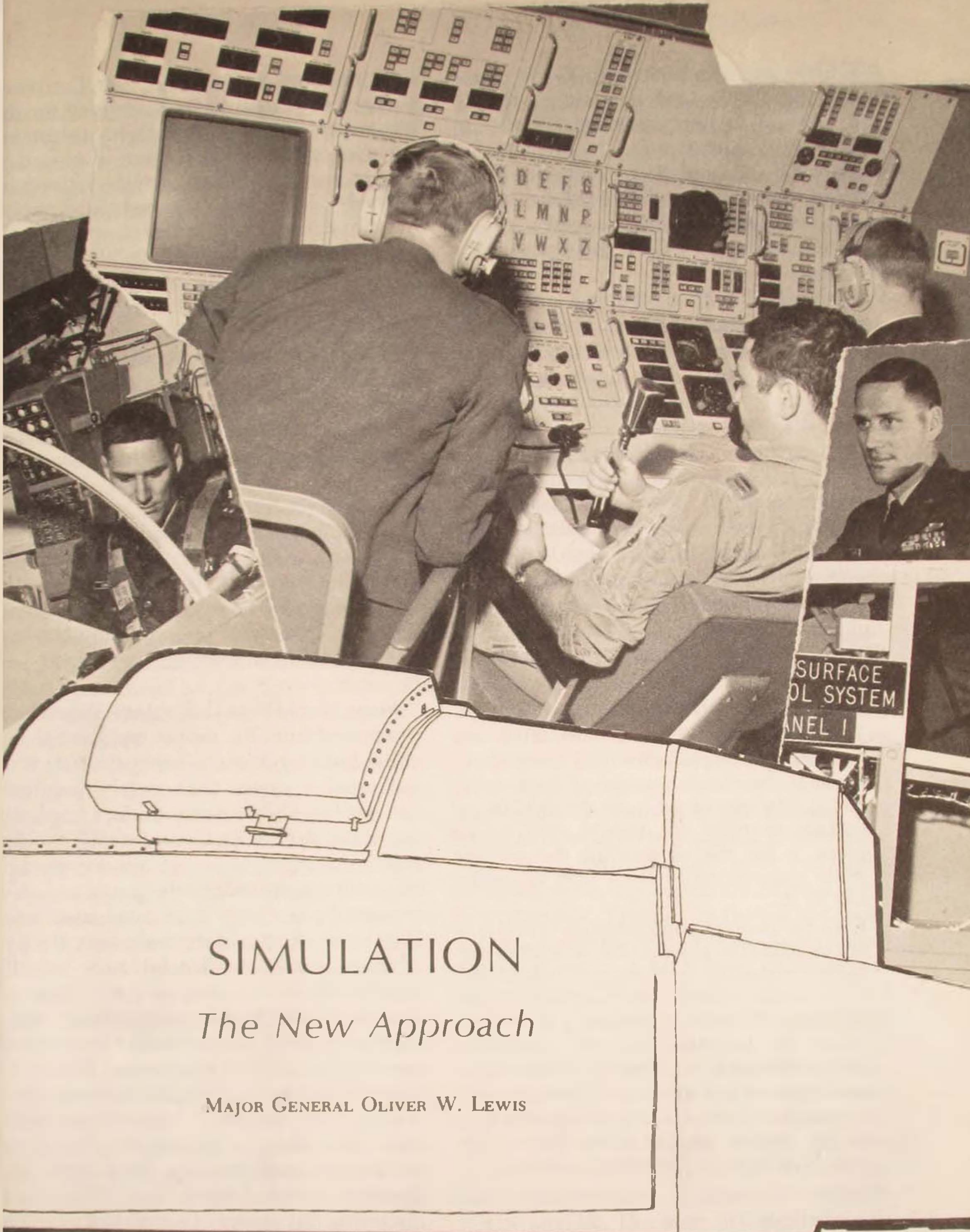
16. For comprehensive technical papers on holographic optical elements for helmet-mounted displays see J. N. Latta, "Design of Holographic Element Systems for Helmet Displays," and D. G. McCauley, C. E. Simpson, W. J. Murbach, and H. W. Holloway, "Holographic Optical Elements for Helmet-Mounted Visual Head-Up Display," in J. A. Birt, Lieutenant Colonel, USAF, and H. L. Task, editors, *Proceedings of the Symposium on Visually Coupled Systems Development and Application*, AMD TR 73-1, Aerospace Medical Division, Brooks AFB, Texas, September 1973.

17. "Foot lambert" (in Table II) is a photometric measure of luminance or brightness. Efforts are under way to improve the quality of miniature CRT devices by increasing display brightness up to 500 foot lamberts while retaining 800 TV lines of resolution and 8–10 shades of gray presentation. A CRT brightness of 500 foot lamberts is desirable to give the specified 150 foot lamberts brightness on the visor display surface.

18. Recent papers dealing with sensing and using eye position in a VCS context include J. Merchant, R. Morrissette, and J. Porterfield, "Aerospace Medical Research Laboratory/Honeywell Remote Oculometer," and T. L. Coluccio and K. A. Mason, "The Viewing Hood Oculometer: A Sighting Control and Display Feedback System," both in J. A. Birt, Lieutenant Colonel, USAF, and H. L. Task, editors, *Proceedings of the Symposium on Visually Coupled Systems Development and Application*, AMD TR 73-1, Aerospace Medical Division, Brooks AFB, Texas, September 1973.

19. Recent papers dealing with visually coupled dual field-of-view displays include J. B. Chatten, "Foveal Hat: A Head Aimed TV System with Foveal/Peripheral Image Format," and E. G. Schone, A. L. and Adamski Foote, "A Head Coupled TV for Remotely Manned Driving and Manipulation Tasks," both in J. A. Birt, Lieutenant Colonel, USAF, and H. L. Task, editors, *Proceedings of the Symposium on Visually Coupled Systems Development and Application*, AMD TR 73-1, Aerospace Medical Division, Brooks AFB, Texas, September 1973.

20. R. N. Winner, "A Color Helmet-Mounted Display System" in J. A. Birt, Lieutenant Colonel, USAF, and H. L. Task, editors, *Proceedings of the Symposium on Visually Coupled Systems Development and Application*, AMD TR 73-1, Aerospace Medical Division, Brooks AFB, Texas, September 1973.



SIMULATION

The New Approach

Major General Oliver W. Lewis

THE intercom came on: "Good morning, ladies and gentlemen, this is your captain speaking. Welcome aboard Easy Airways' DC-10 flight to San Antonio. Be assured that the flight crew is highly experienced and professionally competent. As captain, I have logged a total of three hours on the DC-10. Relax and enjoy your trip."

No airline in its right mind would ever announce to its passengers that the pilot could claim only three hours' experience in the airplane. The point is that *many of them could!* The secret is simulation, the new approach to flying training.

Actually, simulation is not new. In some form, it has been with us since soon after man learned to fly. Two of the earliest examples of flight trainers, or simulators, were in use in England in 1910. One was called the "Sanders Teacher," the other the "Eardly-Billing Oscillator." Both were replicas of early aircraft and were mounted on a base that allowed the trainer to move, in a limited manner, in pitch, roll, and yaw. The Sanders Teacher was described, in part, as follows:

> Those wishing to take up aviation either as a recreation or a profession find many drawbacks at the commencement of their undertaking, but one of the most formidable, especially to those not blessed with a long purse, is the risk of smashing the machine while endeavoring to learn how to control and fly it.
>
> Even the most apt pupil is certain to find himself in difficulties at some time or another during his probation, and owing to lack of skill the machine is necessarily sacrificed to save his life, or at least to prevent a serious accident. The invention, therefore, of a device which will enable the novice to obtain a clear conception of the workings of the control of an aeroplane, and of the conditions existent in the air, without any risk personally or otherwise, is to be welcomed without a doubt. . . ." [1]

That was 63 years ago, yet some people still don't believe it.

During and after World War I, aircraft trainers continued to be developed for the purpose of ground-based flight instruction and training safety. A trainer developed in France in 1917 included such features as control feel, response, assumed speed, engine noise, rudder-aileron crossover, and a simple visual approach.[2] By the late 1920s aircraft development had accelerated, and aircraft were flying higher and faster than ever before. Complexity had increased, and instrument or blind flying was introduced. Since blind-flying training in the aircraft was both dangerous and uneconomical, research and development of ground trainers was undertaken to provide solutions to this new training problem. In 1929 Edwin A. Link built his first flight trainer.

By the beginning of World War II, Link trainers were extensively used in commercial and military aviation training. Data on the effectiveness of these trainers are lacking; however, their contributions to military and civil aviation training were apparently acceptable.

Since World War II, flight simulators have progressed from the simple mechanical machine built by Link to sophisticated, computerized trainers that nearly duplicate the aircraft they represent. As complexity increased, so did cost. Consequently, training value of simulators, heretofore accepted by the military, was seriously questioned. Numerous studies have been conducted since 1949 in an effort to determine how much of what is learned in simulators is actually transferred to the real aircraft. Some of these studies on transfer of training or learning transfer were controversial. Older experienced pilots tended to discount the utility of simulation while younger trainees profited readily from simulated experiences. However, the value of trainers for increasing proficiency and reducing flight time was generally acknowledged. C. B. Westbrook, discussing this aspect of simulators a decade ago, said: "As a matter of fact, . . . numerous analyses have shown that these trainers can quickly save far more than they cost in reducing expensive flight time needed to maintain pilot proficiency particularly in such areas as instrument flight and simulated emergencies." [3]

Flight simulators, in general, were used through the sixties time frame to provide training in basic cockpit, instrument, and emergency procedures. The addition of digital computers and motion systems during this period increased the fidelity and, to a limited degree, the potential transfer of training. Studies have indicated the need for these motion stimuli, and further research has documented that:

a. A fixed-base cockpit should not be used to judge pilot performance or to judge the fitness of an individual to be a pilot.

b. A moving-base cockpit, even for an instrument trainer, provides a substantial improvement in training realism.

c. Sophisticated flight simulators should not be purchased by the United States Air Force without motion systems of comparable sophistication.[4]

Typical flight simulators or trainers have not simulated external stimuli such as those generated by an out-the-window visual display. Again, more conclusive data were required to justify the considerable additional expense associated with simulator visual display systems. Smode, Hall, and Meyer, in their comments on visual displays for flight trainers, said: "Apparently, for student pilots at least, even very crude contact displays have considerable training value, provided that 'good' instruction is given in relation to the device. Quality of instruction may substitute for absent contact cues in many instances." [5]

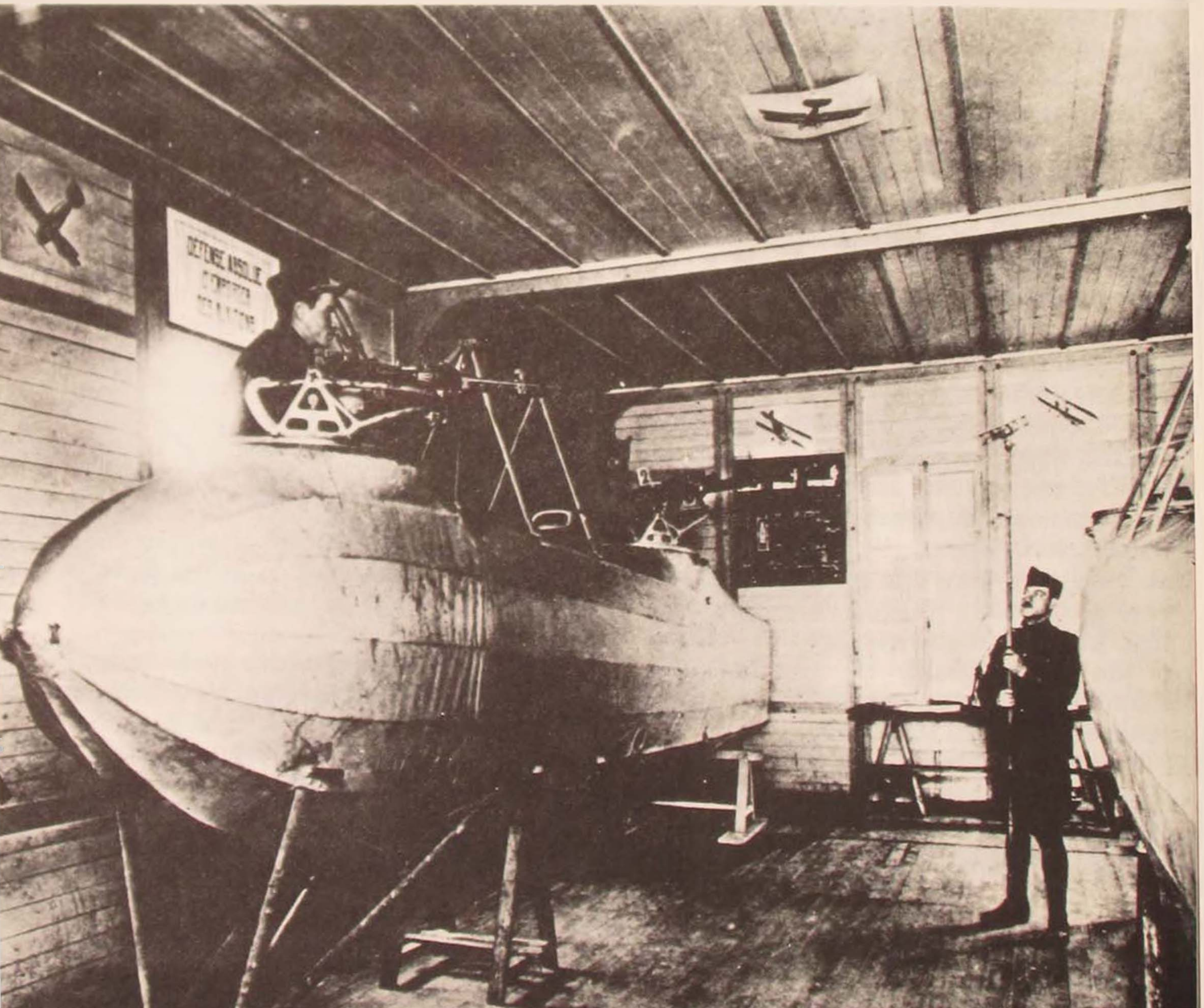
As late as 1967 it was apparent that visual display systems had not been accepted. Visual systems, representing the current technology, had been procured for several Air Force simulators. The lack of acceptance of these systems is exemplified in a 1967 study made by Hall, Parker, and Meyer.[6] In their survey of six different flying-training locations, they were unable to evaluate the training effectiveness of visual simulation because the visual attachments were inoperative at all bases visited. The devices were not used for extended periods of time because of maintenance problems and lack of spare parts. Motion-system capability was available and usable at all the bases visited, but its use appeared to be optional with the instructor.

Many reasons can be given for the failure of the military to accept visual simulation in the late sixties, such reasons as the lack of resolution, poor light level, and maintenance. However, the potential of visually equipped flight simulators was clearly understood by commercial aviation training managers. In February 1968, American Airlines petitioned the Director of Flight Standards, Federal Aviation Administration, for waivers of Federal Aviation Regulation (FAR) 121.418 and other parts of FAR 121 and 61 as necessary in order to conduct an Optimized Flight Training Program study.[7] This study reached several conclusions regarding the Optimized Flight Training Program as compared to standard airline training: "It . . . will produce safer and better qualified crewmen than conventional training programs. Training in the flight simulator can be conducted to a level of proficiency that will assure a high level of success in the airplane: . . . Evaluation in the flight simulator is indicative of performance in the airplane." [8]

Constant refinements to this study have been made by American Airlines flight training managers, and today all training programs conducted at the Flight Training Academy reflect less than five hours' aircraft time necessary to transition a pilot to a new aircraft. The most dramatic example is the average of 2.1 hours' flight time needed to transition a captain to the DC-10 aircraft.[9]

Acceptance of this type of program in military aviation training has been less than enthusiastic. It is only natural that many flyers who have gained years of experience without great exposure to simulation devices might still profess that "the only way man can learn to fly is to fly." Inroads on this attitude are occurring slowly, but they are taking place. In 1972 alone, over 200 senior Air Force officers visited the American Airlines training facility. Most were very favorably impressed with the advances made in training and simulator technology and agreed that the systematized training they witnessed had definite applicability to Air Force flight training.[10] Credit for these advances in training has generally been ascribed to the quantum jumps made in simulator technology. While this cannot be discounted, more credit is due to the quantum jumps in the way simulators are used and the technology of learning or instructing.

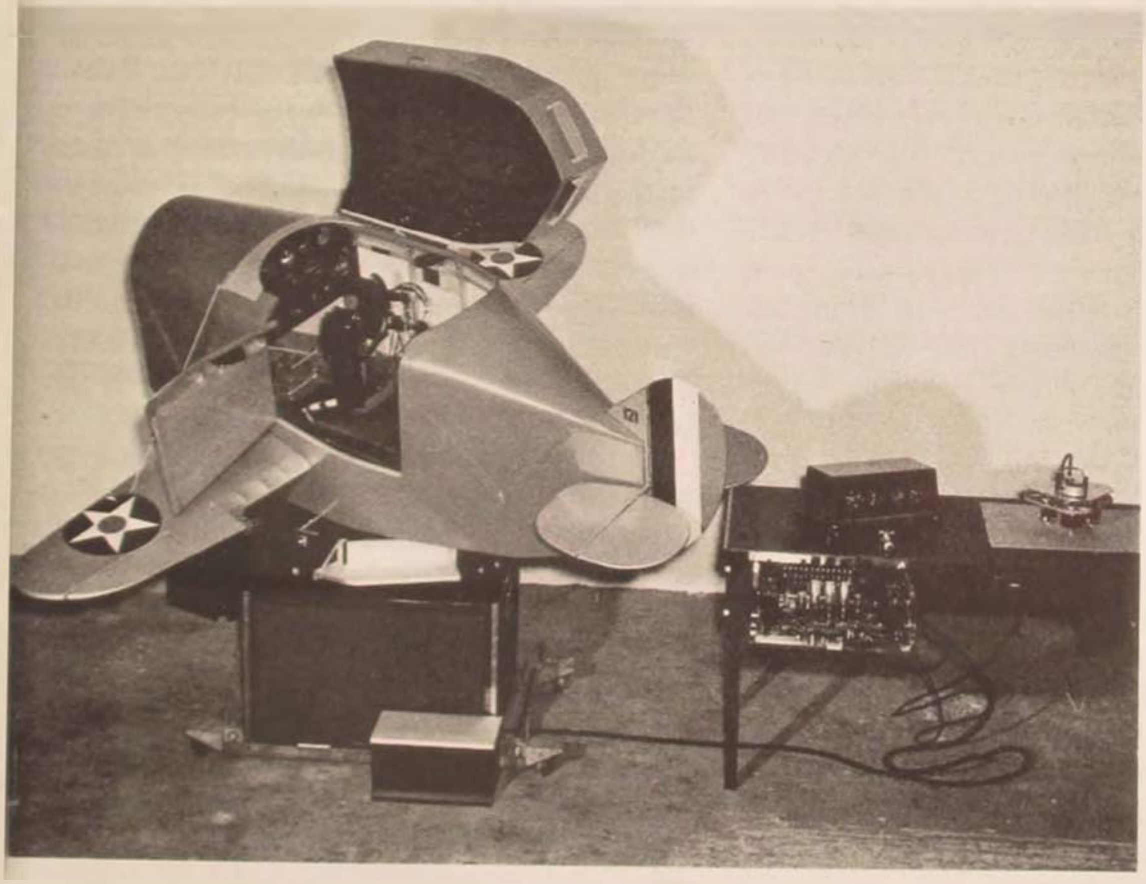
Instructional technology, known in the Air



Force as instructional system development (ISD),[11] has shown the training manager how best to design, use, and integrate the various training media into the instructional system. Without this guidance, lockstep traditional training would still hold sway. Economies would probably result from better equipment and methods, to be sure, but training would still be essentially the same as that conducted prior to World War II. In some respects, it still is. For many reasons, the Air Force has not been able to keep pace and take full advantage of the advances in simulation. But there are good and valid reasons why we must now do so.

The facts are that total defense manpower is at the lowest level since 1950; dollar outlays for manpower have increased; and budget authority for manpower is being held roughly constant. The conclusion is unavoidable that we have fewer people to work with; they cost us more; and manpower funding is limited.[12] The sum of these factors is a continuing squeeze of defense dollars. Our option is to accomplish more with less, or, in a word, *efficiency*.

ial gunnery training today makes early simulated training look definitely quaint, with its tiny airne held aloft on a stick and a wall sign that translates: "CARRYING OF MUNITIONS ABSOLUTELY OHIBITED" . . . The Link trainer, first built in 1929, is a nostalgic reminder of World War II simulation.



The urgency is clear when we note the disparity between Department of Defense personnel-related costs and those of the Soviet Union. Our people-related cost rose to 53 percent of our defense budget in 1973, while the Soviets devoted only 30 to 35 percent to such costs. Given roughly comparable total budgets, the U.S.S.R. has a significant advantage in purchasing power available for weapons-related programs.[13]

The need for efficiency in all Air Force activities is obvious, but it is of paramount importance in those activities of a support nature. Dollars expended in support are dollars unavailable for operational tasks and equipment. Training is such an activity, and, unlike other facets of the total manpower costs, it is under our immediate control.

Not unexpectedly, flying training stands out because of the inordinately high individual training costs.[14] It is costly in terms of people, time, money, and equipment. It is not surprising, then, that the conduct of flying training should be under close scrutiny and that every effort is being made to achieve improvements. As with other support functions, our objective in flying training must be to achieve the highest order of efficiency possible. It is to this end that the present article is prepared.

THE CONCERN of Headquarters USAF with training effectiveness is expressed in a series of policy statements and directives aimed at enhancing our training posture generally and improving flying training in particular. General John D. Ryan's leadership in this endeavor was reflected in his direction to major commands early in 1970: "We can be proud of our past achievements, but our past successes should not diminish our efforts to seek better solutions to our training methods. To make dramatic increases in efficiency requires that we be innovative and have a willingness to depart from traditional methods."[15] The current Air Force policy on training course development, embodied in AFM 50-2, *Instructional System Development*, expands the principles outlined in General Ryan's letter and establishes a systematic methodology for the development of training to achieve our goal of efficiency. The Air Force is committed to this policy.

Simulation, properly used, stands out as our best bet for simplifying the learning tasks of the pilot trainee and improving the quality without increasing the cost of training. This realization is the product of testing and evaluation as old as aviation itself; it is one we have been slow to acknowledge, partly because of difficult design problems and tenuous utility claims but mostly because we could not afford the risk, however remote, of poorly trained combat pilots. Step by step, in a long, agonizingly slow development process, these deficiencies and fears have been overcome. Now, a recognition of their utility and productivity, which is based on documented evidence, and our conviction that better training will result from their use have collectively enlightened our outlook and demanded a new approach. We can no longer deny the validity of simulation, nor can we afford to disregard its potential for cost reductions.

This has not occurred by happenstance. It is the product of Air Force efforts in research and development and accomplishments in training program design methodology. The structure of a training program is the essential ingredient for success, and an understanding of the development process of such programs is basic to the new approach.

The instructional system development process described in AFM 50-2 is one of the most significant breakthroughs of recent decades. It is a combination of the logical and systematic approach used in engineering development and of analytical investigations with evolving education and training technologies. Together they form a methodology for instructional system development.

Applying the systems approach in instructional system development is the orderly process of (a) gathering and analyzing job performance requirements; (b) translating job performance requirements into behaviorally stated learning objectives; (c) identifying, developing, and integrating operating resources and instructional techniques and procedures, based on effective technological advancements in education and training, to provide the required instruction; and (d) assuring achievement of behavioral objectives and confirming that these objectives fully support the job performance requirements.

The process identifies the best possible combination of desirable features and alternatives. On the basis of objectives and limiting factors, the most cost-effective alternative is then selected. The output of the process is an integrated combination of resources (students, instructors, materials, equipment, and facilities), techniques, and procedures, efficiently performing the functions required to achieve specified learning objectives.[16]

The ISD model for course development is the key to simulators and training equipment in flying training. Step four begins by answering two questions: (1) What training equipment is needed to bring a person of known capability to a job-specified level of proficiency in a particular set of tasks at least cost? and (2) How should the training course be structured, sequenced, and integrated to make best use of the training equipment selected? As a part of the study of instructional strategies, several approaches are investigated. The spectrum analyzed might well extend from the use of a traditional classroom-aircraft approach, to a sequence beginning with programmed texts and progressing through a series of part and whole task trainers, to a sophisticated full mission simulator, and then to the aircraft.

The determination of what is needed and how it is used results from cost/benefit analysis applied to each possible strategy. For each learning strategy option, the analysis considers such factors as cost of training equipment, cost of flying time required, program length, number of students programmed, the degree of proficiency required, anticipated life of the system in the force program, and the speed of learning transfer expected. With all these (and other items) quantified in a decision matrix, the optimum strategy results. Now we know the optimum learning sequence and the equipment necessary. The course developers can start planning specific segments of the course, and the acquisitions people can develop the specifications and start procurement action.

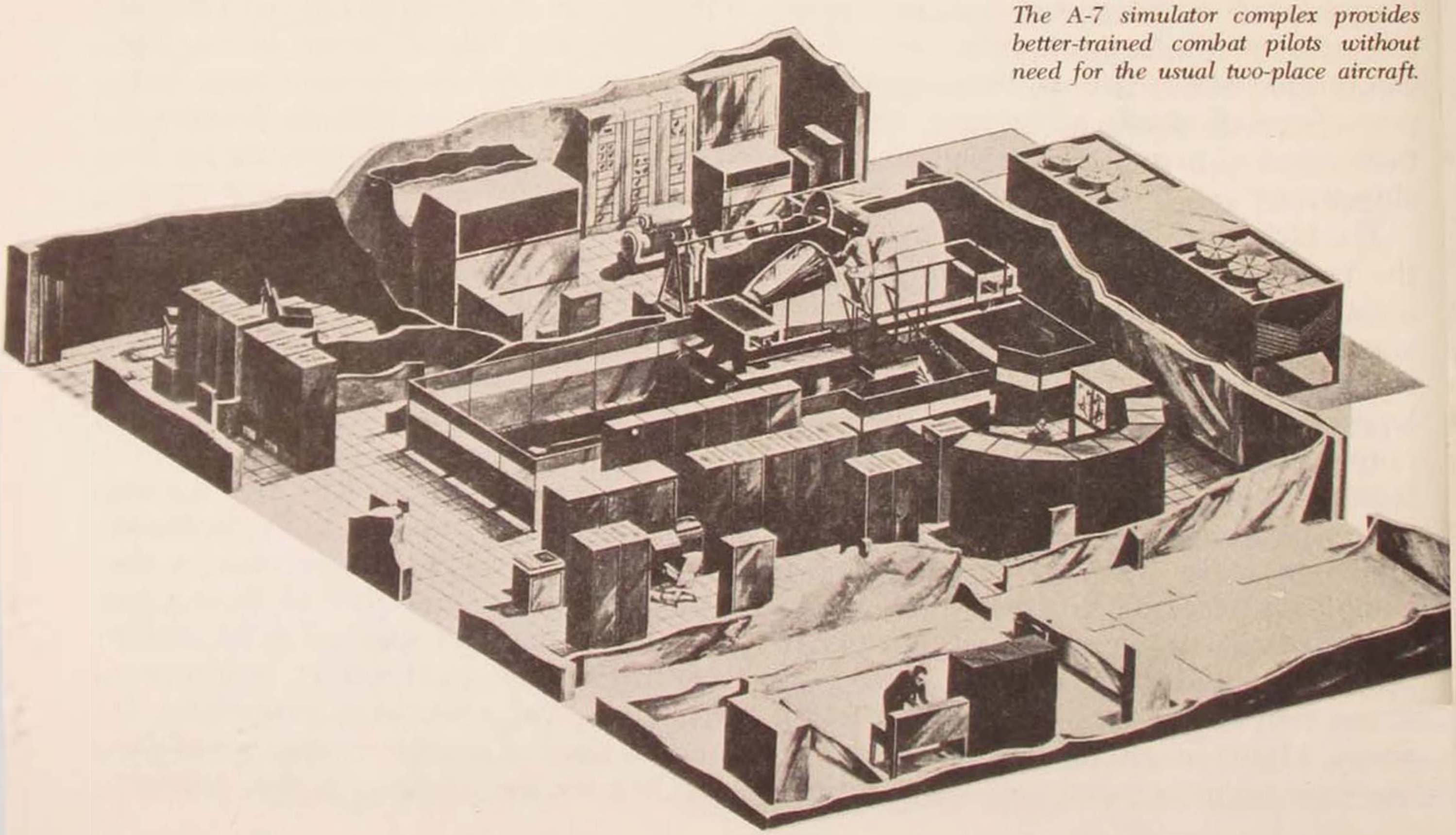
This process was employed by the Tactical Air Command in developing the A-7D course now being presented to undergraduate pilot training (UPT) graduates at TAC A-7 Combat Crew Training School (CCTS) bases. The analysis specified a requirement for a wide spectrum of training equipment, the apex of which was a sophisticated simulator for the A-7D. This device is one of the most sophisticated pieces of training equipment in the Air Force operational inventory today. The three copies cost the Air Force about $18 million. This machine is a fully operational A-7D cockpit mounted on a motion base (rotational motion around pitch, roll, and yaw axes and translational motion in the vertical) and is driven by a high-capacity digital computer. This simulator cannot fully duplicate weapons delivery, air-to-air combat, or refueling—it can do only part of those jobs; but it can simulate a standard flight profile from engine start to shutdown, instrument procedures, and emergency procedures. It does not have an out-the-window visual display, but we are working on that problem and expect to have it soon. The machine has very high fidelity, matching the aircraft in every respect, even to motion feel.

REMEMBER, we started the whole argument on the basis of efficiency in flying training. Simply building and providing such a machine is only part of the task. Let us now look at how it is used in conjunction with other equipment and the magnitude of the resultant benefits.

In the ISD process we first state the specifics of a task. A hypothetical example might read like this: "The student will be able to start the A-7D engine and taxi to the end of the runway with sufficient proficiency to pass a combat-ready standboard check on this portion of the checklist." This is a critical task objective, stated in terms of the actual behavior, degree of proficiency required, and the equipment on which the proficiency must be demonstrated.

Our immediate reaction, under a more traditional approach, would be classroom teaching, using mockups and charts, and then to match up the student with an instructor pilot (IP) and an aircraft and have him practice until he was proficient. This requires lockstep classroom teaching for groups of students, ties up aircraft for training, generates additional maintenance workload, and risks equipment breakage and other problems. This concept unnecessarily consumes operational resources at the expense of Air Force mission capabilities.

The fledgling A-7 pilot will find a quite different approach to learning, which might go something like this: His initial direction



The A-7 simulator complex provides better-trained combat pilots without need for the usual two-place aircraft.

would be to go to the learning center, check out Programmed Text #1 on engine start and taxi, study it and take the included self-test, insuring 100 percent accuracy—repeat if necessary. The last page of the text sends him to the learning center library, where he checks out sound/slide lesson 123 on the same subject. He completes this lesson in a carrel and answers the visually presented test that concludes the lesson. The last audio direction is to proceed to another room, check out video cassette #321, observe the engine start and taxi procedures demonstrated, and then follow through on the cockpit mockup provided. This cassette, after he has checked his own progress, sends him to a cockpit procedures trainer, where he meets an IP. The instructor reviews his cockpit familiarization and clears him for a simulator, where he practices his skills and demonstrates the required proficiency. After following this same approach for other objectives (such as ground and air egress and aircraft systems—learning how to operate the systems, not just how they operate), culminating with aircraft ground operation, our pilot finally arrives at an A-7 on the line with an IP. After one practice he is expected to pass his proficiency check on engine start and taxi, ground egress, emergency procedures, etc. We are willing to wager that he can. TAC experience with the A-7 confirms our view.

THE FOREGOING is actually a comparison of the extreme in traditional training with a hypothetical optimum system using the A-7D for illustration. There are several points here that contribute to improved training and should be noted. First, the objective told our pilot, his instructors, commanders, TAC, Air Force, and the world what he was supposed to do, to what degree of proficiency, and the equipment used. Second, the learning process was individualized and self-paced. The student and his classmates did not at any time have to go to classrooms together; each proceeded at his own pace. Third, progress was frequently checked to insure desired proficiency levels. Fourth, the instructors did not directly teach; rather, they managed the student's learning and built the materials he used. Fifth, he used only equipment necessary to the proper stage of proficiency, using the most expensive training equipment (the A-7D) last and as little as possible to insure desired proficiency. It is these items, resulting from ISD analysis that incorporates simulation as the least-cost learning medium, which produce quality training. The TAC A-7D course was built using this kind of logic and approach to focus training on the mission performance requirements. While traditional classroom methods are still used, self-paced and individualized instruction remain as objectives of the A-7D instructional system.

All these increases in training efficiency, while initially difficult and time consuming to accomplish, produce highly significant improvements. They help insure that the operational mission can be fulfilled by well-prepared aircrew members even though the time spent on training is reduced. The undergraduate pilot training input student to the A-7D course is trained in less time than his F-4 contemporary. His course is 37 days shorter and requires 26 percent less student flying and 27 percent less support flying per student than a conventional training program; and he is graduated "combat ready." In comparison, the F-4 graduate of the equivalent conventional training program is "mission capable" and needs further training by his end assignment unit.

The ratio of flight-to-simulator hours in the two programs is interesting and revealing. In the A-7D program the student spends 45 hours in the simulator and 85 in the aircraft. In a comparable conventional pro-

The C-5 simulator, with motion base and visual attachment, is expensive but will amortize itself through safer, less expensive qualification training and extended life of the C-5 resulting from fewer flying hours devoted to training. Inside cockpit (top right), exterior view (bottom right).

gram he spent about 117 hours in the aircraft and only 27 in the simulator. TAC has revised all major weapon systems CCTS syllabi along lines similar to the A-7D course, and an advanced visual system for the F-4 is under development to simulate air-to-ground weapons delivery that will revolutionize tactics training.

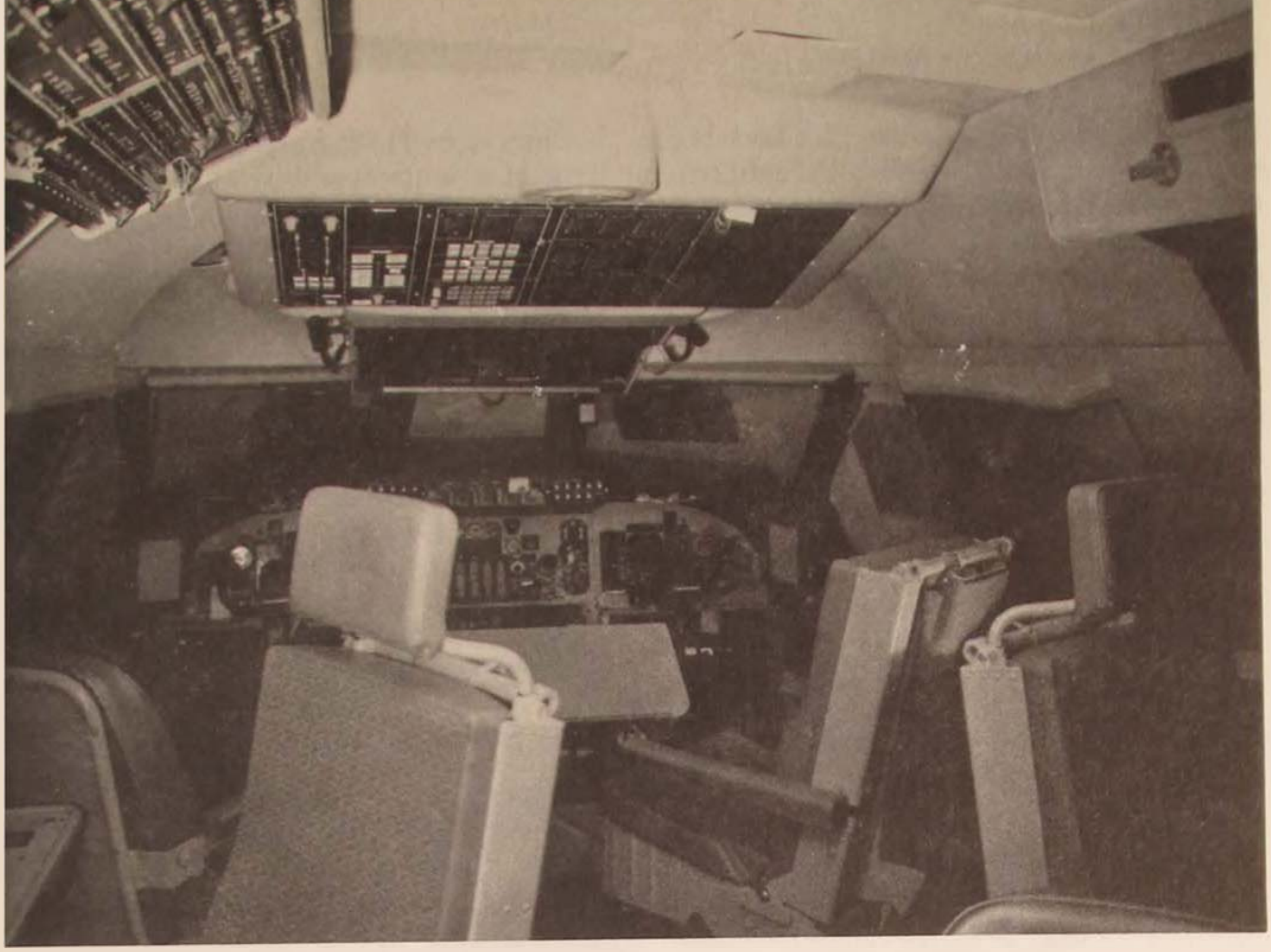
Other completed examples of the efficiency of simulation in systems-developed flying training programs abound, and many more are in the offing. ISD and better use of present training equipment have reduced the length of the C-130A and E programs by 20 flying hours and 15 training days, with no reduction of performance standards. Similarly, the RF-4 program has been reduced by 13 flying hours. Except for the A-7D, this has been done without the cost of new simulation equipment. New simulators have been proposed for the C-130 system that will be integrated into a revised training program. Expenditures for the simulators will be amortized during the life of the weapon systems and will provide net gains in quality and reduced training costs.

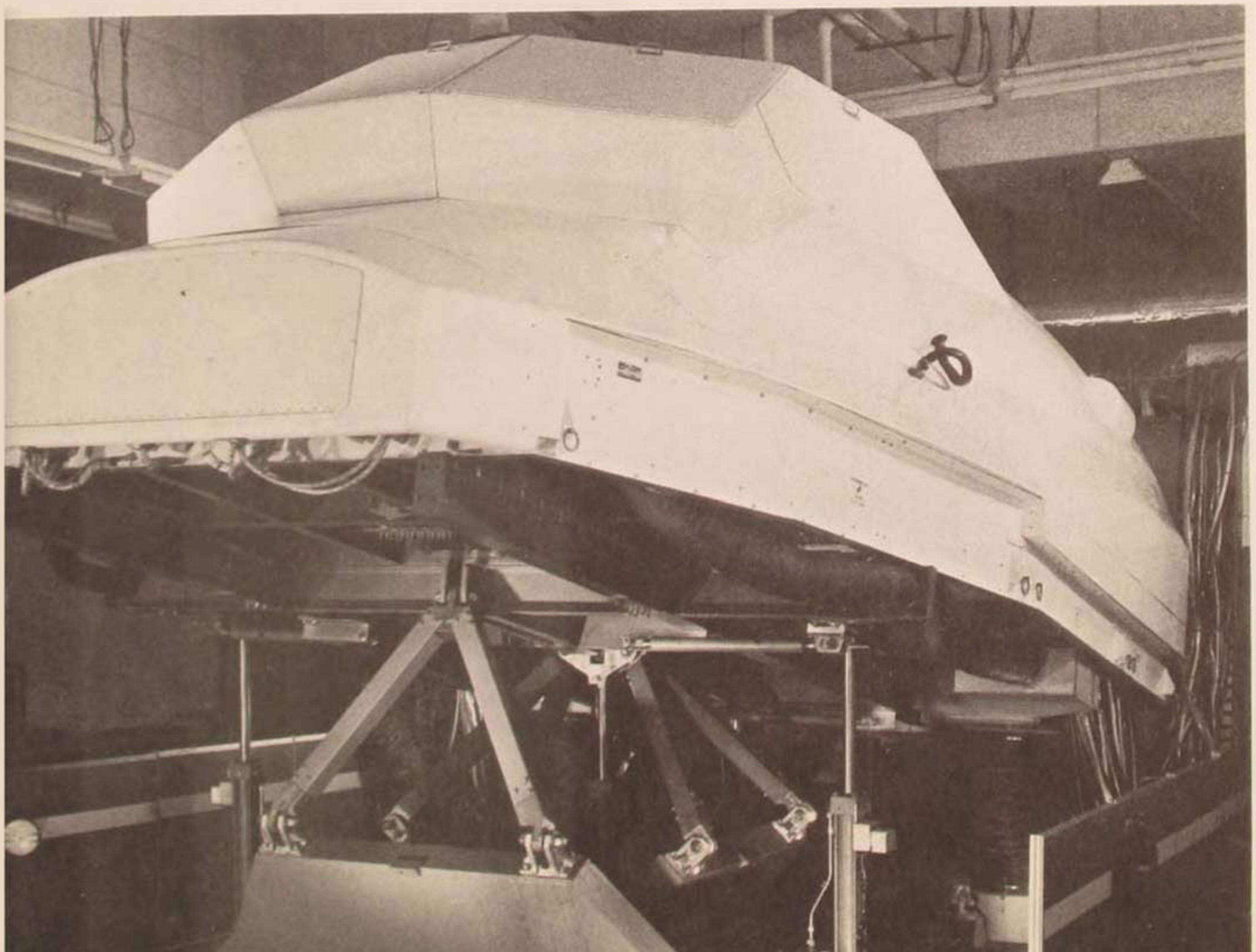
Lest we forget, Air Force aircraft rather frequently fly with navigators aboard, without whom many a weapon system is reduced to a rather expensive mode of transportation, ineffective as a weapon system. Their training is also expensive and lends itself to the application of simulation techniques. In the past few years highly significant changes have been taking place at Mather AFB in California, the focus of all ATC navigator training. Just this last August, as a result of careful application of the ISD process, ATC, in cooperation with SAC, determined that navigator-bombardier training for the B-52 could be conducted to SAC's high standards without flying by using presently available simulation. The result is a nav-bomb course of 14 weeks (versus the previous 27 weeks), using 89 instead of 60 simulator hours, and with flight time reduced from 48 hours to zero. SAC is pleased with the graduates, and 190 officer and enlisted spaces were recouped, largely in pilot and maintenance support for 18 T-29D aircraft no longer needed in nav-bomb training.

A similar adjustment will be made in electronic warfare officer training beginning this summer with the arrival of a new simulator for electronic warfare training (SEWT). This machine and its use will free 12 more T-29s with their attendant support spaces, reduce course length by about three weeks, and preclude the need for 70 flight hours by students in electronic warfare officer training.

The systems approach effort on the undergraduate navigator training (UNT) program has already produced a requirement for two rather spectacular items of training equipment. They are new T-43 aircraft and the T-45 simulator, which we call UNT's. These two machines, in combination, will replace 56 T-29s, with their attendant support spaces, beginning in fiscal year 1975. Training improvements at the undergraduate level allow further refinements in navigator training in SAC, TAC, and MAC CCTS programs as a result of the increased capability of the Mather graduate.

In April of 1972 MAC launched a very ambitious effort to restructure training in the C-5, the C-141, and all Air Force helicopters. This four-year project will apply ISD course design methods to 39 formal training courses. Simulator visual capability will be added to the C-5 and C-141 simulators at the MAC Transport Training Unit (TTU) at



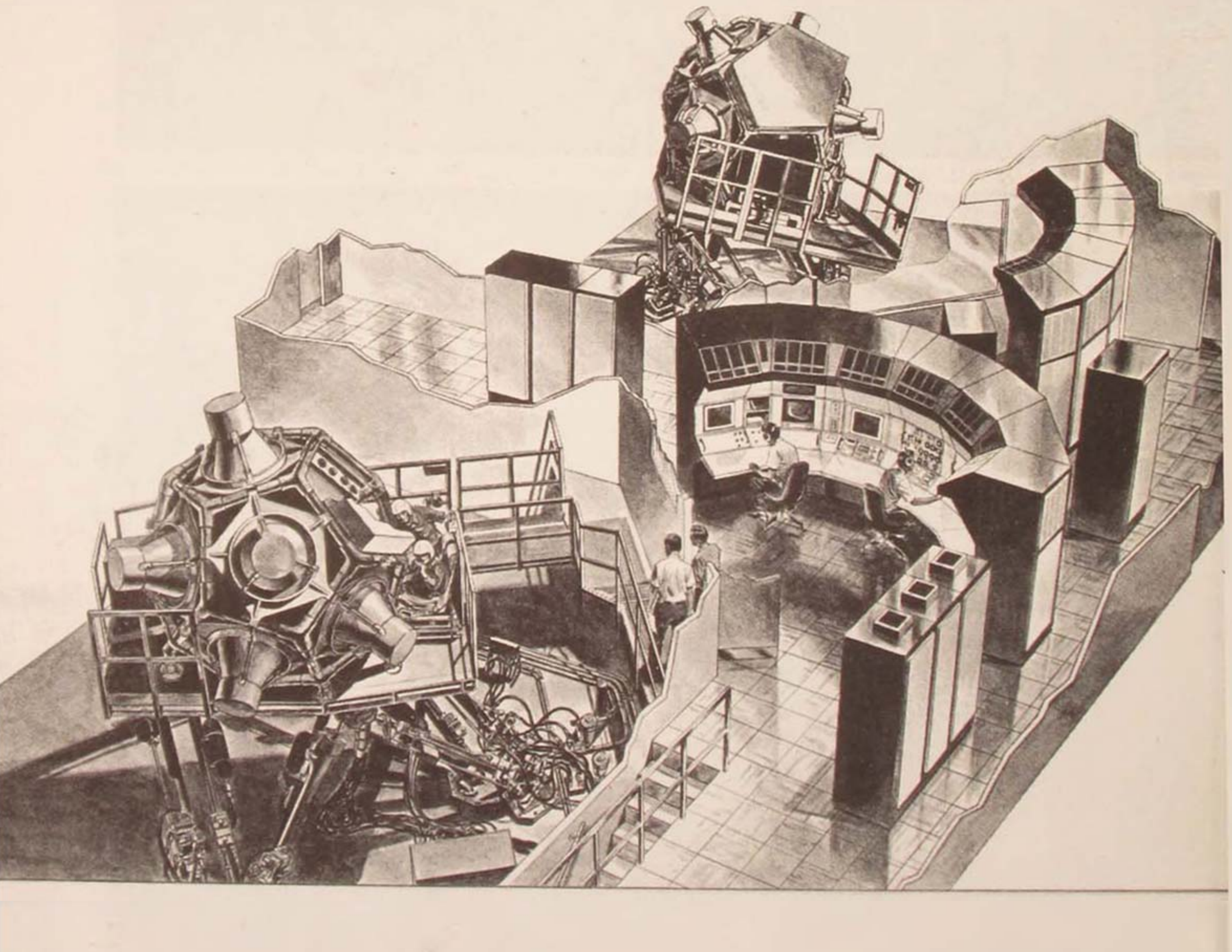


Altus AFB, Oklahoma. New H-3 and H-53 simulators are being added to helicopter training at Hill AFB, Utah. The careful application of ISD methods and the acquisition of cockpit procedures trainers (CPT) and simulator visual systems are expected to achieve significant training improvements in C-5 and C-141 initial qualification training.

Purchase of new simulators is obviously expensive, but the rewards are great. Routinely, they amortize themselves before the las item of a sequenced buy is in place. Thi: will be true of the proposed simulators foi the C-130, the UNT's, and the SEWT. It is true of the visual additions to the C-5 and C-141 simulators, the H-3, and the H-53 simulator: and will be true of a new set of simulator: for undergraduate pilot training that are being procured for Air Training Command.

In addition to the very real efficiency gains, there are other less tangible benefits

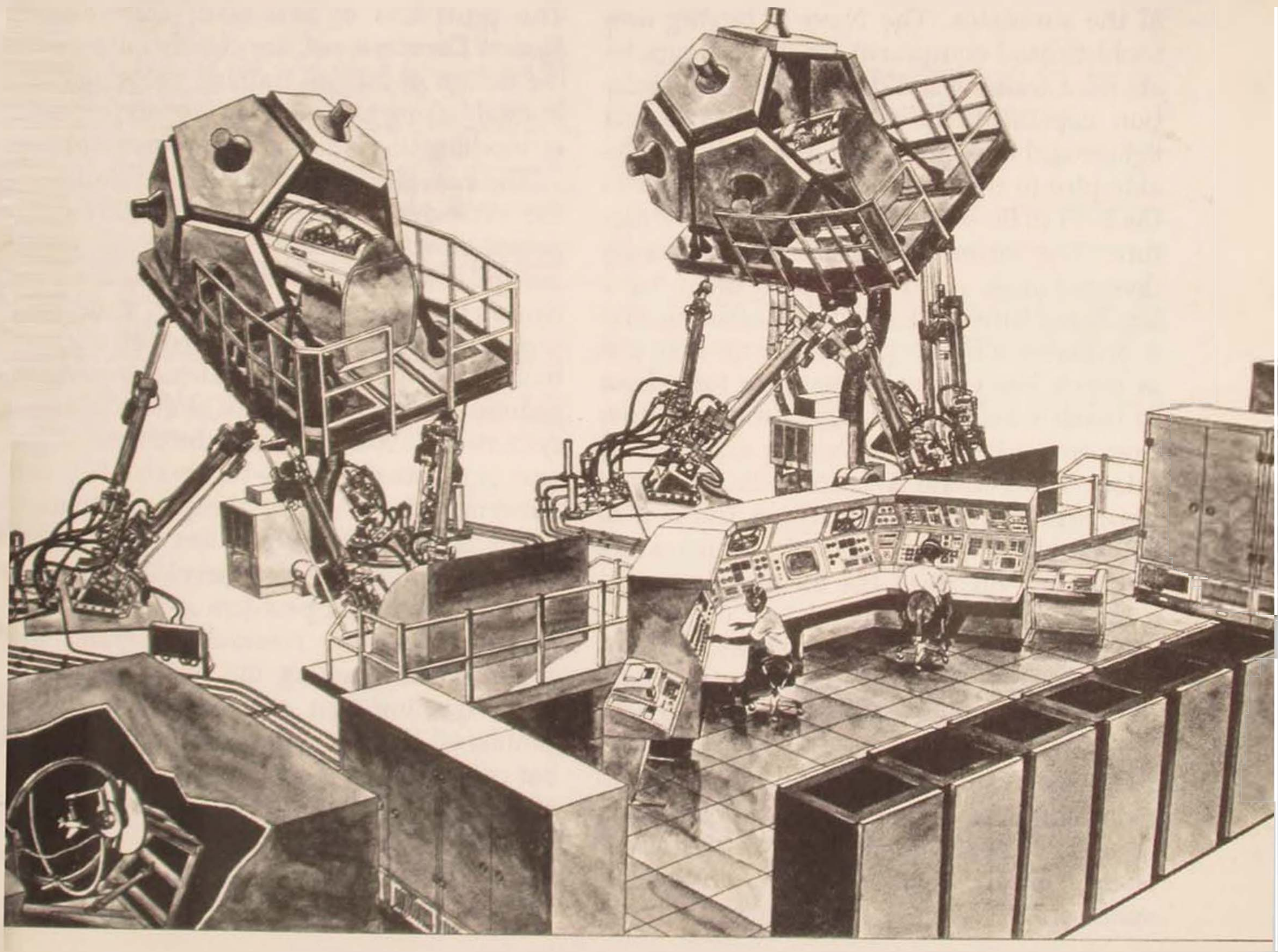
An artist's concept shows the research vehicle that will investigate the kind and the sophisticatio level of advanced simulators required for the specific learning objectives in the undergraduat pilot training environment. Experience with simulation has traditionally yielded gains in quality



from careful use of simulation in flying training. For instance, MAC visual additions to the TTU simulators at Altus will extend the useful life of the C-5 and C-141 fleet in proportion to the associated reduction of flying hours devoted to training. As with all other simulator procurements, the potential for aircraft accident is reduced during the high-risk period of an aircrewman's relatively low proficiency period during training, simply due to less exposure to the chance of an accident; yet when he graduates he is as well or better qualified than those who previously trained primarily in the aircraft. Airspace congestion is significantly reduced. This is no small problem with our increasingly crowded skies. Primarily for this reason several nations have expressed interest in our growing use of simulation and ISD efforts as they are faced with even more severe airspace problems than we.

With less time expended on training, of

A system like this for simulating air-to-air combat pilot training taxes the ingenuity of the most sophisticated engineers, to achieve the realism necessary to accomplish the same results as training in the actual aircraft. To do it better and at even less cost is the eventual expectation.



the total available flying hours allocated each year, more time is available for direct mission flight activities. In this sense we gain an increased operations capability without increased cost: with fewer aircraft devoted to training, more are available for operational units—which can increase the number of units within expected budgetary constraints. This last observation alone justifies increased use of simulation because it makes a direct contribution to the Air Force portion of the national defense posture.

We are not alone in the increased use of simulation. The Army has purchased new simulation equipment for the UH-1 helicopter and now teaches all helicopter instrument flying, except the proficiency check, in the simulator. The Navy is buying new sophisticated equipment for its undergraduate pilot training and state-of-the-art simulation capability for the new F-14 Tomcat fighter and is finding simulation to be a valuable plus in training the systems operator in the F-14 in his extremely complex task structure. The airlines have almost universally diverted more and more of their flight training flying time into simulation, finding that it produces a better pilot more quickly and at much less expense. They are just about to reach what we call zero time transition from one aircraft to another for experienced pilots. The Federal Aviation Administration has certified American Airlines training in the simulator as adequate to demonstrate proficiency on 20 of the 27 maneuvers required of a new DC-10 pilot.

The utility and cost effectiveness of simulation for the achievement and maintenance of combat readiness in missile training programs are conclusively established by the Air Force successes in that difficult field. Operational commitments and the design of launch complexes preclude the use of operations equipment for training launch or maintenance crews. Simulation replaces the traditional method of crew training. In fact, there is no practical alternative in this case. While it is true that occasionally a missile is fired for test purposes and an opportunity for observation is afforded trainees, the firing is accomplished by an operational crew. To provide an intercontinental ballistic missile (ICBM) for each crew would be like expending a B-52 for each flight-crew training mission.

The ballistic launch crew trainers replicate the actual launch facility and simulate all crew functions. Unlike crews for manned systems, missile crews are largely committed to synthetic means of determining combat readiness. But here too, as in flying training, the utility of the devices hinges on their proper integration into the course structure. The provisions of AFM 50-2, *Instructional System Development*, are closely followed in the design of missile training programs and in establishing future requirements for trainer modifications and new procurements.

The complexity of training in relation to the extensive requirement for highly competent crews is a major challenge today. We recognize and accept the unavoidable conclusion that, as part of a properly structured program, simulation is a high-payoff training tool. We are working on all major weapon systems and undergraduate aircrew training systems and looking around the corner at the next-generation F-15, A-10, AWACS, B-1, and airborne command post weapon systems.

We do not yet have all the answers, but our instructional system development concept will highlight problem areas that need investigation. Our research programs are aggressive, addressing the critical areas of flight training that pose difficult learning problems. The Simulator for Air-to-Air Combat (SAAC) Study is investigating one aspect of combat training that is now exclusively limited to airborne instruction. The Advanced Simulator for Undergraduate Pilot Training (ASUPT) Study will seek answers to the questions of degree of fidelity required for specific learning situations; it should suggest a complete family of learning devices that will revolutionize pilot training. These and other research programs are indicative of management support of innovation. They reflect a growing awareness at all levels of management of the potential for efficiency inherent in this new approach to training.

The USAF Scientific Advisory Board has commented on the progress made and future needs:

> These actions are encouraging; but there must be more aggressive actions if the Air Force is to capitalize on simulator technology in a timely way. Expanded use of flight simulation appears less limited by insufficiencies in hardware technology than by management constraints, budget problems, and long-established negative attitudes.[17]

Thus, while we recognize the potential value of simulation, we should not be content with present achievements. We must continually assess our management posture and procedures to judge their relevance to our objective of flying training efficiency. Where necessary to achieve it, we must be disposed to accept change. To this end we present this explanation of simulation as the new approach in Air Force training.

Hq United States Air Force

Notes

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2. Aerospace Medical Research Laboratory Technical Report 68–97, Aerospace Medical Division, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, p. 1.
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7. "Optimized Flight Crew Training, A Step Toward Safer Operations," American Airlines, Inc., Flight Training Academy, Greater Southwest International Airport, Fort Worth, Texas, April 24, 1969, Appendix I, p. 1.
8. *Ibid.*, p. 37.
9. Briefing given to Major General Oliver W. Lewis by Captain Walter Moran, Chief of Flight Training, American Airlines.
10. *Ibid.*
11. Air Force Manual 50–2, *Instructional System Development*, December 1971.
12. Secretary of Defense Melvin R. Laird's Annual Defense Department Report FY 1973, p. 61.
13. *Ibid.*, p. 31.
14. AFCCS ltr, "Flying Training Efficiency," to ADC, ATC, MAC, SAC, and TAC. The attachment to General Ryan's letter provides examples of USAF flying training costs: e.g., F-106, $218,310, F-105, $237,640, UPT, $82,640.
15. *Ibid.*
16. AFM 50–2.
17. USAF Scientific Advisory Board Report on the Ad Hoc Committee on Air Force Simulation Needs, January 1973, p. 7.

Air Force Review

THE NEW OFFICER EFFECTIVENESS REPORT

Lieutenant Colonel Raymond C. Preston, Jr.

THERE are a few things in this world that we cannot seem to avoid, death and taxes being two of the more common examples. For the Air Force officer, another certainty that can be added to the list is the annual effectiveness rating. Most of us might openly resist placing the OER in the same category as death and taxes, but the fact remains that, like them, the OER would win few popularity polls and is disliked by rater and ratee alike.

A number of techniques can be used to evaluate an individual's performance and potential. The possible types and combinations of rating forms are nearly infinite in number, but the overall process is not favorably accepted. Developing an evaluation technique to measure individual

performance that will consistently render agreement among different raters is, at best, difficult to achieve. Nevertheless, some type of officer performance evaluation is necessary. The task of guiding and controlling the careers of thousands of officers requires documentation that will fairly and efficiently support the personnel actions to manage the force. It is little wonder, then, that the OER system does not satisfy all officer personnel. Such has been the case in the past, and the present OER system is no exception.

brief history of the Air Force OER

The Air Force originally adopted the Army Officer Evaluation system in 1947. In 1949 the Air Force developed its first OER, AF Form 77. A new form was approved in 1952 which is essentially the same OER form used today. A few refinements of an evolutionary nature have been made, but the basic concept remains. In 1968 efforts were initiated to develop a new system, but no agreement was reached among the Air Force Council and major air commands on how new forms should be designed. In 1971 the Air Force Council directed that the Air Force Human Resources Laboratory (HRL) develop a research solution for a new OER. The present OER system has been and continues to be effective for promotion boards and assignment personnel to make the best possible selections. However, it is no secret that rating inflation has become more pronounced of late. The continued influx of very high ratings for most of the officer force could in the long term greatly reduce the value of the current system. Therefore, the Air Force felt it was essential that a new system be developed.

the proposed OER

The Air Force Human Resources Laboratory conducted extensive research into a variety of possible rating techniques and forms. Conferences with evaluation experts from industry, government, and the academic community were held. The HRL proposal for an OER was completed in early 1972. A few of the key elements of this OER proposal that vary significantly from the present OER system are the following:

- Two forms were selected: one evaluated the ratee's current job performance, while the other addressed the ratee's promotion potential.

- The ratee would see his job performance evaluation, thus termed an "open" evaluation. Some consideration was given to *not* making his promotion potential evaluation available to the ratee, thus a "closed" evaluation.

- Some variations were made in the job performance rating factors from those presently appearing on the current OER form: e.g., "Facts and Decisions," "Adaptability," and "Train Others" were added; "Leadership" and "Military Qualities" were eliminated.

- Job performance rating factors would be evaluated against standards of performance in lieu of contemporary comparisons. Any evaluation other than "Meets Standards" required an actual example of performance.

- Two rating scales were developed. A 3-block scale evaluating the ratee's overall job performance was related to standards: "Does Not Meet Standards," "Meets Standards," and "Exceeds Standards." A 7-block scale involved the ratee's promotion recommendation: e.g., "Retain in Present Grade," "Promote Lower, Middle, Top ⅓ of the Primary Zone," "Promote 1, 2, and 3 Years Ahead of Year Group."

- An extensive system was proposed for feeding back rating data in point averages to the rating, additional rating, and reviewing officials. The rating officials' OER point averages would be compared to all other officer evaluations, thus identifying the high and low raters. The ratee would be given a general indication of his relative standing among his contemporaries prior to being considered for promotion.

field test results

In the OER field test conducted between September and December 1972, 1745 officers took part. A representative sample of officers by grade and Air Force Specialty Code (AFSC) was carefully selected. Extensive analysis of the field test results revealed some interesting details. Support for the proposed OER was varied. Less than a third of the participants felt that the proposal was an improvement over the present OER system. There was no clear indication that the new forms would take any more or any less time to accomplish. It was felt, however, that promotion boards would require more time to complete the selection process than with the present system. Offsetting this possible disadvantage was the fact that trial simulated promotion boards using the new forms found an increase in the overall consistency and reliability of those selected for promotion than has been true in the past. There was some dissatisfaction with the selection of job performance factors. Most felt that "Leadership" and "Military Qualities" should be retained. There was general support for using performance standards in lieu of contemporary comparisons for rating job performance factors. Junior officers strongly supported the use of standards while senior officers were split between standards and contemporary comparisons. Considerable concern was shown that the standards selected were not applicable to all grades and all career fields. The use of a "closed" promotion potential evaluation drew a varied reaction among junior and senior officers. Junior officers were generally opposed to a "closed" rating, while senior officers indicated much stronger support for it. A similar response was indicated toward the objectivity of ratings. Junior officers felt that a "closed" rating would offer neither more nor less objectivity, whereas 63 percent of the colonels and 82 percent of the general officers indicated that a "closed" rating would be more objective than an "open" evaluation.

A few conclusions can be drawn from the field test results:

- It would be difficult, if not impossible, to obtain across-the-board agreement and support for any proposed OER system.
- Junior and senior officers view the OER from different perspectives.
- The OER proposal could be further refined to simplify administrative procedures and reduce the time necessary to accomplish the evaluation.
- The OER proposal was an improved instrument when compared to the present system, for promotion boards, special boards, and assignment officials to perform their responsibilities more effectively.
- Strong overall support for the proposed system was lacking.
- The OER proposal required additional refinement prior to implementation.

This is not meant to imply that the OER field test proposal was without merit. This proposal established an excellent base for the final proposal, and the lessons learned from the field test were key to developing the new OER system.

new OER proposals

A General Officer OER Review Group was established to monitor the progress of the field test and to recommend a final course of action. This group was comprised of the Deputy Chief of Staff, Personnel, and the

Deputy Chief of Staff, Research and Development, Hq USAF, and the Vice Commander, Air Force Systems Command. After reviewing the OER field test data in March 1973, this group reached essentially the same conclusions outlined above. As a result, the General Officer OER Review Group suggested that two independent OER proposals be developed using the favorable elements of the HRL proposal as a point of departure. One proposal was to be developed by Personnel officials in the Air Staff while the other effort would be directed by the Air Force Systems Command.

Prior to the development of new forms, a meeting was held to establish the objectives for the revised system. The following objectives and rationale were agreed on:

• *Identify as fairly and objectively as possible those officers who should be either retained in grade, promoted in the primary zone, or promoted below-the-zone based on available quotas.*

A good rating distribution is desired if the evaluation is to be meaningful to promotion and special personnel action boards. The greater rating objectivity of a "closed" promotion potential evaluation should, therefore, be considered. The phrase "available quotas" is significant, as not every officer can be promoted. Grade limitations force a highly competitive environment for promotion to major, lieutenant colonel, and colonel. This stark fact must be fully understood and appreciated by both the ratee and the rating official if any officer evaluation system is to be effective.

• *Establish a control system which will effectively encourage and preserve rating objectivity.*

One of the critical elements in establishing an effective OER system is that of control—controls which encourage fair and objective appraisals in light of promotion opportunity and which take effect concurrently with the implementation of the evaluation system.

• *Separate job performance rating from promotion potential evaluation.*

The current Air Force OER system attempts to evaluate both job performance and promotion potential on the same form. The two are separate entities and, as such, deserve different evaluation criteria; therefore, they should be treated separately. Most of our officers perform their current jobs in an excellent manner. You can expect most officers to receive fairly high ratings on job performance. The promotion potential evaluation is another matter. It does not necessarily follow that a major performing his job as a squadron supply officer in an outstanding fashion would make an outstanding wing chief of materiel as a lieutenant colonel. When promotion opportunity of about 50 percent to colonel is assessed, as an example, only the most outstanding officers who possess growth potential as a result of proven performance, demanding prior assignments, management skills, education, and initiative would be competitive.

• *Inform ratee of job performance strengths and weaknesses.*

The job performance form should serve as a vehicle for the supervisor to indicate to the ratee his strong points as well as areas where improvement is warranted.

• *Assist personnel officials in assignment and other related personnel actions.*

Unique features and responsibilities of a job should be spelled out. The ratee's strongest qualifications should be stated. In relation to a suggested future assignment, the job, level, and timing should be specified.

• *Avoid tying points to rating blocks.*

The new OER should avoid the 9-point scale we have today as well as the overall evaluation adjectives such as "Excellent," "Outstanding," and "Absolutely Superior." There are those who believe that the publication or discussion of an officer's OER point index in relation to critical personnel actions such as promotion, school selection, job assignment, and retainability is one of the major factors if not the major contributor to OER rating inflation. The recent increase in rating inflation under the present OER tends to parallel the increased emphasis which has been placed on the OER point index. This was recognized several months ago when the use of the OER point index was dropped under the current system. When success tends to be tied to a certain OER point rating, you can expect that rating to be equalled if not, in fact, exceeded as a hedge against inflation.

• *Administer simply in a minimum amount of time.*

Significant room for improvement exists in this area. Many felt that the field test proposal was too complicated; too many forms were used; too much writing was required; and it was difficult to administer. An imaginative approach must be taken to streamline the administrative process for the new system.

When the final two proposals, which were independently developed, were completed in April 1973, there were a number of common elements that could be agreed to. Significant refinements to the present OER and the field test forms were made:

Job description: The breakout of certain key elements of a job were to be specified, such as unique duties and tasks as well as type and level of responsibility. Promotion boards and personnel officials should find these data of interest.

Job performance factors: Ten factors were established, with "Leadership," "Military Qualities," and "Equal Opportunity Participation" added; "Train Others" was omitted.

Assignment data: A separate area on th form was set aside to address specificall the ratee's strongest qualifications, suggeste job assignment, organizational level, an timing. This information is of considerabl importance to personnel officials.

Performance standards: The performanc standards which were field-tested would re quire refinement to make them less genera

Additional duties/self-improvement area: Any significant accomplishments would b addressed in the "Comment Section" of th OER.

Confidence factor: The rater, addition rater, and reviewing officer would indicat the frequency of contact that they have wit the ratee, i.e., daily, weekly, or seldom.

The "open" job performance rating for standardized for all grades. The job per formance evaluation would be "open" fo all grades. Job performance is observabl and can be objectively evaluated agains performance standards. The ratee has a nee to know how well he or she is performin against these standards.

"Closed" promotion potential evaluation A "closed" promotion potential evaluatio will initially be rendered only on lieutenan colonels. This evaluation, which is basicall subjective in nature, is expected to give pro motion boards greater insight into an of ficer's readiness for increased rank and re sponsibility. The form will be handwritten with no copies made. Only temporary pro motion boards at USAF Military Personne Center (MPC) would see the "closed" pro motional potential evaluation. The rate and personnel officials will not see thi form. Lieutenant colonels will also receiv the "open" job performance evaluation which can be reviewed by the ratee. Th "open" job performance evaluation will b the only rating that lieutenants throug majors will initially receive.

Reviewing official selection: The review ing official must be an Air Force colonel o general officer. Other military reviewing officials will not be permitted to submit additional evaluations.

Use of impression paper for the promotion potential form: It was decided that the additional rating official should not be allowed to see the rating official's "closed" evaluation. The reviewing officer should, however, see both these independent evaluations prior to making his rating. A unique form was developed utilizing impression paper which will make these stipulations possible. This procedure adds a greater degree of independence to the rating and more assurance for the ratee. The "closed" promotion potential evaluation must have built-in safeguards if the system is to work effectively and gain the confidence and support of the officer corps. No derogatory comments of any kind are allowed. The fact that the rating and additional rating officials' evaluations are entirely independent protects the ratee from any undesired influence that they might have on one another. The third rating by a senior officer assures a "corporate" evaluation for each officer. It is the senior officer's responsibility to carefully review all the facts and arrive at an independent judgment. Promotion boards now have three separate ratings to weigh.

New OER implementation date: An April 1974 implementation date was established. Every lieutenant colonel would have a "closed" promotion potential evaluation completed shortly after this date and prior to the next lieutenant colonel to colonel temporary promotion board.

The only issue that was not resolved between the two proposals was the rating scale for the job performance and promotion potential forms.

selection of the final rating scales

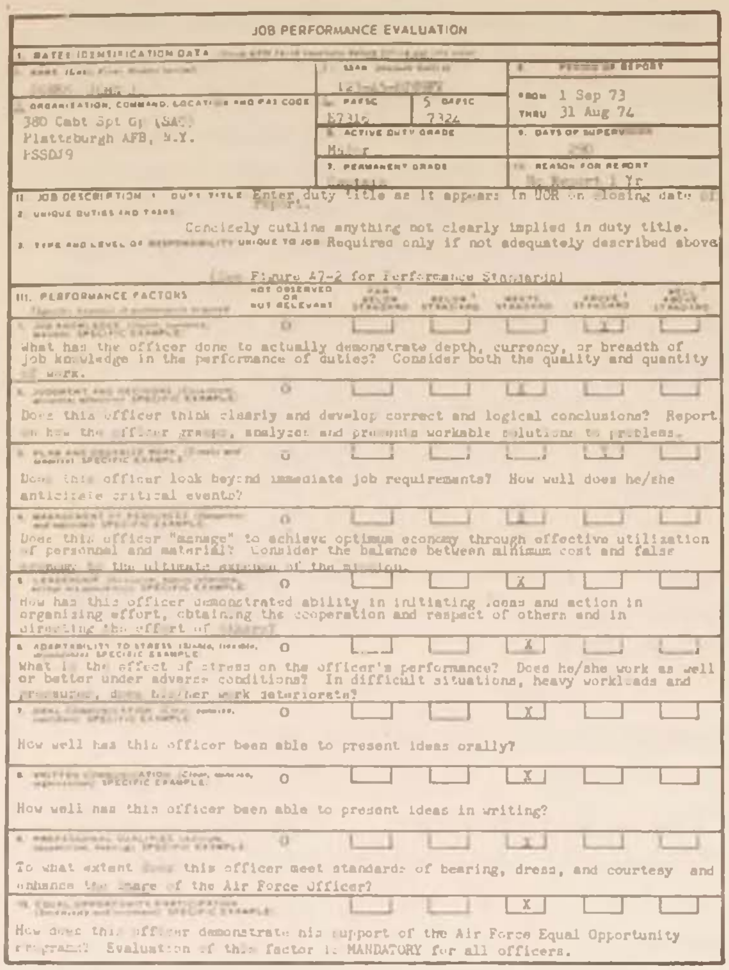
More than fifty different rating scale designs were considered. Nearly every conceivable variation was proposed. As few as two and as many as twenty rating blocks, unstructured scales with no blocks, bell-shaped curves, triangles, circles, blocks placed on end, blocks stacked on top one another, contemporary and peer ranking, rating on an exception basis. You name it, and you can be pretty well assured that your favorite proposal was examined. A number of factors guided the selection of the final proposal:

- The rating must mean the same thing to the rater as it would to a promotion board.
- A nine-block scale was unacceptable. A carry-over of the possible nine-point OER index that we presently have must be avoided.
- Points would not be assigned to the rating blocks or to a rating scale.
- The present OER terminology of "Typically Effective," "Excellent," and "Absolutely Superior" would be avoided.
- A good rating distribution was necessary.
- The rating terminology should be compatible with the proposed Defense Officer Personnel Management System (DOPMS).

The rating scales selected for the job performance and promotion potential forms are shown in Figures 2 and 3. The primary objective in designing the two rating scales was to assure a good rating distribution but, more important, a system which was fair, had a high degree of consistency, and would directly support the types of decisions that promotion and special boards and personnel officers are required to make. The attainment of this objective gives the new system a distinct advantage over the effectiveness of the present OER and the field test proposal.

the new Air Force OER

These, briefly, then, were the steps which led to the final selection of the new system.



JOB PERFORMANCE EVALUATION

I. RATEE IDENTIFICATION DATA

380 Cmbt Spt Gp (SAC)
Plattsburgh AFB, N.Y.
FSSDJ9

FROM 1 Sep 73
THRU 31 Aug 74

II. JOB DESCRIPTION 1. DUTY TITLE Enter duty title as it appears in UOR on closing date of report.
2. UNIQUE DUTIES AND TASKS Concisely outline anything not clearly implied in duty title.
3. TYPE AND LEVEL OF RESPONSIBILITY UNIQUE TO JOB Required only if not adequately described above.
(See Figure A7-2 for Performance Standards)

III. PERFORMANCE FACTORS

What has the officer done to actually demonstrate depth, currency, or breadth of job knowledge in the performance of duties? Consider both the quality and quantity of work.

Does this officer think clearly and develop correct and logical conclusions? Report on how the officer grasps, analyzes and presents workable solutions to problems.

Does this officer look beyond immediate job requirements? How well does he/she anticipate critical events?

Does this officer "manage" to achieve optimum economy through effective utilization of personnel and material? Consider the balance between minimum cost and false economy to the ultimate extension of the mission.

How has this officer demonstrated ability in initiating ideas and action in organizing effort, obtaining the cooperation and respect of others and in directing the effort of others?

What is the effect of stress on the officer's performance? Does he/she work as well or better under adverse conditions? In difficult situations, heavy workloads and pressures, does his/her work deteriorate?

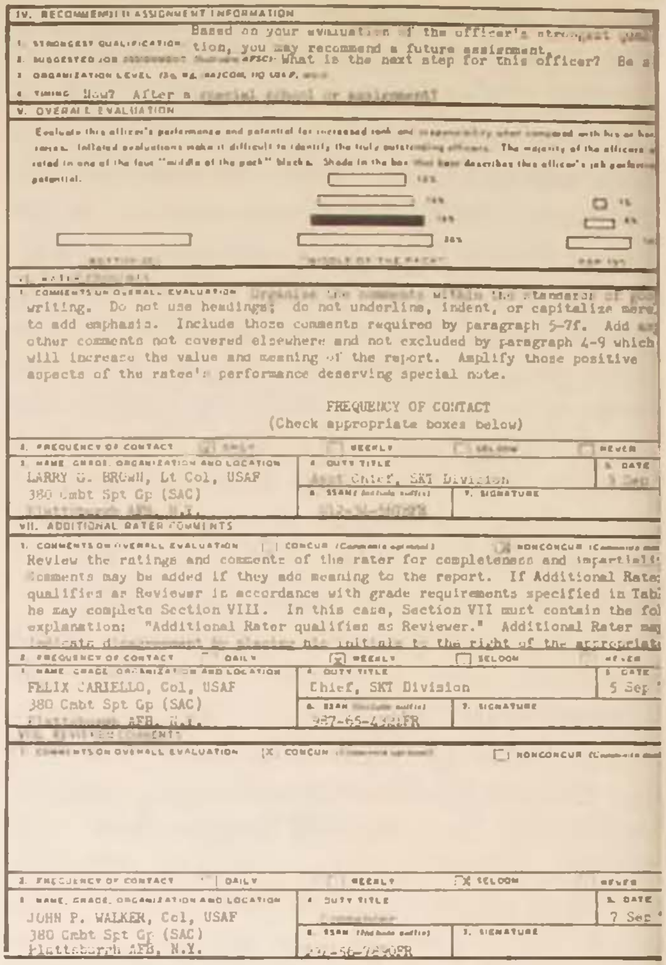
How well has this officer been able to present ideas orally?

How well has this officer been able to present ideas in writing?

To what extent does this officer meet standards of bearing, dress, and courtesy and enhance the image of the Air Force Officer?

How does this officer demonstrate his support of the Air Force Equal Opportunity Program? Evaluation of this factor is MANDATORY for all officers.

Figure 1. Job Performance Evaluation form, page 1



IV. RECOMMENDED ASSIGNMENT INFORMATION

Based on your evaluation of the officer's strongest qualification, you may recommend a future assignment. What is the next step for this officer? Be as specific as possible.

V. OVERALL EVALUATION

VI. RATER COMMENTS

Organize the comments within the standards of good writing. Do not use headings; do not underline, indent, or capitalize more than necessary to add emphasis. Include those comments required by paragraph 5-7f. Add any other comments not covered elsewhere and not excluded by paragraph 4-9 which will increase the value and meaning of the report. Amplify those positive aspects of the ratee's performance deserving special note.

FREQUENCY OF CONTACT
(Check appropriate boxes below)

LARRY G. BROWN, Lt Col, USAF
380 Cmbt Spt Gp (SAC)
Chief, SKT Division

VII. ADDITIONAL RATER COMMENTS

Review the ratings and comments of the rater for completeness and impartiality. Comments may be added if they add meaning to the report. If Additional Rater qualifies as Reviewer in accordance with grade requirements specified in Table ..., he may complete Section VIII. In this case, Section VII must contain the following explanation: "Additional Rater qualifies as Reviewer." Additional Rater may indicate disagreement by placing his initials to the right of the appropriate ...

FELIX CARIELLO, Col, USAF
380 Cmbt Spt Gp (SAC)
Chief, SKT Division
5 Sep

VIII. REVIEWER COMMENTS

JOHN P. WALKER, Col, USAF
380 Cmbt Spt Gp (SAC)
Plattsburgh AFB, N.Y.
7 Sep

Figure 2. Job Performance Evaluation form, page 2

The new forms are shown in Figures 1 and 2, Job Performance Evaluation, and Figures 3 and 4, Promotion Potential Evaluation. The Air Force Council, Air Force Chief of Staff, and the Secretary of the Air Force approved the new OER in August 1973.

OER feedback and control

The importance of immediate and stringent control over the release of evaluation data was emphasized earlier in the article. The new system will selectively limit the feedback of data to both the ratee and personnel officials.

Although the ratee may see his or her job performance evaluation, the overall evaluation will not be reduced to a number or made part of a numerical index which would be printed on personnel forms such as the Career Brief. Immediate controls will be placed on the "open" overall job performance evaluation. USAFMPC will closely monitor and analyze the rating distribution by grade for each major air command. A significant number of either very high or very low ratings will trigger an immediate in-depth review. If it appears that the ratings are in fact out of line, USAFMPC will notify senior officials of the major air command. If the problem is not corrected in a timely manner, the Air

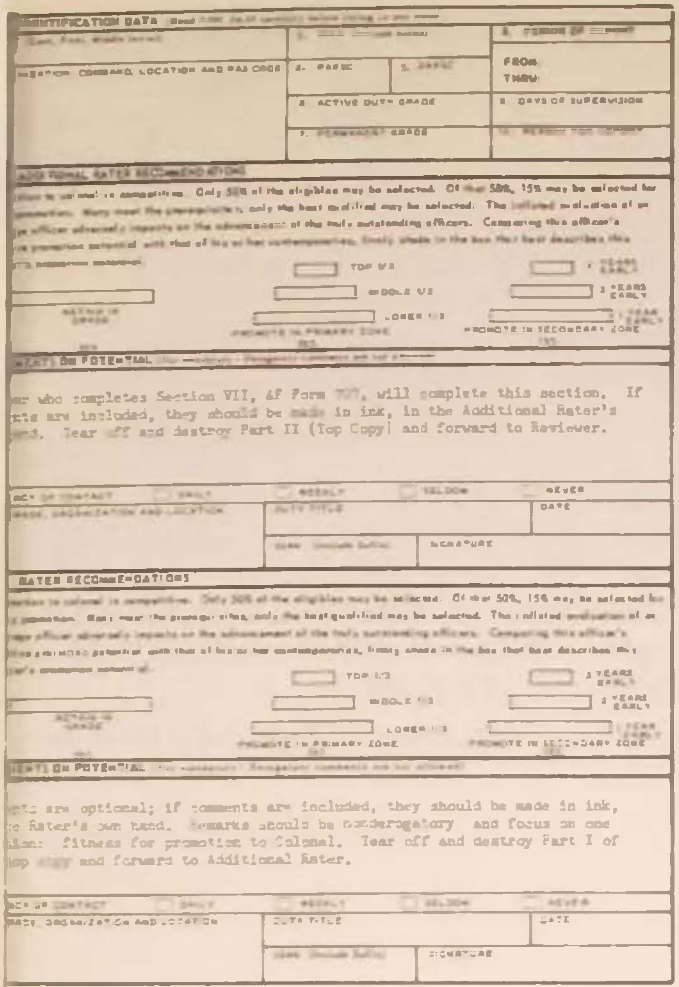


Figure 3. Promotion Potential Evaluation form, page 1

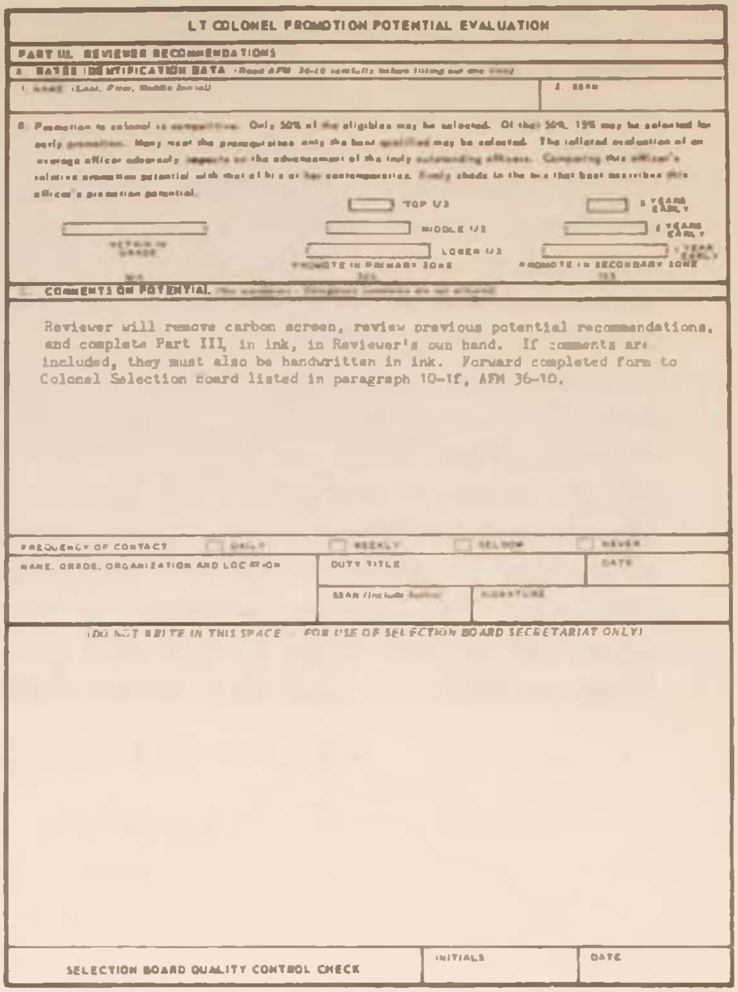


Figure 4. Promotion Potential Evaluation form, page 2

Force Chief of Staff will, if necessary, personally become involved to assure that effective corrective action is taken.

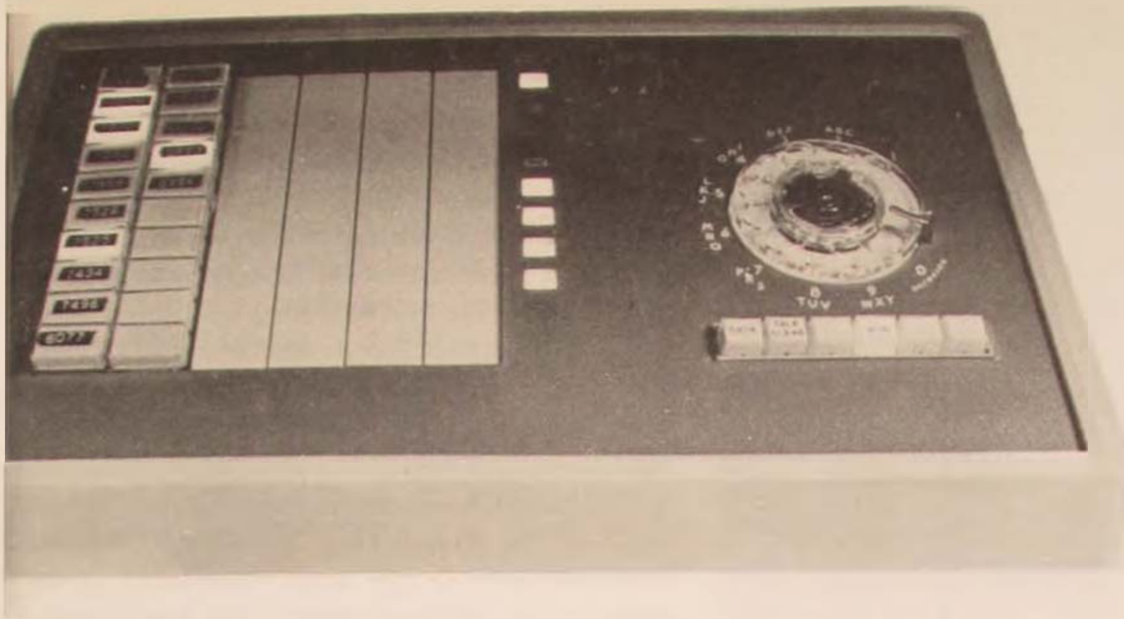
Tight controls will be placed on the analysis and feedback of the closed lieutenant colonel promotion potential evaluation data. Lieutenant colonels will not see the completed form nor receive any feedback on their promotion potential rating. These ratings will not be subject to analysis unless specifically directed by the Deputy Chief of Staff, Personnel. Only a very few select individuals in a vault-type environment at USAFMPC will be involved in the quality control of the reports.

The necessity for some type of control is highlighted by the recent experience that another service had in implementing a new officer evaluation system. It was found that changing to a new form in an "open" system had little, if any, effect on rating inflation. No initial system for tracking and, in turn, controlling rating distribution was implemented. The experience there to date indicates that some type of effective rating control in an "open" OER system is essential.

THE new OER is responsive to the objectives which were established. The new forms add a new dimension in rating fairness and objectivity. Promotion and special boards will gain additional insight into officers' readiness for increased rank and responsibility. The difficult job of selecting officers for promotion, key assignments, school attendance, and other important personnel actions should be accomplished with greater efficiency and validity. A system which will identify and correct obvious abuses in rating inflation or deflation has been established at the major air command level. Emphasis has been placed on clearly identifying the difference between current job performance and promotion potential. The ratee is informed by specific example as to how he measures up to established standards. The unique elements of the ratee's job as they relate to type and level of responsibility are identified. Some of the traditional elements of the present OER system were dropped to discourage the transfer of the same patterns of rating inflation into the new system. Finally, significant progress has been made in reducing the administrative details of accomplishing the new forms. The use of preprinted identification data, restricting required written detail, limiting the number of additional reporting officials, restricting comments to the space provided, and the application of impression paper—all have simplified the rating process.

A better system has been established. It has been three years in the making. It is the approved system; it is a fair system; and it will be an effective system, with the anticipated support.

Industrial College of the Armed Forces



AN AIR WAR COLLEGE COMPUTER STEP FORWARD

Colonel Fredrick R. Westfall

OFFICERS attending the Air War College in 1973–74 are participating in a computer exercise that introduces new dimensions of realistic complexity to their force posture planning study. This computer application is in answer to a question being asked within the Air University academic complex at Maxwell Air Force Base, Alabama: How can the computer be used to improve the quality of professional military education? This is an especially pertinent question today because the Air University schools have local computer support for the first time.[1]

The Air Force Data Systems Design Center, located at nearby Gunter Air Force Station, began operating the Honeywell 6060 computer in October 1973 and was made responsible for providing time-sharing and data processing service to Air University.[2] This local capability enables the schools to explore and exploit use of the computer to a degree not possible before.

Through the years all the military services have experimented with the computer in their education programs. Interest has been particularly high in the senior service schools, where projects have ranged in size from small experiments involving a few students working in highly specialized disciplines to the large, complex project involving an entire class.

Though the Air University schools have engaged in such activities, the degree of participation has been necessarily limited because of the absence of local computer capability. Computers at distant bases have been tried. For example, IBM cards and computer print-outs were at one time carried by air courier between Maxwell and Eglin Air Force Base, Florida. Also, teletypewriter terminals have been used to access the Rome Air Force Depot computer in New York. But these arrangements were less than satisfactory because of inconvenience, poor reliability of the remote terminal operation, and low priority of student problems in the computer work schedules. Now the situation has changed.

In 1973, in anticipation of the nearby computer capability, the Air War College performed an experiment. From twenty-four student seminars, two were selected to use the RAND Corporation computer and force posture planning model for support in their accomplishment of the force structure part of the National Security Study.[3] The other twenty-two seminars developed forces without these tools. They, as previous classes, accomplished the task manually with pencil and paper. The success of this pilot program has led to a research project designed to provide force structure planning computer support simultaneously for all student seminars.

The National Security Study

At the Air War College, this is a time of change. The curriculum is under special scrutiny to make sure it is in phase with shifting Air Force needs. New subjects and approaches vie with old ones for a place in the schedule. In this climate, the application of the computer to the National Security Study is progressing with unusual success.

The National Security Study was developed in response to Air Force concern that senior officers who are preparing for high command and staff positions should acquire an appreciation for the difficulties associated with functions such as:

Perceiving threats to the nation
Postulating national objectives and policies
Estimating constraints on the defense budget
Formulating national security strategy
Developing a total force posture
Coping with crisis situations.

These six major parts to the study are approached consecutively in the year-long academic schedule, each following the presentation of closely associated subject material. The study is a "common thread problem" because responses to its requirements tend to summarize and interrelate major areas of instruction.

The study addresses an assumed twelve-year time period. Students analyze current five-year force and financial programs for all the services before looking at force requirements in the far term, the last seven years of the study. The final step in the student exercise is the most important group project, for each seminar must present and defend its results to civilian guests during the week of the National Security Forum in May.[4] Since this presentation is the last student requirement of the academic year, it in many respects resembles a final examination. Many of the guests are knowledgeable in defense matters, and all are interested in learning what the students believe should be done to preserve the security of the United States. The experience is an excellent proving ground for the students, and guests describe the session as the high point of the National Security Forum week.

Force Posture Exercise

The force posture exercise has been the most heavily emphasized single element in the National Security Study. It carries the urgency of the present, and it projects into the future the impact of difficult decisions. Consequently, students should tackle this problem with considerable interest because the size, composition, and mix of weapon systems and force elements, along with their associated costs, are at the heart of national security planning. The academic exercise tries in a few classroom hours to provide the Air War College student a better appreciation of the enormity, complexity, and importance of the force planning task.

Application of the computer to the force posture exercise culminates step-by-step, essentially year-by-year, revisions to relieve the student of voluminous, almost unmanageable detail and to afford him the means of organizing and determining costs of force elements and weapon systems meaningful to his solution. For example, four years ago students worked the problem from the published service five-year programs.[5] The size of these documents and their detail made them difficult for seminars to

Air War College is using computer technology to provide students better tools to accelerate and improve their accomplishment of force posture requirements for a year-long student exercise, the National Security Study.

Faculty and students extract the force elements and weapon systems data that form the basis of AWC studies directly from the Service Five Year Force and Financial Programs. . . . An AWC student, assisted by a computer specialist, accesses the RAND Corporation computer and Force Posture Planning Model in Santa Monica, California, by teletype.

Major General James V. Hartinger, Commandant, Air War College, experiments with the force posture planning model on a video display terminal and listens while a systems designer explains the merits of the cathode-ray-tube type of terminal. This terminal is being considered for the near future because it will reduce the quantity of hard copy that comes from the teletypewriter now in use. Force structure data are manipulated arithmetically, inputs are changed until the display represents the intended force posture, and then results are expressed in tabular form on batch print-outs. . . . Faculty team members review the batch print-out of a force posture to ascertain that the data are compatible with the quick-response video display. These print-outs give each seminar a complete, well-organized summary of its specified force posture and associated costs.

hurdle in the short time allotted in the schedule. Then in March 1972 RAND published a document for the college that aggregated data from the service programs and simplified the presentation and organization so that students could accelerate their familiarization with pertinent forces and more readily build and cost their force structure for the National Security Study.[6]

Still the process had to be accomplished in the classroom at the blackboard, and arithmetic operations had to be done by hand. Obviously, the pace was slow, and the force development was crude. Under these circumstances, the introduction of a simulated national or international crisis was virtually impossible. As a consequence, students did not experience a formal opportunity either to review their problem-solving methods critically or analyze the interrelationships among the parts of the National Security Study.

In November 1972, local computer support appeared a certainty, and this, in combination with a RAND presentation of its force posture planning model at Air University headquarters, sparked the conception of a pilot program in which the computer was to be applied to the force posture exercise.[7] The computer and the model offered a way to handle the reams of force posture information so that it could be quickly, mechanically, and accurately organized, arithmetically manipulated, and presented. Thus, the student would be removed from the morass of tedium and elevated from the role of accountant to that of national decision-maker.

Pilot Program

Over the years, the theme of the National Security Study has remained the same—to provide students an appreciation for the difficulties associated with building an adequate and responsive force posture from limited resources. Only the scope and thrust of individual parts of the study have changed. Usually, variations have reflected fine tuning whereby the college updated and refined student tasks. But introduction of the computer promised several major changes. Consequently, a pilot program was devised to explore the possibilities.

RAND made its computer available to the Air War College, and a team of Air University and RAND personnel modified and expanded the RAND model so that it could be tested under actual classroom conditions in April 1973.

The RAND model is available in two independent but compatible versions. One is for quick response. It is programmed on RAND's on-line, time-shared computer. The other version is programmed for batch processing on general-purpose computers. In the pilot program, only the quick-response version could be used. The batch model promised scheduling flexibility and more extensive and informative print-outs, but it was incomplete. Furthermore, a nearby computer on which the batch program could be run was not readily available. Consequently, special force posture problem requirements and instructions were prepared so that the two student seminars in the pilot program could utilize teletype terminals at the Air War College to access the quick-response version on the RAND computer.

Originally, the RAND model addressed only strategic forces. This limitation was removed by a series of modifications that enabled the model to exercise data also on general-purpose, airlift/sealift, national guard, and reserve force programs. The model calculates time-phased funding over a twelve-year span for the various weapon systems, force elements, and the complete military force posture. Particular costs that are forecast include research and development, investment, operating, and totals. The model accepts either single or multiple changes in the weapon systems line items and provides the associated costs to permit comparison and identification of spending requirements and trends.

In contrast to students in the regular course who could work only superficially with the very major line elements, participants in the pilot program were able to develop rapidly in some detail the size, composition, and mix of strategic, general-purpose, airlift/sealift, national guard and reserve, and committed allied forces with little manual effort. The total force was designed to support their national security strategy from 1974 through 1985. The computer took into account the seminar's research and development programs and determined the cost of the entire force for each year of the study.

Seminars began the exercise with a given data bank on some 150 key weapon systems/force element aggregates that together represented a reasonable facsimile of the United States line force posture for the current year. These line items were identified and briefly described in a systems list. This "menu" included systems currently in inventory, those in research and development, and conceptual systems that could be brought to fruition in the time frame of the study.

Costs associated with the systems were provided from the terminal in the format shown in Figure 1. The columns in the figure may be explained as follows:

R&D costs are allocated either for the development of a conceptual weapon system, line item 5—Air Mobile Missile Carrier (AMMC), or for continuing development of an existing system, line 6—B52 Advanced Model (ADV). Total cost and years for the R&D program are specified. An algorithm in the model takes this input and divides the outlay among the years of the program. Another option is illustrated after line 4—B1. The total R&D cost and program length

	#	R&D $	R&D YRS	SLOPE	$/UE	INV LEAD	AO/UE
B52 C/F	1	.0	0	.000	.00	0	1.650
B52 G/H	2	.0	0	.000	.00	0	1.650
FB 111	3	.0	0	.000	.00	0	.900
B1	4	.0	0	.879	130.00	4	1.700
		1	475.0	370.0	275.0	195.0	120.0
			.0	.0	.0	.0	.0
AMMC	5	400.0	4	.903	64.00	4	1.000
B52 ADV	6	75.0	2	1.000	3.00	1	1.500
KC 135	7	.0	0	.000	.00	0	.500
KC 235	8	125.0	4	.980	35.[illegible]	3	2.500

Figure 1. The cost data made available to the seminars in computer format enable them to base their work on a reasonable facsimile of the real USAF line force posture.

are entered as zeros, then the annual R&D costs are printed out after the "1." Thus, 475 million dollars appears in 1974, 370 million in '75, 275 million in '76, and so on through '85.

Numbers in the "Slope" column, ranging from 0 to 1, give the value of the investment learning curve slope, which states that as the total quantity of units produced doubles, the cost/unit declines by some constant percentage.

The next column, $/UE, gives the investment costs beyond the development phase to deploy a weapon system as a mission-capable force.

The lead time in years from initial funding to deployment appears next.

The final column, AO/UE, shows the annual costs to operate and maintain each of the weapon systems.

Initially, each seminar had either to accept or modify this data base so that it conformed with the seminar's view of the current-year force posture. For example, seminars could add or delete systems, change cost factors. and introduce other conceptual packages. Then they used planning worksheets to project their force year by year. The RAND model provides several informative data output options so that organized tabulations of weapon systems and associated cost information were readily available. Whole force programs or single line elements were readily manipulated at the terminal according to the designs of the student.

Next, students compared the cost of their objective force with a given budget that incorporated the spendout phenomenon. "Spendout" is the downward projection of expenditures for weapons that occurs in the out years because weapon systems and their costs are not well defined far out in time. This improvised defense budget effected an economic constraint in the far term, which forced students to control their force projections carefully.

Throughout the exercise, the computer contributed significantly to the decision process, providing an elevated perspective of the problem. Students were able to con-

A computer technician monitors operation of the Ho well 6060 computer by console typewriter and display. . . . The 6060 disk storage device used the AWC force posture data base and computer grams can store 27.6 million characters of informa

centrate on the more important aspects of problem solving: addressing and assessing their goals, hypotheses, criteria, guidelines, approach, and judgment.[8] Also, the time the computer saved and the capability it provided allowed introduction of the exercise section, Crisis Situations. As a result, the study acquired new dimensions. Hypothetical crises with which students had to cope—a defense budget slash of several billion dollars or a technological breakthrough in surveillance equipment that degrades one leg of the TRIAD—caused repercussions that reverberated through every element of the study. Consequently, the entire package was viewed from a different perspective. The prime question, of course, remains: What is your force posture? Now, however, students have the opportunity to address in some detail very relevant questions that previously could only be treated superficially. How does a major change in any one part of the National Security Study impact the other parts? How can we improve the problem-solving methodology?

The pilot program manifested the real and important benefits that accrue from the application of the computer to the National Security Study. Accordingly, the Air War College has expanded the program. In April 1974, all twenty-six seminars will be using the computer to satisfy the requirements of the study.[9] This decision has led to a rather large Air War College research project.

Computer Application Research

The work necessary to prepare a force posture planning model for simultaneous use by all the student seminars exceeded the manpower resources of the Air War College faculty and staff. Several areas of research are involved, and all must be integrated into a schedule that leads to a final product in less than an academic year.

The manpower problem was resolved by the formation of a team of Air War College faculty and students and professional computer personnel from other Air University

organizations. The nature of the research qualified the project for student participation under the college's Professional Studies Program. In fact, it is particularly appropriate to that program. Students are concerned with a primary military subject, force posture. They interact directly with a computer and contribute to the improvement of the college curriculum. The project has first priority in the professional computer personnel work schedules, and three officers have been assigned full-time to develop the model and make it operational.

The thirty participating officers were organized into groups to address the five major research areas, each having a specific purpose:

- Force posture planning model—To develop a time-share/batch model that satisfies the unique requirements of the National Security Study for use on the Gunter computer.
- Weapon systems—To expand, refine, and improve the weapon systems data base used in the RAND model and to investigate the possibility of an allied force data base.
- Support systems—To explore ways to provide seminars with the capability to include support program costs in the force structure exercise.
- Mobility program—To search for ways to include airlift/sealift programs in the new model.
- Overview—To update and improve every part of the National Security Study in consonance with the advances made possible by the application of the computer.

Before the groups embarked on their research, team members went through an intensive orientation program. They learned to operate the teletype terminals and to access and use the RAND computer and model just as the student seminars had in the pilot program. The trial of the new model and data base by the faculty early in February 1974 assured time to fine-tune the entire package—computer model, data base, special instructions, and documentation—before use by the class in April.

As ILLUSTRATED by this example, productive uses for the computer in professional military education are waiting to be discovered. Certainly, the Air University academic complex at Maxwell Air Force Base will be employing the machine more and more in the future, now that it is readily available. And every worthwhile application will advance the curriculum in which it occurs. The ultimate result will be an improved Air University product—a better qualified and more fully informed officer graduate.

Air War College

References

1. The Air University academic complex includes Air War College, Air Command and Staff College, Squadron Officer School, AU Institute for Professional Development, Academic Instructor and Allied Officer School, and the Senior Noncommissioned Officer Academy.

2. The Honeywell 6060, a worldwide military command and control system type of computer, became operational in 1973. Air University is custodian.

3. K. J. Hoffmayer, D. C. Kephart, and B. A. Horner, "Force Posture Planning Model," R1150-PR, RAND Corporation, Santa Monica, California, March 1973.

4. The National Security Forum week always occurs close to the end of the academic year. The forum provides prominent American citizens and Air War College students the opportunity to exchange ideas on national security affairs.

5. "Department of the Navy Five Year Program, FY 73–79," Department of the Navy Program Information Center, Washington, D.C., October 1973. (Report is SECRET.)

"Department of the Army Five Year Defense Program, FY 69–82," Office, Director of Army Budget, Comptroller of the Army, Washington, D.C., February 1973. (Report is SECRET.)

"USAF Force and Financial Program, FY 72–78," Office, Director of Budget, Washington, D.C., February 1973. (Report is SECRET.)

6. J. C. Davidson, "Cost and Building Block Data for the Air War College's 'National Security Problem' Study," RAND Corporation, Santa Monica, California, March 1972. (Report is CONFIDENTIAL.)

7. Colonel J. L. Sibley, Deputy Chief of Staff, Education, Air University, invited personnel of RAND Corporation to demonstrate its force posture planning model at Maxwell Air Force Base. K. J. Hoffmayer and D. C. Kephart made the presentation in November 1972.

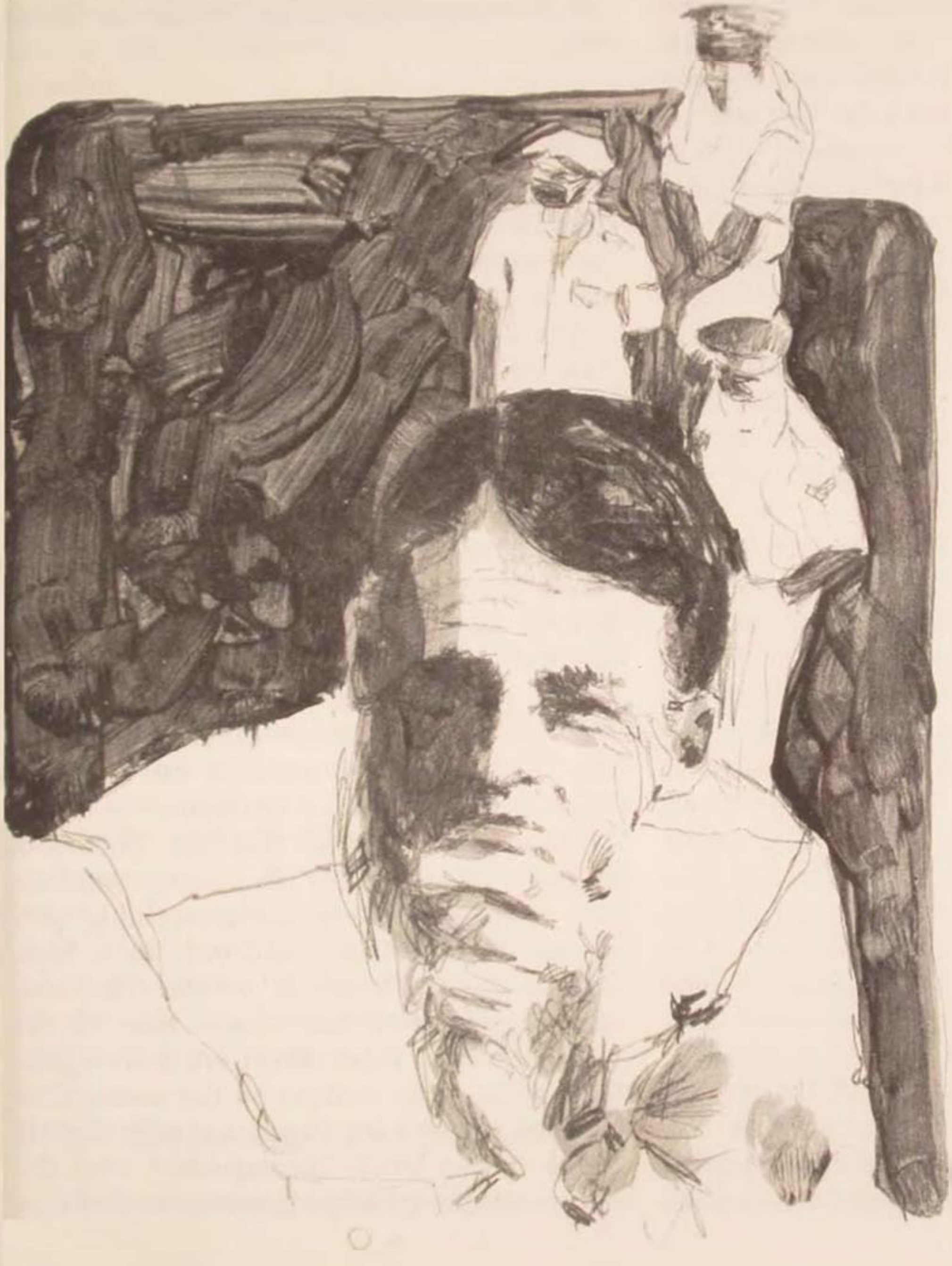
8. Lieutenant Colonel James E. Hughes, "The Next Decade in Computer Development," *Air University Review*, May-June 1966, pp. 64–70.

9. The Air War College class of 1974 was expanded to 315 students, causing the increase from 24 to 26 seminars.

In My Opinion

PERSONNEL MANAGEMENT

Lieutenant Colonel Frank W. Jenkins



DEVELOPMENTS in the past few years that will have significant impact on managing people are especially worth exploring in view of the advent of the "all volunteer force" in the military. If productivity and efficiency can be heightened while making the worker better satisfied with his job, the Air Force cannot help benefiting. The management developments to which I refer derive from findings of the behavioral scientist.

One problem with many ideas of the behavioral scientist is that they seem so obvious we assume them to be already in use. Also, we often tend to look upon the behavioral scientist approach as "too soft" to work in the military. For example, because we question the feasibility of participative management in flying an aircraft or commanding a unit, we tend to discard the idea altogether. Nevertheless, if we believe even half of what we espouse regarding the value of people in the Air Force, it is clear that we cannot scoff at any personnel management ideas that might help attain and retain a force of people capable of performing the mission.

The behavioral science influence has become increasingly noticeable in military management philosophy in the recent past. The Air Force Personnel Plan lists certain objectives to be met, each objective having an attending officer-in-charge whose job it is to ensure that the objective is attained. In the jargon of the behavioral scientist, this is known as "management by objectives" or MBO. However, the Personnel Plan guidelines, while effective, do not follow the MBO concept as originally conceived by Peter Drucker, Douglas McGregor, and others, which was based upon true participative management.

There is nothing wrong with listing specific objectives in the Personnel Plan. On the contrary, I believe this is a much-needed action that would certainly be of benefit in other management areas as well. But we delude ourselves if we think we have harnessed the essence of the management by objectives concept. Such an assumption exemplifies a common tendency in the military to grasp a popular phrase or basic idea, write a regulation around it, and believe that the latest management methods are being exploited. For this reason I intend to discuss some of the major concepts of managers oriented in the behavioral sciences and relate their findings to the personnel management task facing the Air Force today.

Theory X vs. Theory Y

When Douglas McGregor introduced his Theory X and Theory Y concept in 1960, he endowed his Theory X manager with the firm belief that the average human being was a slacker who had an inherent dislike for work.[1] A Theory X manager, said McGregor, must coerce, direct, and threaten his subordinate with punishment to make him perform. In contrast, a Theory Y manager believes that expending energy for work is as natural as expending it for play. He tends to regard the individual as having a high degree of imagination, ingenuity, and creativity to apply in solving organizational problems. It is important to note that McGregor was not differentiating between management methods but between the ways people think of others.

McGregor believed that the Theory X manager was by far the most common and that most literature concerning personnel management could only have been written by a Theory X writer. This certainly appears to have been true in the military, since most directives and regulations seem to be written on the assumption that the reader's intelligence is only slightly above moron level. Consequently, over the years we have helped create a first-line supervisor, middle manager, and even commander who believe that the only way to lead is to direct, coerce, control, and threaten the individual worker. If he doesn't respond with acceptable performance, we "throw the book" at him. In this age of increasingly expensive training and with our goal of an all-volunteer force, we cannot afford to so readily discard such a valuable resource. If we are going to make the volunteer Air Force work and keep the cost of such a force to a minimum, we must listen to what the behavioral scientists are saying and adopt their techniques when possible.

Not all of us truly believe the individual we lead, manage, or command is just as anxious as we are to accomplish the job at hand. More likely, we look upon many of our subordinates as near impediments to mission accomplishment. Often the supervisor believes he can do the job better himself anyway, so he does it. Or the commander feels he can handle virtually all problems that arise within his unit, so he tries to. These attitudes not only presuppose that the subordinate is incapable of handling the situation but, more important, cause the manager or commander to get so tied up in detail work that he neglects his own job. He is not making those decisions which he alone can make.

Any improvement in our personnel management techniques must begin with the Air Force manager drastically changing his basic attitude about people. An all-volunteer force, by its very nature, will consist of people who are trying, as best they know how, to get the job done. We must give them the knowledge needed to do the job, tell them what is to be done, and trust them to do it.

Management by Objectives

The term *management by objectives* was first used by Peter Drucker in his book *The Practice of Management.*[2] As mentioned earlier, this is one of the catch phrases currently in favor but rather poorly interpreted nevertheless. Drucker's use of the term is based on a participative approach to management. He believes that a man tasked to do a job needs to get involved in decisions regarding ways to accomplish that job and, in coordination with his supervisor, should set measurable goals for achieving the objective. This approach works best when there is a more or less repetitive task to be performed or when a time limit can be established, but it will work to a large extent in almost any work situation. We all have faced the totally unrealistic suspense date that must be met, yet how many times have we been asked what a reasonable time limit might be? When you are about to give your subordinates a job to do, why not call them together, present the problem, solicit their recommendations for accomplishing the objective, and reach an agreement on a time limit? This approach has two distinct benefits: first, some excellent ideas may surface that otherwise would not; and second, the individuals selected to perform the task will be more committed to attaining the objective than they would be had they not participated in the decision-making process. The essence of MBO is simply to establish realistic objectives or targets that are mutually agreed upon between supervisor and subordinate.

Integrate Individual into Unit

Chris Argyris has pointed out that the organization that manages to have every individual working toward a common goal, matching that of the organization itself, will be more successful than one that does not.[3] Two key elements must be present for this to happen in any work unit: first, the individual must know where he fits in the organization as well as where the organization fits in the larger mission; and second, he must accept the goals of that organization as his own.

This may seem like a most obvious idea, but I recall an incident when I was executive officer in a refueling squadron. A sergeant from maintenance brought a young airman to me with various complaints about his not wanting to work on the flight line. The sergeant wanted to court-martial the man for insubordination. I took the airman into my office, sat down with him, and we began to talk. I asked him if he knew what the mission of the unit was. He replied, "To fly airplanes." I asked him if he knew where they flew to or what they did. He knew neither. For the next few minutes I explained that our job was to refuel fighter aircraft in the event we were called upon for help in various parts of the world. I showed him maps of places where similar aircraft were deployed and explained why they were vital to our nation's security. I even scheduled him to ride as an observer on a training mission. The young man never had any trouble after that.

The point of the example, of course, is that something was drastically wrong when that young airman had to get so close to serious difficulty before having explained to him the importance of his role in the unit mission. After I related this incident to the Commander, we initiated an education program, not for the one-, two-, and three-striper on the line but for every supervisor in the unit. These are the men whose job it is to explain the unit goals to the young airman and get his efforts directed toward those same goals. Their goals must parallel those of the organization.

Job Enrichment

A further step in our attempt at better personnel management in the Air Force is extremely difficult to achieve and may in some cases be impossible. Frederick Herzberg refers to it as job enrichment.[4] Some in the military have confused this concept with a need for job enlargement. They falsely believe that by giving a man more of the same work to do they have enriched his work and made his job more rewarding. Not so. Job enrichment means making the task at hand as meaningful and worth doing as possible. Some jobs are so routine that they can never be enriched, and every effort should be made to automate these, if at all possible. (On the other hand, the fact that sometimes a job can become richer merely by giving it to a different person indicates that richness lies within the perception of the doer.)

A job can often be enriched simply by increasing responsibility. A sergeant who worked for me in a major command personnel shop took over a very routine task. He was a college graduate, so I was not surprised when he very quickly requested more to do. I gave him two new tasks. First, using information from his work unit, he was to prepare the biweekly briefing given to the Director, which had previously been prepared by a senior NCO or officer. Second, he was to devise a means of mechanizing his job. The first task he accomplished within thirty days, and the second in about six months. Needless to say, the tasks I gave him after that time were neither dull nor routine.

If the Air Force doesn't want dull people, it had better make its jobs interesting and rewarding; only dull people like dull jobs. Unfortunately, the trend in the Air Force seems to be to mechanize many of the more interesting jobs because we have the capability to do so, rather than to improve management. One very interesting NCO or officer job that is becoming more mechanized is the assignment process. A mechanized system has been justified with regard to reassigning enlisted personnel because of the large numbers involved, but I find little justification for its use in the officer assignment area. Yet we seem to be heading in that direction. One reason we have relatively fewer complaints from officers regarding reassignment than we do from airmen may be that the officer still has someone to talk to if he is not satisfied, while the airman does not. After conferring with his career counselor, an officer may continue to be unhappy with his assignment, but he has at least received an explanation for the action. We've designed the system so the airman has no one to talk to regarding his assignment except the computer, and I'm afraid we will eventually do the same for the officer. We not only lose several challenging jobs but also forsake good management practices for the sake of computer capability. On the other hand, many dull, repetitive tasks that could and should be mechanized by the Air Force continue to grow in size; the base of preference and assignment swap programs are examples in the personnel area.

Organization

A difficult problem facing the military manager today is how to work within an outmoded, bureaucratic organizational structure and still get the job done. The Air Force is organized around traditional line and staff relationships handed down through the centuries. We have so entangled the work force within a web of organizationally oriented manpower systems that it is becoming impossible to get the job done without deviating from those systems.

In his book *Changing Organizations*, Warren Bennis points out that because of the increased rate of technological, social, and political change in the world it has become necessary for large organizations to adopt a more responsive work structure.[5] Many progressive companies, for example, are adopting unstructured work units consisting of perhaps twelve to fifteen members. The work unit is given a task to perform, and, using participative management techniques mentioned earlier, the unit decides how best to accomplish the job. If the method adopted proves less than ideal, the unit is free to change the system until a workable one is found. Finally, each worker performs the job for which he is best suited, and the unit operates at peak efficiency. If the task changes, the unit adapts to that change after another "brainstorming" session. Most of us have seen this situation in the military when an ad hoc committee is formed to accomplish a particular task. Usually, the committee is dissolved, and the individual returns to his "assigned" position. I would not recommend creating additional work for an ad hoc committee simply to keep it in being, but I would argue that the ad hoc group may be the "normal" organization of the future, while the structured line and staff organization may be needed only in specific cases.

Part of the web I mentioned is the OER/APR system, which cannot readily adapt to flexible manpower shifts. Also, the traditional chain-of-command, which requires that each man have but one boss, can foster specialization to the point of inefficient workload distribution.

I recently had the opportunity to experiment with an unstructured work unit. One of the first things I did when I assumed the job was hold a meeting of all personnel in the division, acknowledge that they knew what their tasks and capabilities were better than I, and ask for their recommendations on organizational structure and job tasking. I received three not dissimilar recommendations, all significantly different from the established organization. We resolved the minor differences and reached agreement on workload distribution. As a necessary concession to the established system, everyone in the division was informed that although I would act as the rating official for OER/APR purposes, the senior NCO or officer in each work center would prepare an evaluation on each man working with him on a given task. A follow-up meeting about thirty days later took care of some minor job adjustments. After that time, adjustments were made only as job requirements were changed. We worked that way for the next two and a half years, and I believe that group to be the most capable, efficient work unit I have ever supervised. One major benefit was the ability of the unit to accept a "crash project" with no difficulty whatsoever. I also found that ours was the only work unit in which some individuals did not sit on their hands while others had work piled on their desks. Every member got to know the peaks and valleys of all the work centers and automatically pitched in to help where needed.

Obviously, these results could not be repeated for every work unit regardless of the size of the organization or the mission to be performed. But I find that more and more the Air Force is of necessity using what Alvin Toffler refers to as ad-hocracy management.[6] It is rather commonplace for a specialist to be pulled out of his work unit to perform on a particular project. This is good as far as it goes, but I believe the Air Force must devise methods of allowing this procedure to be the norm rather than the exception. Two stumbling blocks to this end are the inflexible manpower system as well as an unrealistic and unresponsive rating system.

We need a more flexible manpower system that will allow the manager to adjust his force as necessary. Unfortunately, because of computer capability, the Air Force is allowing the system to dictate its organizational structure, rather than force the system to adjust to a more satisfactory management method when one is available. We also need a rating method that will allow for a far simpler evaluation to cover jobs of short duration—a system, for example, that would enable an ad hoc committee chairman to rate an individual on his performance even if it covered only a few weeks.

THERE are two significant factors affecting personnel management that the Air Force must recognize if it is to remain a viable force capable of performing its mission. First, in the near future we can anticipate an austere manpower budget that will force optimum use of the personnel resource. In such an atmosphere, it becomes increasingly important that we reduce personnel procurement and training expenses wherever possible. Every fully trained individual we are able to retain will reduce these costs. Second, the Air Force must review its personnel and organization management techniques to ensure that latest methods are being used at all levels. Air Force managers must break away from using stereotype methods simply because bureaucratic inertia makes the introduction of new and better techniques difficult. Such techniques are available if we have the resolve to implement them.

Air War College

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PERSPECTIVES ON RACE RELATIONS

Time To Consider Phase III

Captain George H. Wayne

In the armed services *progressive* race relations have been realized only tentatively and incompletely. Since this viewpoint permeates the article, I will not hesitate to support and explain the conclusion it urges upon the reader.

For my purpose, *progress* has two meanings. In a first sense, *progress* refers to doing what has been directed—complying with the regulations. This first sense of progress allows us to cope with our environment—it involves a working knowledge of what is required to give the appearance of "doing a good job." This type of progress, in many ways, describes the services' approach to race relations almost from the beginning. We tend to show what is going on without providing the actual details of what has been accomplished or what is to be accomplished.

Typically, this kind of progress illustrates the working dilemma of a bureaucracy and the pitfalls involved when we fail to consider the entire spectrum of activities surrounding a new program. While this definition of progress explains many facets of our current race relations programs, it is a simplified approach in which a complex problem has become manageable for analysis and exhibition but not for lasting efficiency.

The second definition of *progress* is more meaningful. Here we are concerned not just with what is going on but also with what has gone on and what the plans are for the future. The two types of progress may be sharply contrasted. With the first we are providing "computer fodder" for bureaucratic "eyewash"; with the second we are focusing on the basic objectives—providing "equality of opportunity and obtaining equality of results." To clear up a semantic point here, "equality of results," in the words of Civil Rights activist Bayard Rustin, means a "distribution of achievements among minorities roughly comparable to that among the dominant groups." Within the framework of the second definition, I submit that our race relations programs in the armed services have not been progressive. Obviously we have not yet achieved equality of results. This is understandable, but failure to know where we have been or where we are going is not. It is now time to evaluate what we have accomplished, how far we have come, and consider what course or courses of action we have yet to follow.[1]

That our race relations programs in the armed services have still not become progressive, according to my second definition, implies some serious consequences. Yet, to conclude that the measures taken and investigations made into the problems of discrimination and racism by the Department of Defense have not contributed to the improvement of race relations would be a grave error, but to assume that we are on the safe side of the problem would be both naïve and misleading. The success is obvious; the deficiencies, however, are still present, suggesting that we are relying upon a bag of tricks which if adroitly manipulated will eliminate the problems associated with racism. What can be done to make the current programs more progressive? First of all, we must recognize our failures. Then we must continue, as Lieutenant Colonel

Earl W. Renfroe, Jr., candidly put it, "thrashing about for effective methodology." [2]

Since bureaucracies, by their very nature, tend to be intolerant of problems, they have a proclivity toward accepting temporary solutions and making hasty decisions before the problem is thoroughly solved. To find effective methodology to deal with the problems of discrimination and racism in the armed services, we must avoid total institutionalizing of any program until we reach our ultimate objectives: equality of opportunity and equality of results. The accompanying table lists some characteristics and consequences of three patterns of bureaucracy, which show the various approaches and the problems involved. Most organizations reflect various mixes of these three patterns; consequently, bureaucracy is unavoidable. The catalog of influencing factors causing organizations to institutionalize is endless. In spite of the "red tape" and "heavy-handedness" associated with bureaucratic organizations, we must meet dual demands. Briefly, we must be committed to today's policies and procedures, but not so deeply committed as to resist meeting and considering the challenge of tomorrow. In this context, I think we must take a hard look at what I shall call Phase I and Phase II of race relations programs and then consider a third phase.

Phase I

Phase I was implemented in 1948 when President Truman issued his historic Executive Order #9981 integrating the armed services. This was progress. Despite the pessimism expressed by top military leaders that it was not up to the armed forces to engage in social reform and that desegregation would degrade morale, efficiency, and mission accomplishment, vast improvements were realized in all three areas. For example, integration made overutilization and underutilization of skills no longer inevitable. The greatest achievement was that minorities could be assigned and promoted on the basis of merit, rather than race, creed, or color. The discarding of the quota system eliminated the necessity for recruiting or retaining minorities, especially blacks, regardless of qualifications. In other words, the abandonment of a quota system eliminated the necessity to admit minorities into the military who did not qualify for service. In the 1950s, even though the quota system was not eliminated in all branches of the service, the degree to which it was eliminated gave minorities, in both the service and civilian life, the incentive to meet the standards. As the 1960s approached, the quality of minority servicemen, both officers and enlisted men, had improved, and remaining vestiges of racial discrimination were rapidly being eliminated.[3]

The signs, however, were at times deceptive. Many observers, both military and civilian, interpreted the positive goals achieved during the fifties not simply as steps in the right direction but as curative. There was no Phase II in the contingency plan. Commanders and supervisors took great pride in stating, "I treat all my men the same." There was a tendency to oversimplify the building of altruistic character, which closed our eyes to the racism and discrimination that still existed. Overt racism was not acceptable, but covert racism was still a cause of unrest in the military. Specifically, even though many of the barriers to equal opportunity were removed, the fact of equality was inhibited by practices that "kept minorities in their place," by leaders who were ignorant of minority culture, insensitive to minority wishes and demands, and more concerned with mission accomplishment than with the tools necessary to accomplish that mission. In essence, the airplanes flew, the ships sailed, and the

Some Characteristics and Consequences of Three Patterns of Bureaucracy

Mock Bureaucracy	Representative Bureaucracy	Punishment-Centered Bureaucracy
1a. Rules are imposed by some outside agent, perhaps a headquarters staff group. Neither superiors nor subordinates in the unit affected participate in establishing the rules or enforcing them.	2a. Both superiors and subordinates initiate rules and help enforce them.	3a. Rules arise from pressures by superiors or subordinates, but not both, so that one feels imposed upon by the other and attempts evasion.
1b. There is usually little conflict between superiors and subordinates.	2b. There is some tension but little overt conflict.	3b. There is usually much tension and conflict.
1c. Joint violation and evasion of rules is supported by shared norms.	2c. Joint respect of rules is supported by participation of superiors and subordinates, their common education about problems, and their consensus about solutions.	3c. Rules are enforced by punishment based on norms of either superiors or subordinates, but not of both.

Adapted from Alvin Gouldner. *Patterns of Bureaucracy* (Glencoe, Illinois: Free Press, 1954), pp. 216–17.

tanks fired, and many concluded that no real problem existed when military units demonstrated such efficiency to the nation.

The realization that racism was still a primary problem facing the military came slowly. In the civilian communities across America, black Americans had launched a revolution considered by many to be the greatest upheaval since the organization of the large industrial trade unions in the 1930s. Influenced by this activity, which began to alter the nation's economy and to a great degree its politics, racial conflict and racial polarity became one of the most pressing problems confronting commanders and supervisors.

The military failed to act on its own. Consequently, many commanders were not prepared to cope with young minority recruits coming from communities in which the revolution was fully under way. These commanders did not realize, for instance, that one of the major prerequisites for revolution—rising expectations—had been added when the Kennedy-Johnson administration committed the federal government to the cause of black equality and took three steps to implement it. First, beginning with the establishment of the President's Committee on Equal Employment Opportunity and the enactment of the Manpower Development and Training Act of 1962, the federal government launched a national effort to redress the profound imbalances between the races. Second, the Economic Opportunity Act of 1964 began a major national effort to abolish poverty, a condition in which many minority recruits previously had lived. Third, the Civil Rights Act of 1964 marked the end of the era of legal and formal discrimination against minorities and created important new machinery for combating covert discrimination and unequal treatment. Naturally, with these events behind them, minority soldiers, sailors, and airmen entered the service demanding their rights, and in many instances they resorted to violence when they felt their long-denied privileges were being withheld.[4]

Whereas the military had led the nation in the area of race relations in the 1950s, it now barely qualified for second place when compared with industry and other federal agencies. Commanders who "treated all their men the same," especially in the area of discipline, sought to fight force with force. Thus, in the military, violence became an increasingly common reaction when the racist refused to alter his position. Not until 1968, when the Report of the National Advisory Commission on Civil Disorder, known as the Kerner Report, concluded "that racism was the primary problem facing the Nation and was the major contribution to racial unrest throughout the country," was action initiated to evaluate our position. Phase II evolved from this action.

Phase II

In 1970 a study to determine the causes of racial unrest in the armed forces was conducted. The study committee, chaired by Air Force Colonel (now Brigadier General) Lucius Theus, reached a conclusion similar to that of the Kerner Commission and recommended many of the programs that are now included in Phase II.[5]

The emphasis in Phase II is on education. To support this philosophy, a Defense Race Relations Institute was established in June 1971. The objectives of the institute are to train armed forces personnel as instructors in race relations, to develop doctrine and curricula in education for race relations, to conduct research, to perform evaluation of program effectiveness, and to disseminate educational guidelines and materials for utilization throughout the armed services. In conjunction with this program, a Race Relations Education Board was established to determine policy and approve curricula for the program. This board also serves in an advisory capacity to the Secretary of Defense.[6]

Anyone who has been in the military over the past ten years can easily recognize that new developments of significance in the area of race relations have occurred. These changes have taken place primarily in education and command support. For example, a more effective military service has been realized through a more effective use of the classroom, the mass media, individual therapy, and the law. In Phase II we regulated against prejudice. We have learned that regulations may not reduce prejudice directly but do help equalize advantages and thereby lessen discrimination. As a by-product of these and other actions, servicemen and women have gained the experience of working and studying side by side; and such "equal status" contact has made indirectly for lessening prejudice.

While the positive aspects of Phase II would give the casual observer the impression that we have finally solved the race problem, I hesitate to give the reader such an impression. The tendency today is again to become complacent. Currently, there are a number of impediments to making our present race relations programs progressive in the sense of achieving equality of results. I will discuss three. First, we have not devised a plan to insure equality of results after an atmosphere has been created to afford equality of opportunity. Second, we must insure that race relations and human relations remain an integral part of everyone's responsibility. Third, and most important, the tendency toward apathy must be checked until a final solution can be obtained. By examining these impediments more closely, I hope to justify the necessity for a Phase III.

Phase III

By and large, the concepts of Phases I and II—desegregation, race relations classes, equal opportunity training, etc.—have helped to make opportunities available. But they cannot insure the outcome—equality of results. This becomes obvious when we recognize that it is not enough that all individuals start out on even terms if the members of one group almost invariably surpass the others. The distribution of success and failure within one group cannot be made comparable to that within the other groups unless the system that favors one takes the initiative and favors the other. I am not recommending tokenism. What I am suggesting instead is that we create the incentive to achieve, thereby rejecting tokenism. For example, we need not select a minority member for promotion, assignment, or higher education because he or she is of the minority, but we can identify those minorities that have achieved in spite of system past failings and, after close evaluation of their achievements, develop a method to measure and correlate their success against that of members of the dominant groups. Promotions, school assignments, and special assignments could be made accordingly, thereby achieving equality of results.

A good example of taking corrective action without lowering requirements or creating dual standards was recently cited by Colonel Ernest R. Frazier, Director, Army Equal Opportunity Programs. The Artillery Officers Candidate School has an inordinately high washout rate for blacks; the black failure rate is 44 percent, compared to 22 percent for whites. The reason for such a disparity is primarily the result of deficient background in mathematics. Colonel Frazier recommended remedial math training for men who were otherwise qualified or that those with severe math deficiencies be transferred to Infantry OCS.[7] Implementation of such bold programs will naturally require restructuring our present personnel policies, but once this has been accomplished decision-making would be relatively easy and more acceptable. While this system is not the answer, it is a way of insuring that we avoid quotas and tokenism and at the same time achieve some semblance of equality of results.

Race relations must remain human relations. We must keep in mind that the only reason for a dynamic race relations program is our failure in the area of human relations. The race relations programs, in a sense, serve as a reminder of our failure. Race relations and human relations, two components of our responsibility, must not become mutually exclusive. When commanders and supervisors rely upon the race relations officer or NCO to solve racial problems, they are widening the breach between race and human relations. Specifically, when commanders and supervisors avoid conflict with minorities, or when they endorse a "hands off" policy for fear of being called racist, they actually succumb to racism by "giving them enough rope to hang themselves." At the very least they are guilty of "benign neglect."

Along this same line, the race relations climate can easily become apathetic. The capitulation to minority demands for their own reading materials, cosmetics, entertainment, and social life represents a greater degree of sensitivity than previously demonstrated. To allow minorities to break regulations, not report for duty on time, and not carry their share of the load tends to damage their character, thereby making a farce of the changes realized. Lieutenant Colonel John H. LaBarrie, Race Relations Officer, Fort Carson, Colorado, has commented:

> Anytime a man is successful in the Establishment there is a mistrust as to how he got there, with the exception of such professional people as doctors and lawyers. When I was commander of the 2d Bn 8th Infantry (Black Panther Bn), I had soldiers come in and test me with complaints of miscarriages of justice, discrimination and inequities in promotion. After eight months a group of black soldiers gave me a brother's arm band and said, 'We've

> been watching you for eight months and we accept you as a brother.' I also watch to make sure that my subordinates are not overreacting to a black commander by being too easy on black soldiers.[8]

The point here is that commanders and supervisors must assume the moral responsibility inherent in their positions. Responsibility cannot be practiced in a vacuum. Unless elements of sincerity, compassion, and a real desire to share one's own life-benefits with others are present, progressive race relations are likely to be a husk. The leader must create the atmosphere in which the programs are to operate. If he reveals a tendency to support the programs merely to comply with the regulations, he is only creating a time bomb; if he pampers and pacifies a minority member under his command or supervision, he is only crippling that individual and thereby weakening the morale within his area of responsibility. On the other hand, if he gives evidence of being competent, human, enthusiastic, and responsible, he will be able to maintain rapport with his subordinates even when it becomes necessary to be demanding. When our commanders and supervisors recognize this relationship between their mission and race relations, then race relations becomes human relations as well.

Insuring that our race relations efforts do not create conflict at the working level is another problem we must consider in Phase III. The quick reaction to command decisions has, to some degree, placed many of the present programs in brittle and trivial terms. Today we see minorities not only participating in the race relations programs but occasionally representing the bulk of the leadership. The burden of responsibility for solving problems that took hundreds of years to create should not be the task of minorities. This overuse of minorities not only reinforces the misconceptions of "race relations efforts as a black pacification program" but also fosters a tendency to blame them when failure takes place. All groups, particularly the dominant groups, must remain active if the problems associated with racism are to be solved. Racially exclusive areas occupied by the dominant groups have traditionally been the problem; we must avoid creating racially exclusive areas for minorities. There is no justification for the Social Actions Career Field having a greater representation of minorities than Intelligence, Communications, or Aircraft Maintenance.[9]

The local race relations classes must maintain high standards. On many bases, these classes are geared to teach the dominant groups about minorities. The approach is one-sided. To teach the dominant groups so-called minority culture by emphasizing "Do's" and "Soul Food," at the expense of more substantive issues such as minority accomplishments and contributions, only serves to reinforce the negative image many students had before going to a race relations class. Even minorities are beginning to see the shortcoming of such an approach. Major G. R. King, a black Air Force officer, in a letter to the editor, Hahn AB, Germany, made this point as he stressed the necessity for blacks to go beyond such prosaic symbols. In paraphrasing a similar view expressed earlier by Carl Rowan, he stated:

> Hair alone cannot be passed on for "racial pride." Black airmen in the Air Force face a grueling challenge of survival and advancement against the most powerful forces in the world. These forces are arrayed against us now, some openly, some secretly. So we need to get down to the nitty-gritty. No nonsense or bull . . . get about the business of manning the ramparts for equality in a democratic society.[10]

If race relations training is to be effective, minorities must be taught about the dominant groups. How much does a black know about the Irish or Germans, except that they are white? They need to be taught, for example, that if we removed every white person tomorrow, much of this system would remain; they need to be taught that not *all* whites are racists and that being white does not in itself represent the "good life." It is true that discipline in this society is an avenue to greater success, and whites recognize that discipline can increase their chances of success; minorities must be made aware of this requirement. American society, during most of our lifetime, will not change or alter to any great degree the foundation upon which it was built—the "work ethic." Minority members of the service must *not* be encouraged to reject this concept but instead must be taught to recognize the value of the work ethic and adjust accordingly. Phase III, if and when it becomes a serious consideration, should come to grips with these and other interrelated problems.

Curtis R. Smothers, who recently resigned as acting Deputy Assistant Secretary of Defense, painted a bleak picture of things to come in the area of race relations. In a wide-ranging 40-minute interview, he "accused the Defense bureaucracy of 'a damn serious failure' to move forward with credibility in relating to blacks, women, and other minorities." He further stated: "The impact of black and of the equal opportunity program will increase not decrease. Unlike on the outside, where social and residential segregation continue, we in the military have to sleep side-by-side."[11] If Smothers is correct in his prediction, "the problems are getting tougher and more complicated." I have stressed the necessity for immediately implementing a Phase III in our race relations programs in order to prevent such a prediction from becoming a reality and to avoid the crisis approach taken in the initiation of Phase II.

The fact that progressive race relations is still being hampered by these impediments should discourage the feeling that the problems connected with racism are solved. While I recognize that the argument of this article does not offer solutions, I have kept it within these confines for one reason. While the whole concept of race relations is new, it needs to be evaluated and criticized in order for it to remain viable. No one person can effectively do both. I trust that this critique will add the stimulus for readers to formulate solutions. We must recognize that perfunctory programs are meaningless; an individual will succeed and contribute only if we want him to be successful. Only in this way can we avoid burdening the present programs with bureaucratic trappings that would prevent us from obtaining our ultimate goals: equality of opportunity and equality of results.

United States Air Force Academy

Notes

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ON BUILDING ONE'S SUCCESSORS

Captain W. E. Gernert III

Ability is of little account without opportunity.
—Napoleon

JOHN BROOKS is an Air Force major, aircraft commander, and flight commander. After 13 years in the blue suit and 3500 total hours of stick time (400 over Vietnam), he's an expert at his trade and an acknowledged fast burner. In addition to his reputation as a "hot stick," John has completed both sos and acsc in residence; he's fulfilled his community obligations through Little League coaching, working with a scout troop, and teaching Sunday school.

The squadron operations officer is due to leave soon, and John hopes to get his slot, followed by jobs as squadron commander, assistant director of operations, director of operations, wing commander, and a running start at a star. It's the acknowledged route upward, and he's watched many of his seniors take it in the past. In fact, his squadron commander and director of operations have both recommended it. John is well aware that it's by far the most common desired career pattern on Form 90s, but he's gone head to head with his peers before and won, so why should he shrink from it now?

He feels both ready and well prepared for the challenge of command. But he's not! John has never written an Airman Performance Report or a reprimand. He's never counseled an airman or been through a barracks. In fact, he hasn't spoken more than two minutes to any first-term airman in the last ten years. MAST, DRRI, DACC, BOSS, PREP—they're only miscellaneous collections of initials to him. He's never served as a court-martial member, a 39–12 evaluation officer, or on a selective re-enlistment board. In fact, although John has never really thought of it this way, he knows virtually nothing about today's airman force.

There are a lot of John Brookses in the Air Force today. For the last 8 to 10 years the influence of Vietnam has been so powerful that they are the rule rather than the exception. While John was developing and using his battlefield skills and training others in what he knew, the managerial abilities and sensitivities he will need as a wing commander were being developed in nonrated and more junior officers. As John and his rated peers and supervisors were pulled from their support functions back to the cockpit, their place was taken by new, nonrated lieutenants and captains who were thrown into major or lieutenant colonel positions and forced to sink or swim. During this period the gradual transition to an all-volunteer force and changes in civilian society induced radical changes in the Air Force managerial environment. The incoming airman force became increasingly more articulate, perceptive, and skilled and yet less disciplined, more adept at questioning and manipulating the system, and less willing to be bent to its often arbitrary mold. Young minority airmen entered the Air Force proud of their heritage and dignity, determined to eradicate any vestige of personal or institutional racism. Drug abuse became a major source of concern and action. Traditional and authoritarian styles of leadership became less appropriate and often counterproductive, while participatory management and human relations techniques blossomed. Social actions officers were established on every Air Force base, and commanders and supervisors were force-fed drug-abuse education, race-relations awareness seminars, and new techniques in human resources management. The elimination of racial tension and amelioration of social dysfunction approached the operational readiness inspection in importance and, in the eyes of some, exceeded it.

The combat crew force remained insulated from this turmoil. The rise of the organizational maintenance shop concept removed virtually all airmen from operational squadrons and enabled combat crew members and their immediate commanders to continue to define closely their mission and duties along historical lines. The former efficacy of squadron additional duties in developing managerial skills was almost eliminated by the condensation of the operational squadron to an all-officer group where peer relationships were crucial but management of airmen and NCO's nonexistent. John and his fellow crew members rarely interacted with airmen and then only in the flight-line cafeteria or while boarding their aircraft. They were not sent to race-relations awareness seminars because slots were limited, and those currently on the firing line as commanders and supervisors received first priority. Their community efforts, structured along traditional lines and dealing with more traditional people, could not and did not prepare them for the real shock ahead. Even the "rated supplement" was of small help, since John and most of his fellow fast burners pulled every string to elude it or get into operations staff jobs if they had to go.

Thus the Air Force is faced with a dilemma. Crucial management expertise and sensitivity are concentrated to a large extent outside the combat crew ranks, while the combat crew member is virtually precluded from access to this expertise and sensitivity. It is unrealistic and unfair to expect a man with 8, 10, 12, or more years' experience in crew duty, who has developed his management skills only in the peer relationship area and in isolation from the airman force, to lead and manage a large force of airmen and officers successfully. The real question is, Can the Air Force afford the errors these men will make at the level they will make them, while developing their managerial skills? In an era of increasing civilian criticism and austere funding, the answer is very likely no.

This leaves several options for the Air Force. The first is the classic civilian response to similar situations: change the line of succession and make senior managers and executives (wing commanders and general officers) from staff rather than line functions. There may well be a shift in this direction, but it is not a total solution. First, its effect on combat capability is unknown and may not be worth risking. Second, it is unfair to those who in good faith (and urged by their supervisors) chose the classic route to the top. Third, it is too great a departure from past tradition and current practice to be rapidly or fully implemented.

Another option is to increase the education in human-relations management provided to our combat crew members. This has already been done to some extent through both professional military education and the Air Force Institute of Technology. Yet it, too, is only a partial solution. Even if funds and time available for this purpose were unlimited, there would remain an absolute need for hands-on experience.

The final and most viable option is to start now to build human relations experience into our combat crew members. This can be accomplished in several ways. First, there must be clear and unequivocal guidance from the Chief of Staff down to squadron commander level that successful experience in managing human resources will be weighted heavily in promotions through lieutenant colonel and will be an absolute necessity for promotion beyond this level. For senior officers, experience as a support squadron commander or base commander should be made a mandatory prerequisite for duty as a wing commander. For more junior officers, routes must be established and expanded by which combat crew members may gain experience in human-resources management at less critical levels and then return to the crew force. The present rated supplement does not fulfill its promise in this area, since it is heavily weighted on the side of technical resource management. It is difficult to find a rated headquarters squadron commander or CBPO chief, and it is virtually impossible to find a set of wings on a social actions officer. Social actions officer positions in particular must be recognized and treated as a crucible for the development of potential commanders, not simply a place for former personnel and administrative officers to try their hand at social work. The Air Force cannot continue to send a token trickle of rated officers to Defense Race Relations Institute and the Air Training Command courses in drug education and counseling and human relations and expect to get full value from them. Key positions in the management of human resources must receive a far greater share of the rated supplement under TOPLINE.

Firm career guidance and a revamped supplement cannot do the whole job. In the final analysis, the role of the combat crew member is to perform as a combat crew member. Supplement positions, and particularly those that are heavily concerned with human-resources management, are limited. More important, they are not an adequate tool for the maintenance and growth of managerial skills. Just as the crew member in the supplement needs to maintain his flying skills, so does the crew member on a crew need to develop and maintain his managerial skills.

This requires two critical changes. We must begin by reversing the current trend toward filling all of the combat crew member's time with new crew-oriented requirements. A portion of the time and effort spent in preparing the combat crew member for his assigned duty must be diverted to preparing him for future duties. This is not unreasonable, since much of the nonflying workload placed on combat crew members has been subject to minimal evaluation to determine the extent to which it achieves its desired outcome. Application of SAT (systems approach to training) techniques or even more basic evaluation methods to this workload should uncover areas which can be cut back or eliminated. If we view the nonflying time of combat crew members as a limited resource subject to priority allocation rather than a free resource, more considered and hence less frequent demands on this time will result. Through asking hard questions about the utility and benefit of the combat crew members' full-time duties, we should be able to free enough time for more additional duties.

The second change is to view combat crew members as a wing asset rather than a squadron or director of operations asset in the assignment of additional duties and then to establish and structure additional duties to best utilize this asset. The exact form and extent of these additional duties will depend on such variables as wing mission, TDY commitments, and size and on such individual characteristics as career expectations, prior education, and aptitudes. They should focus on the general area of human-relations management and should range from "big brother"-type one-on-one duty with airmen in trouble or counseling duty in the social actions office to more standard duties such as training officer for a maintenance squadron work unit. The extent of prior training or orientation will depend on the duty involved and the qualifications of the crew member, but it should not be overly lengthy. To prevent excessive turnover and insure that the support function gains as much in useful work from the crew member as it loses in orientation and training time, each duty should normally be held to a minimum of six months. In addition to developing the management skills of the combat crew members, these duties will enable them to try out various support skills before actually entering the rated supplement.

The availability of a pool of crew members who are experienced in support duties will provide the wing commander with a currently latent asset to utilize in developing new programs or revitalizing old ones that are not achieving their goals. Most important, the continuing flow of additional-duty crew members in and out of support positions will aid in communication and understanding between line and staff functions and help develop the concept of a wing as a cohesive and concerned community rather than a group of encapsulated subcommunities.

A classic attribute of good management and leadership is the ability to develop potential successors. The failure to prepare John Brooks adequately may be unfair, but it is sustainable. An overall failure to develop adequate managerial skill, with a consequent repetition of our past and current problems in human relations, is not sustainable.

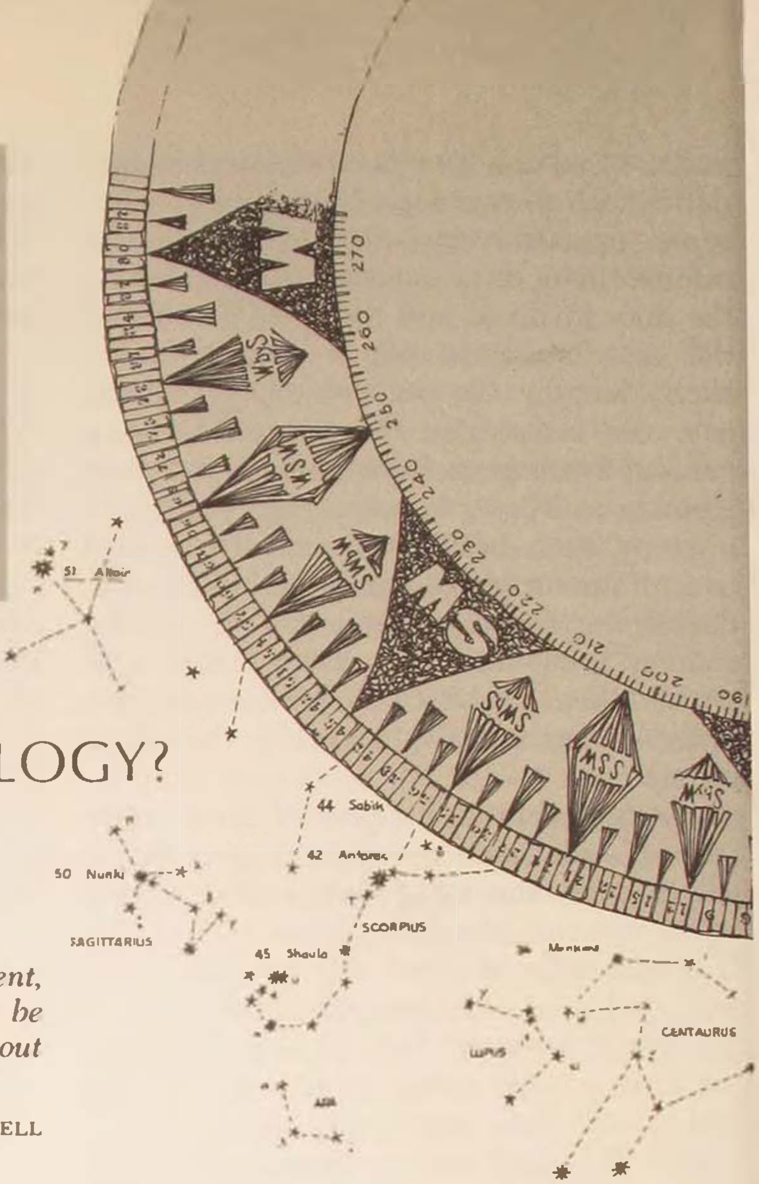
Headquarters USAFE

CORRECTION

In the "Basis of Issue of *Air University Review*" criteria published in our January-February 1974 issue (page 82), there is an error. USAF general officers no longer receive their copies of the *Review* from the Editor. The Publications Distribution Officer ensures the availability of the *Review* to all organizations and individuals authorized to receive it. If your office or organization does not receive the *Review* on a regular basis, check with your local Publications Distribution Officer (PDO).

THE EDITOR

Books and Ideas



WHICH CAME FIRST, THEORY OR TECHNOLOGY?

Lieutenant Colonel David R. Mets

I am far too much in doubt about the present, and far too perturbed about the future, to be otherwise than profoundly reverential about the past.

—Augustine Birrell

SOCIAL scientists have long employed models in their analytical work, and this has been a source of bewilderment for the layman. Now there is a growing need to understand the nature, the utility, and the limitations of such models because their use and misuse have been spreading to other fields. Historians have been becoming more interested in the technique, a recent example being Robin Higham's *Air Power: A Concise History*.[1] Dr. Higham's model presents a kind of cyclical theory of the development of air power. His pattern suggests that in the typical case a nation's air power is developed in a cycle that reaches its peaks in the midst of recurring wars. The cycle starts with a period of "peacetime equilibrium," is followed by a time of "rearmamental instability," reaches a peak of "wartime equilibrium," enters a phase of "demobilizational instability," and finally returns to an era of "peacetime equilibrium."

What is the use of a model like Dr. Higham's? Certainly it cannot be used as a reliable predictor of the future. Any model that is broadly defined to fit all cases would necessarily be so general as to be of no use as a guide to the future. Any that is narrowly defined would necessarily apply to so few cases as to be of equally little utility. Perhaps models like these are of some use as conceptual devices to help one organize his thoughts about his subject and its future—whether that subject be history, social science, or the theory and technology of air power. Dr. I. B. Holley was mainly thinking about the future and technology in his *Ideas and Weapons*, its theme being that a nation which neglects the proper and rapid development of weapons technology and an accompanying doctrine for its application to the problems of war is seriously jeopardizing its chances for survival.[2] That is also one of the themes of *Air Power: A Concise History* as well as of the work under review: Monte Wright's *Most Probable Position*.†

How, then, are we to organize our thinking about theory and technology? Two possible models spring to mind: one might start with a theory of war and move toward the development of a technology that would implement that theory; in another, the weapon might first appear and the theorist would then conceive a scheme for its employment.

It is hard to think of instances when the theory came first and a technology was then created to suit it. One example might be the strategic bombing theory of the U.S. Army Air Corps in the 1930s. Mitchell handed down a long-range bombing theory to his successors, and they created a bomber, the B-17, which they thought suited the theory.

More frequently, the technology has first appeared, and only after a long delay has the theory for its employment in war been created. Gunpowder provides a fine example. It appeared in the thirteenth and fourteenth centuries, and the military history of the next 400 years or so is largely a story of trying to find the proper mix of shot and pike. Captains like Gonsalvo de Cordoba and Gustavus Adolphus achieved great successes with mixes that temporarily gave them advantages, but it was not until the time of Marlborough in the late seventeenth or early eighteenth century that someone came up with the simple but brilliant idea of combining the two functions by fixing a bayonet to the firearm. Thus the methodology for employment of gunpowder was a long process of trial and error and ingenious effort.

The former of our two models describing the evolution of theory and technology might be termed the "theory first" type. Someone creates a theory, then it is necessary to develop the hardware for the application of that theory. The test of the scheme comes with its use in war or maneuvers, defects become apparent, adjustments are made, and a doctrine emerges that serves as a guide for the organization and employment of forces until changing conditions make it obsolete.

Another possible scheme might be named the "technology first" model, which starts when someone devises a new weapon. It is then necessary to conceive a theory for the application of that new weapon to the problems of warfare. When war comes, the theory is usually found defective through the occurrence of excessive casualties, and trial and error methods are employed to overcome the defects. If that is successful, a doctrine again emerges that temporarily guides the organization of armed forces and the development of their materiel.

Of course, it must be remembered that these models are necessarily oversimplifications. They separate theory and technology too neatly. In reality, it is practically impossible to put one ahead of the other, for they are interrelated and evolve more or less simultaneously.

How does *Most Probable Position* relate to these models? Colonel Wright's work is a case study that certainly seems to sub-

† Monte Duane Wright, ***Most Probable Position: A History of Aerial Navigation to 1941*** **(Lawrence/Manhattan/Wichita: University Press of Kansas, 1972, $13.50), xi and 280 pages.**

stantiate the validity of Robin Higham's model. Colonel Wright, himself an Air Force navigator, has examined the development of the art of aerial navigation from the earliest times to the outset of World War II. Thus, he covers only one of the two cycles through which American air power has thus far traveled. In accord with Higham's pattern, Wright's work shows that the technology of navigation was making only sporadic progress during the period of "peacetime equilibrium" preceding World War I. The development of the techniques and instruments went on at a fever pitch during the eras of "rearmamental instability" and "wartime equilibrium," and then the pace slackened drastically during the interwar period. One suspects that were a sequel to *Most Probable Position* to be written it would suggest that the Second World War experience would also confirm the Higham model, but the development of aerial navigation and American air power in general since 1945 would depart from the scheme.

Wright's monograph might well be taken as a possible example of the "theory first" model. Insofar as long-range navigation is concerned, a theory postulating the possibility and effectiveness of jumping over the adversary's surface forces and striking directly at the sources of his moral and material power came ahead of the technology. A corollary to this theory was that the aircraft could be efficiently guided to and from the target and that the bombs could be accurately directed at the target. In theory, this scheme should then have been tested and its faults identified. That, however, was one of Wright's complaints. At that point, practice departed from our model, and the proper tests were not made. None of the long-range navigation missions of the interwar period was combined with realistic bombing training. Had the deficiencies been understood, the corrective measures then should have been devised, and the final product would have been a complete doctrine governing the organization and employment of the strategic bombing weapon system. But, according to Colonel Wright, it did not work that way because of faulty air leadership during the interwar period.

As Holley has pointed out, the thorough and rapid exploitation of all the possibilities of new weapon systems is essential to national security.[3] The thing that prevented the proper exploitation of the air weapon in World War I was an inefficient organization. Holley further says that any organization designed to accomplish this must be composed of two parts: one for the acquisition of data and the other for making sound decisions based on the data. These decisions must be made in two areas: the creation of new technology and the formulation of a coherent doctrine for the exploitation of that technology. He holds that in the post-World War I period the most serious fault was in the data-gathering part of the organization. I suppose Wright would agree with that view to some extent, but *Most Probable Position* argues that the most serious fault was the failure to solve the navigation and meteorology problems. Wright's informative treatise shows how practically the whole technological foundation for the ultimate solution of the navigation and bombing problems existed long before the United States entered World War II.

It is amazing to this reviewer that most of the equipment and techniques which he had supposed had their origins in the Second World War were really conceived in the days of the Zeppelin raids on London—and even before. Efforts had been made prior to 1914 to develop a sextant with an artificial horizon not only for naval vessels but also for airships and balloons. Even before motive power was applied to lighter-than-air vehicles, airmen were experimenting with devices for determining ground speed by timing. Long before the Armistice, the Germans were working with acoustical devices that would have given the Zeppelins their absolute altitudes—devices that had much in common with the ultimate electronic solution to the problem. During World War I, RDF and DF were extensively used by both sides in their long-range aircraft. Wright's thoroughgoing research of these and many other matters leaves little doubt that it was not the state of the art which prevented the U.S. Army Air Forces from finding its targets and hitting them in the early days of World War II.

According to Monte Wright, the real limiting factor in the development of the long-range bombing weapon system was the failure of the organization's leadership to understand that the task was not complete when a fine airplane had been acquired and the requisite pilots had been trained. According to Wright, the leaders should have seen that a centralized navigation school was essential, as was also the establishment of a separate navigator rating. For too long, the pilot was expected to be a generalist who could handle every job on the aircraft. For too long, the U.S. Army Air Corps was dependent upon the smaller units for such navigation training as was done. For too long, the high leadership remained ignorant of the capabilities and limitations of the navigation part of the weapon system.

Although Colonel Wright is certainly correct when he states that our navigation system was not ready for war in 1941, perhaps he is a bit too ungenerous to the leaders of the thirties. In many other works, that same leadership has been faulted for failing to see the need for fighter development, especially the need for an effective long-range escort. The critics have often oversimplified, saying that Mitchell proclaimed a need for the fighters and Chennault after him echoed those sentiments but that the big bomber men were so blind as to feel the B-17, by itself, was enough. Defenders of Arnold and the other bomber men have correctly pointed out that the airmen were never really hostile to the acquisition of good fighters. Rather, it is inherent in the responsibility of office that the leader must establish a system of priorities.

The B-17 first flew in the year 1935. That was the year of the Nye Committee "merchants of death" hearings and a time when the interwar isolationist sentiment had reached a peak—an environment hardly conducive to the acquisition of *all* the desirable aircraft types listed by Mitchell. Quite possibly Arnold and the others felt that they were lucky to get *any* new airplanes. Their problem was to choose the *most*—rather than *all*—desirable types of aircraft.

The same idea might well be extended to the area of Wright's monograph: perhaps Arnold was fully aware of the importance of navigation—he had led the famous B-10 expedition to Alaska and back—but he knew that he could not have everything. While Wright is certainly correct in his view that there is little hope of completing the long-range bombing mission if the proper navigation equipment and personnel are not at hand, Arnold might reply that the mission would not even get started if the airplane and its "driver" were not available.

On the whole, Wright's *Most Probable Position* is a splendid work. Even when he is working a bit out of his area, in the chapter on maritime navigation, the substance of his study is of a very high technical order—though sailors will doubtless wince at his one technical slip: he refers to the bow of a ship as its "nose." Wright's many years at the Air Force Academy and his Ph.D. studies at Duke are apparent in the fine workmanship he has used in both the research and writing of the book. In short, it is a book which will be found fascinating by all who are interested in the history of science and technology, and one which probably should become a part of the personal professional library of all Air Force navigators.

Colonel Wright's addition to the history of air power is a significant contribution to a larger literature that pleads the need for a continuing effort to fully develop the technology and doctrine of military power—especially in peacetime when the threat seems remote. The utility of the models cited is, of course, quite limited. Though they are not good predictors of the future, they may be employed as conceptual devices that will help us organize our thinking about air power and the future. The pattern we find most often starts with the development of a new weapon, goes on to the creation of a theory for its employment, the testing of that theory in combat, and its perfection through technology or tactical improvements, and ends with the articulation of an approved doctrine.

The Wright brothers developed a new weapon and proved it on the sands of North Carolina. The ideas for its employment were created by many men in the heat of the First World War and the debates of the twenties. Its defects were exposed in the Battle of Britain and over Schweinfurt. Those defects were made good by the development of the long-range escort fighter and some changes in tactics. And the doctrine which emerged was quite different from the theory which had been preached by Douhet. He had insisted that the bomber would always get through and that it would win the war. The doctrine which emerged held that the bomber would usually get through if properly escorted and that it would be *one* of the decisive factors in the winning of a worldwide but nonnuclear war.

Where does *Most Probable Position* fit into this story? Monte Wright describes another of the defects of the theory—or more accurately, one of its oversights. He shows how the theory of the interwar period incorrectly assumed that long-range navigation would be no particular problem and that the dropping of bombs on target in a neat, geometrical pattern would be a simple matter. Now that he has outlined the defects of the theory, it is to be hoped that he will soon apply his considerable talents to writing a sequel which will explain how the faults were overcome in the Second World War and how, during the postwar years, a complete doctrine for the organization and employment of the long-range bombing weapon system emerged.

United States Military Academy

Notes

1. Robin Higham, *Air Power: A Concise History* (New York: St. Martin's Press, 1972), p. 4.
2. I. B. Holley, *Ideas and Weapons* (Hamden, Connecticut: Archon Books, 1953, 1971), pp. 175–77.
3. *Ibid.*, pp. 176–77.

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AWARD

The Air University Review Awards Committee has selected "Toward a Common European Armaments Effort" by Lieutenant Kenneth C. Stoehrmann, USAF, as the outstanding article in the January-February 1974 issue of *Air University Review*.

ATTENTION

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