AIR UNIVERSITY REVIEW

aerospace medicine

JULY-AUGUST 1968

AIR UNIVERSITY
REVIEW

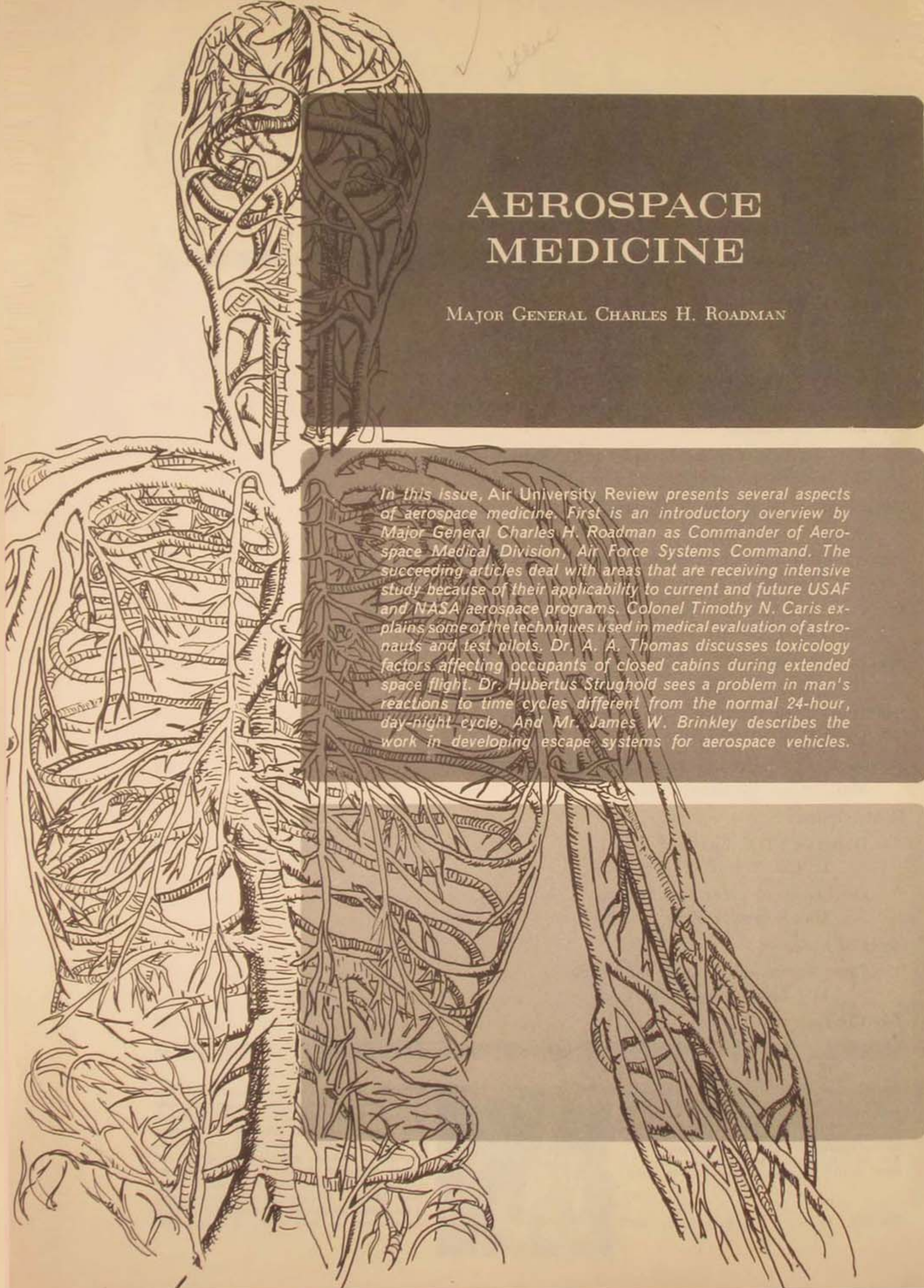
THE PROFESSIONAL JOURNAL OF THE UNITED STATES AIR FORCE

Address manuscripts to: Editor, *Air University Review*, Aerospace Studies Institute, Maxwell Air Force Base, Ala. 36112. Printed by Government Printing Office, Washington, D.C. Subscriptions are sold by Air University Book Department, Maxwell Air Force Base, Ala. 36112: yearly $4.50, back issues 75 cents. USAF RECURRING PUBLICATION 50-2.

Vol. XIX No. 5 July-August 1968

the cover

With the advent of manned space flight early in this decade, aerospace medicine came into its own. Through intensive scientific research, man has been enabled not only to withstand the alien conditions of space but also to understand hitherto unknown aspects of the human organism. In this issue, Major General Charles H. Roadman, Commander, Aerospace Medical Division, AFSC, and several of his specialists discuss some of the Air Force contributions to that body of knowledge.



AEROSPACE MEDICINE

Major General Charles H. Roadman

In this issue, Air University Review *presents several aspects of aerospace medicine. First is an introductory overview by Major General Charles H. Roadman as Commander of Aerospace Medical Division, Air Force Systems Command. The succeeding articles deal with areas that are receiving intensive study because of their applicability to current and future USAF and NASA aerospace programs. Colonel Timothy N. Caris explains some of the techniques used in medical evaluation of astronauts and test pilots. Dr. A. A. Thomas discusses toxicology factors affecting occupants of closed cabins during extended space flight. Dr. Hubertus Strughold sees a problem in man's reactions to time cycles different from the normal 24-hour, day-night cycle. And Mr. James W. Brinkley describes the work in developing escape systems for aerospace vehicles.*

SINCE man's first feeble efforts to lift himself on fragile wings, medical men have had a part in his struggle to conquer aerospace. Military men had been flying only a few months during World War I when it was discovered that over half of all pilot casualties were directly attributable to the physical unfitness of the man for flying duty rather than to mechanical or other external causes.

Although the term "aerospace medicine" is relatively new, aerospace medicine as a separate technical discipline began in America early in 1918 with the establishment of the Army Medical Research Laboratory at Hazelhurst Field on Long Island. The history of this discipline can be traced through the last fifty years by following the development of that laboratory into what is today the USAF School of Aerospace Medicine. The school and associated units that make up the Aerospace Medical Division (AMD) of the Air Force Systems Command, together with the personnel who have served in them over the years, have played a key role in the development of aerospace medicine.

Aerospace medicine today encompasses specialty areas that did not exist fifty years ago, primarily because we did not know as much about the human body as we know today. The progress in aerospace operations has also resulted in physiological stresses being applied to the human body that could not have been foreseen fifty years ago. Both these factors have influenced the efforts of aerospace medical personnel. Most of the research work being done in aerospace medicine falls within three very broad categories: medical evaluation, environmental control, and physiological stresses imposed by aerospace operations.

The physical standards that were developed for the early aviator were considerably simpler than those used today. The earlier medical evaluation procedures were also less sophisticated. As we learn more about the human body and the physiological stresses imposed by contemporary aerospace operations, we are modifying our standards. In the process, we are developing completely new standards for the healthy human being. Traditionally, the health standards of this country have been derived from sick people, for they were the ones most in contact with the nation's physicians. We are now dealing with very healthy people, we have amassed considerable information about their normal state of health, and thus we are establishing new health standards.

A case in point, during the past few years we have found that one of the peculiarities of an electrocardiogram tracing that had been thought to be indicative of heart disease is in fact benign. The result is that we have several thousand pilots flying today who might have been grounded because of their electrocardiogram interpretation a few years ago.

Another important facet of our medical evaluation program is that we are actually doing predictive medicine. The astronaut or aerospace test pilot who takes his initial medical evaluation today will not go into space for another four to five years. Our job is to predict his fitness at that time.

In the area of environmental control, AMD has for several years been involved in research to determine the best gaseous mixture and the best possible pressure for a specific space cabin on a given mission. In an effort to determine man's ability to survive and perform normally in an atmosphere that can be provided by the engineers, some of our more comprehensive studies have required human volunteer subjects to remain in space-cabin atmospheres for up to sixty days. During this time we not only study their ability to survive and perform but also do detailed analysis of their bodies' ability to metabolize certain space foods while in this environment.

We as a nation are becoming more and more conscious of the air we breathe and the possible contaminants that it might contain. It is important to realize, of course, that we are surrounded by and exposed to materials that were not even known fifty years ago, and some of the simplest of our everyday materials can become toxic in such confined quarters as a space cabin. AMD has expended a considerable amount of its resources in recent years to determine the toxicity of various materials in confined quarters and the possible effect of long-range exposure on the human body. These

The Aerospace Medical Division of Air Force Systems Command and the USAF School of Aerospace Medicine share these facilities at Brooks Air Force Base, Texas, as well as the threefold mission of research, education, and clinical evaluation in the field of aerospace medicine.

studies will provide some basic data to the nation's clean air program.

Almost from the beginning, medical personnel have been concerned with the physiological stresses imposed by aerial flight on the human body. These stresses manifest themselves in many ways, and they become more important as our aircraft fly faster and higher. Escape from early aircraft was uncomplicated: the main problem was to push oneself over the side in such a way as to avoid the vertical or horizontal stabilizer. Escape from the aerospace craft of today and tomorrow imposes problems that make a "step over the side" impossible.

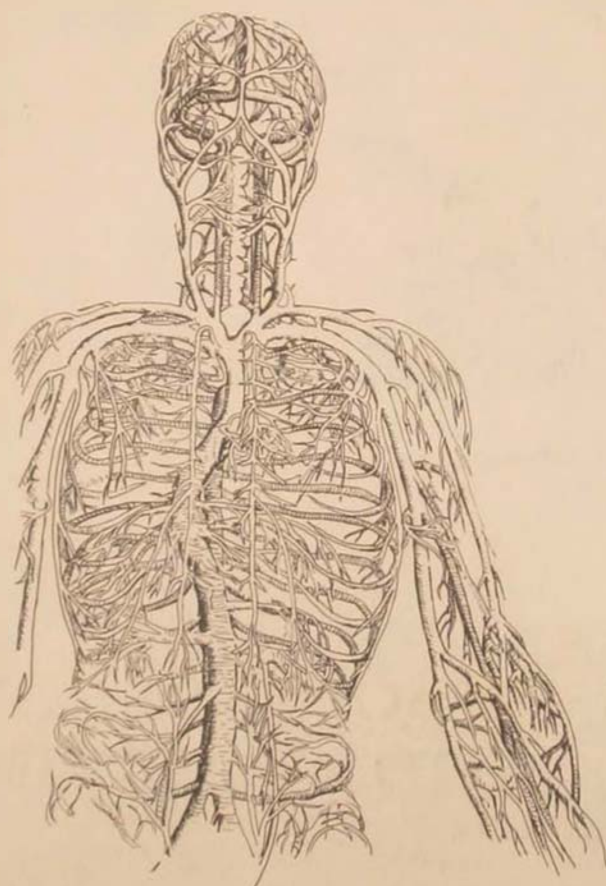
We are now flying at speeds and altitudes that compel us to resort to escape systems which, in themselves, impose physiological stresses that test the extremes of human effort and endurance. We have, for several years, studied these stresses individually. We have studied the effect of increases in the pull of gravity on the human body, the effect of a sudden change in atmosphere, sudden changes in temperatures, and even the effect of rotation in all axes. After studying these stresses individually, we have a pretty good idea of man's ability to withstand each. However, when the stresses are applied simultaneously as they are in a real-time escape situation, these parameters for withstanding may not apply.

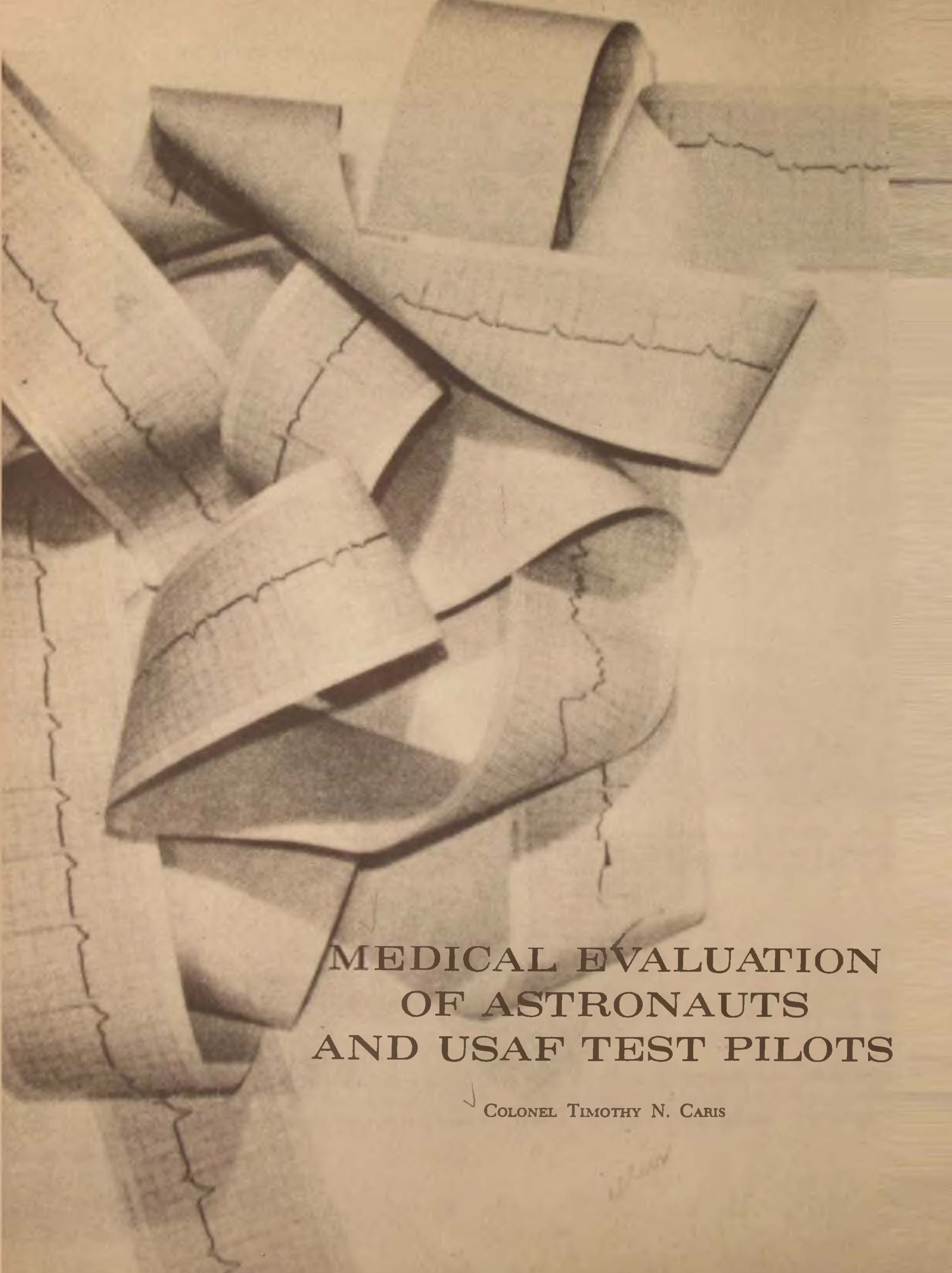
We are in the process of developing new devices to apply these physiological stresses in such a way as to duplicate almost any real-time escape situation from any type of aircraft or spacecraft. When perfected, the ability to do this will save untold dollars and possibly some lives by permitting us to experiment at lower levels of stress before duplicating a real-time escape environment where many factors may be unknown.

Although each of the component organizations of the Aerospace Medical Division makes a somewhat different attack on aerospace medical problems and each has its unique facility with which to work, all of them have one goal—to keep aircrew members functioning effectively and efficiently in their environment.

Aerospace medical personnel may seldom be seen in the forefront of development of aerospace systems, but they have played a key role —if backstage—in the development of every aircraft or space system in the last twenty years. Our business is to support the Air Force mission by insuring the health and welfare of Air Force personnel and their ability to perform, whether it be in an aircraft, on the flight line, in an underground silo, or in a spacecraft.

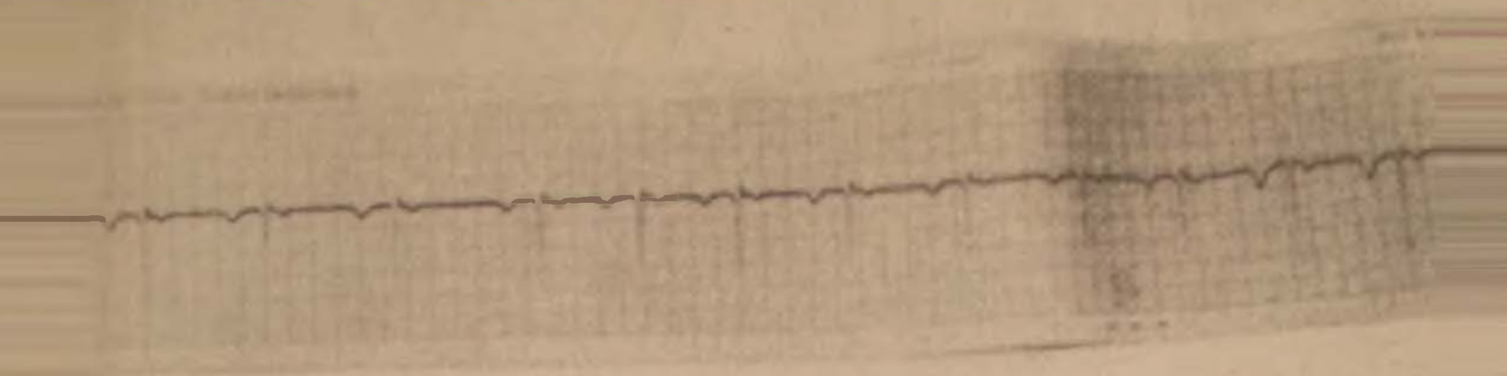
Aerospace Medical Division, AFSC





MEDICAL EVALUATION OF ASTRONAUTS AND USAF TEST PILOTS

Colonel Timothy N. Caris



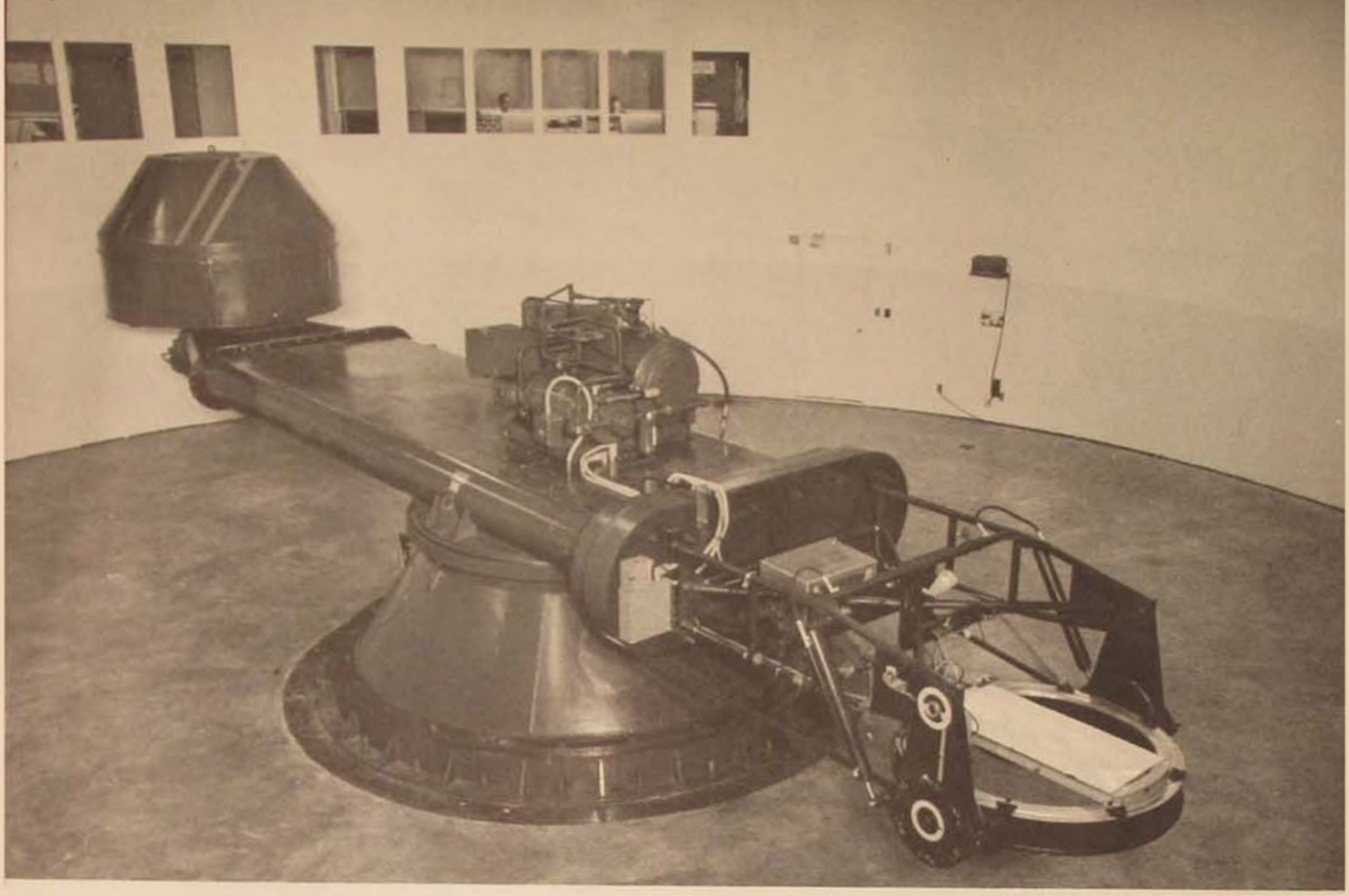
PRESENT-DAY flight research activities, including manned space flight and testing of advanced aircraft, impose new and increasing demands on man's biologic tolerance. Not all apparently healthy individuals possess the physical and mental stamina needed to cope with the exacting mission requirements. As a consequence, the Air Force has developed a medical evaluation program to identify those candidates who have the biologic capacity to complete such specialized missions safely.

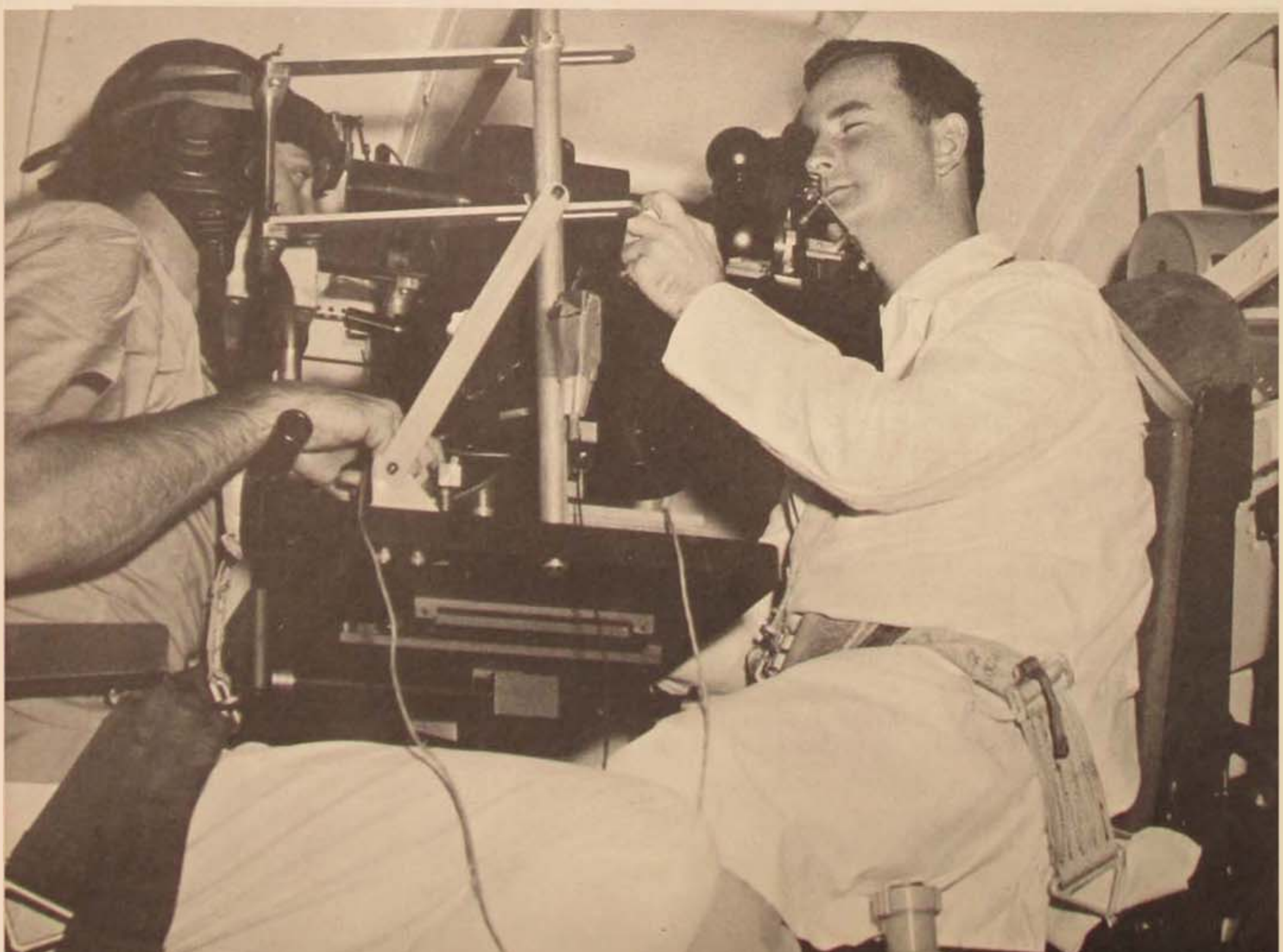
The primary goal of the examination continues to be the detection of significant disorders or disease processes, but emphasis is placed also on the measurement of an individual's response to various forms of stress and to those procedures that might provide information of a predictive nature regarding his future health.

The foundation of any medical evaluation consists of a comprehensive history and a detailed physical examination. Many health disorders, some not suspected by the individual himself, are detected by these means. As some significant abnormalities may not be uncovered by these techniques, additional laboratory, X-ray, and other diagnostic tools must be utilized. Finally, despite all these procedures, some disease states may remain hidden when the subject is examined in the basal or resting state. Only when he is evaluated under conditions that tax the functions of the various organs do the defects appear. Thus, medical evaluation during dynamic states characterizes the Air Force program and distinguishes it from the more conventional and traditional approaches of medicine.

One of the most prevalent disorders that we watch for during the Air Force regimen is coronary heart disease. This entity is not limited to the aged but is encountered frequently in the fifth, fourth, or even in the third decade of life. It is of particular significance in aerospace medicine in that it may cause sudden incapacitation or death. Not uncommonly, warning symptoms that may be present for variable periods of time are misinterpreted by the individual and passed off as merely gas pains, indigestion, muscle soreness, etc. A skilled examiner is alerted once he elicits such a history, but then he must obtain confirmation that these complaints are really due to significant underlying heart disease rather than to innocent bodily changes. In some instances, there may be no symptoms whatsoever preceding the catastrophic event. It is obvious, then, that one cannot rely on history alone to detect susceptible individuals. Physical examination usually is not revealing in these cases. The electrocardiogram will show diagnostic changes if permanent damage has been done to the heart muscle. It should be noted, however, that heart muscle damage is the end result of coronary heart disease. Significant abnormality can exist in the coronary arteries for long periods of time before segments of heart muscle are altered in any way.

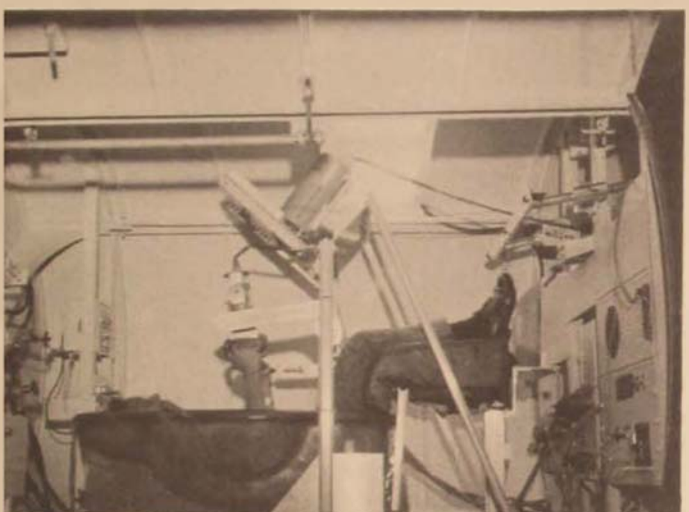
Years ago, it was noted that characteristic electrocardiographic changes occurred in individuals with coronary heart disease during their episodes of pain. After the pain subsided, these changes disappeared and the tracing returned to completely normal limits. Since pain in people afflicted with this disease is usually brought on by physical exertion, a diagnostic test was developed utilizing the electrocardiogram in association with exercise. This procedure, known as the Master 2-step test, is one of the earliest (1940) stress tests still in use

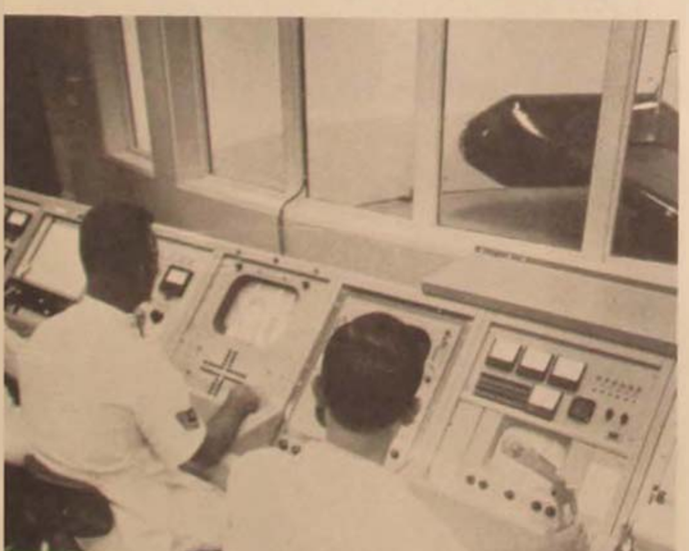




Human Centrifuge

The human centrifuge at the USAF School of Aerospace Medicine, Brooks AFB, Texas, exerts up to 50 times the pull of gravity on a subject when rotated at 90 revolutions per minute, thus simulating stresses experienced in space missions. It is used for research, teaching, and medical evaluation. . . . As g-forces increase, contraction and expansion of blood vessels can lead to blackout, the effects of which will show up in photograph of blood vessels in the fundal disk (retina) of the eye. . . . The subject in the centrifuge gondola is protected and instrumented for the high-g ride. . . . Just outside the centrifuge, operators keep check on the subject's electrocardiogram, blood pressure, and other reactions, by instruments, by direct and television surveillance, and by constant two-way voice communication with him.



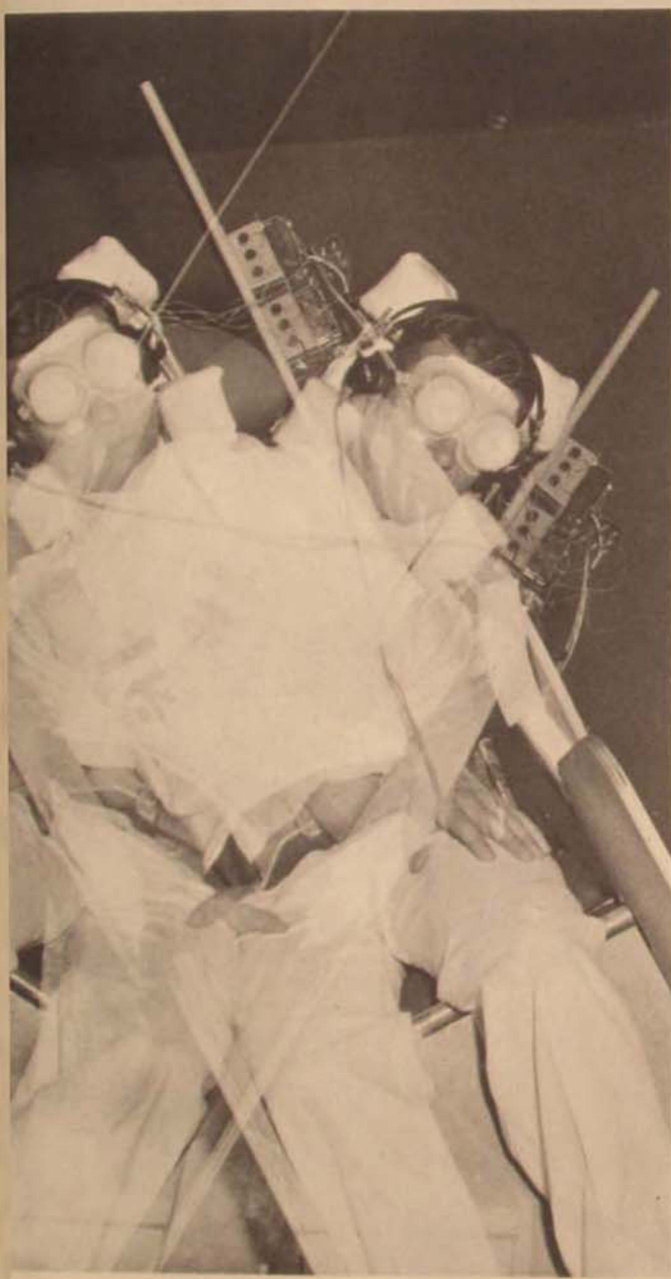


today. Equipment and techniques were not available at that time for recording the electrocardiogram successfully while the subject was exercising, so tracings were taken immediately after, two minutes after, and five minutes after a standardized work load: a given number of trips up and down two steps in a given period of time, depending on sex, age, and weight. Because excessive physical exertion in individuals with latent coronary heart disease may induce not only pain but also other very serious consequences, great care was taken to limit the work load on the heart in the Master test to safe levels.

As was hoped, this test did indeed produce characteristic findings in 50 to 70 percent of patients in whom the diagnosis of coronary heart disease could be established by other criteria as well. Apparently healthy groups have been tested with the Master technique, and abnormal responses have been obtained in a very small percentage of them. When followed over a period of years (up to ten), healthy individuals who demonstrated an abnormal response to this test have developed overt signs of coronary heart disease twenty times more frequently than control groups of healthy individuals who had a negative response to the test originally. This procedure, then, is useful in evaluating those who complain of chest discomfort, indigestion, gas pains, etc., as well as providing data of a predictive nature in individuals with no complaints at all.

More recently, with the advent of devices that permit reliable electrocardiographic monitoring during physical activity, subjects can be placed on a treadmill and exercised to any degree of exhaustion. If electrocardiographic changes appear indicating potential hazard, the activity can be stopped at any time, before pain or other untoward effects appear. Maximal exercise testing has increased considerably the yield of diagnostic responses in patients with known coronary heart disease, providing an even more sensitive method for identifying high-risk individuals who are otherwise apparently healthy.

The specialty of aerospace medicine has had to develop new knowledge from experi-



ences undergone in space flight, in order to accommodate man to meet the physical and mental requirements demanded of him. Some of the new phenomena encountered, e.g., in weightlessness, were found to have a useful basis in old and elementary medical knowledge. The state of consciousness is dependent upon adequate perfusion of the brain by oxygenated arterial blood. The contraction of the heart provides adequate force to propel oxygenated blood to the brain and the other organs of the body. This pressure head is dampened considerably by the passage of blood from arteries to the smaller arterioles, to the capillaries, and through the tissue spaces, so that once it reaches the venous side of the circulation for its trip back to the heart it is flowing under very little pressure. Since the greater part of the body lies below the heart with man in an upright posture and since venous flow must overcome the effect of gravity, blood would tend to pool, particularly in the lower extremities, if some other mechanisms were not present to add impetus to continuing blood circulation. If for any reason the amount of blood returning to the heart should be diminished, the amount it could expel to the lungs and subsequently to the remainder of the body would likewise be less. Brain perfusion would be compromised, and loss of consciousness would ensue. Compensatory bodily mechanisms do exist, however. The bellows-like action of normal breathing activity tends to "suck" blood up the veins. The large veins in the legs all lie in close proximity to large muscle groups. Muscle contraction tends to "milk" blood up

Biaxial Stimulation

In the biaxial stimulator, the subject is tilted at an angle, rotated, then tilted in the other direction, approximating what is experienced in aerospace flight. Electrodes attached to the eye area enable determination of the subject's sensitivity to changes in attitude and his recovery rate. . . . A biaxial stimulator, called the Coriolis chair, rotates in one plane and simultaneously tilts on another axis, to determine the subject's response to such stresses and detect any abnormality of the vestibular mechanism. . . . Action sequence of the Coriolis chair is suggested by a double exposure.

Rotation and Weightlessness

Pilots trained in the rotational flight simulator learn to recognize symptoms of disorientation experienced in flying—thus prepare to avoid the cause of many early accidents. . . . During the 20 to 30 seconds of weightlessness achieved as an aircraft executes a Keplerian trajectory, researchers are able to test devices developed to improve man's maneuverability in space.

the veins. Even when an individual stands still, the muscles are active, antagonistic groups alternately contracting and relaxing without conscious effort on his part. This activity is sufficient to help propel blood upward. Finally, neurovascular reflexes prevent excessive dilatation of the blood vessels and in this manner resist pooling.

It has been shown that prolonged exposure of normal man to weightlessness causes some loss of blood volume, wasting of muscle mass, and a temporary sluggishness of the neurovascular reflexes due to disuse. These changes become significant when man returns to earth's environment and his blood must overcome the effects of gravity to return to the heart. Obviously, men whose cardiovascular system is not compromised even to a minor degree must be selected for such missions. Furthermore, various diseases that begin insidiously may affect either the neurovascular reflex components or the vessels themselves without any other manifestations at first. Under normal circumstances, the respiratory factors and muscle activity may well compensate for this deficiency, excessive pooling may be limited, and no symptoms may be recognizable. If such an individual is placed in an upright posture without permitting any weight bearing, the lower-extremity muscles could be relaxed completely. With both the neurovascular reflexes and the muscle activity gone, blood flow back to the heart would diminish considerably. Cardiac output and blood pressure then drop quickly, the brain receives inadequate circulation, and loss of consciousness follows.

The tilt-table orthostatic tolerance test provides these circumstances to identify loss of normal neurovascular responses. The subject lies on a table to which he is attached by a parachute harness. He is then tilted to an upright position and remains suspended so that no weight bearing is required. His pulse rate, blood pressure, electrocardiogram, and state of consciousness are monitored continuously. In healthy individuals, the normal breathing activity and neurovascular reflexes are sufficient to maintain adequate circulation for a good number of minutes despite the absence of muscle action.

Our pilots and astronauts frequently encounter circumstances for pooling of blood in the lower body during aerospace missions while "pulling" positive g-forces. All the compensatory mechanisms that have been described are required to maintain circulation, but these are eventually overcome even in normal individuals if the accelerative forces are maintained or increased enough. The range of tolerance varies. Individuals who are less able to cope with such forces, although they are physically normal, can be identified by their reactions in the human centrifuge. The accelerative forces of any flight profile, including lift-off and re-entry of space flight, can be accurately produced by this mechanism. The subject's heart rate, heart rhythm, and electrocardiogram as well as his visual capacities can be monitored continuously during the procedure. The appearance of grayout can be determined quickly and the test concluded before actual loss of consciousness occurs. During the run, the subject is visually monitored continuously by television as well.

The strenuous medical evaluation of candidates for aerospace missions includes a thorough search for diabetes, another disorder that may develop insidiously. This entity is important in that its complications can progress significantly before the symptoms of diabetes itself can be recognized. Diabetics tend to develop atherosclerosis much earlier in life than others, and this degenerative process progresses at a rapid pace. If the arteries supplying the brain are involved primarily, sudden stroke may develop; if the small arteries of the eye are the targets, blindness may ensue; and if the arteries of the heart are implicated, coronary heart disease results. In diabetes, a common occurrence is a malfunction of the nerves supplying the arteries and providing the neurovascular reflexes so important in preventing the pooling of blood in the lower extremities.

For many years, testing urine for sugar has been one of the hallmarks of a standard medical evaluation and is a part of aerospace medical evaluation, too. Diabetes mellitus is a complex disease process in which the action of insulin, which is produced by the pancreas, is inadequate, hampering the steps by which the liver takes up excess sugar and stores it. The blood sugar levels become inordinately high, the kidneys' threshold to preserve blood sugar may be exceeded, and then sugar spills into the urine. People with severe diabetes usually show a positive response for sugar when their urine is tested. In moderate diabetes, though, even if the blood sugar level is high, it may not reach the point where the kidney threshold is surpassed, in which case such a test may be negative. Unfortunately, the complications of diabetes are very common even in moderate or mild instances of this disease. Obviously, the measurement of sugar in the blood is a better test than urinalysis. In mild or latent cases, however, the blood sugar level with the patient in a fasting state may well be within normal limits. The liver-pancreas axis must be stressed to bring out the abnormality. Such is the rationale for the glucose tolerance test. A heavy sugar load (a specific amount of glucose in lemonade or some other vehicle) is ingested by the subject. Blood sugar determinations are checked one-half, one, one and one-half, and two hours later, and the blood sugar levels are plotted in a curve. The normal ranges are well known, and levels above them are indicative of diabetes.

Because of the complete incapacity produced by a convulsion, a susceptible individual cannot be considered qualified for flying missions. Epilepsy, brain tumor, blood-vessel disease, and brain scarring from previous injury or infection as well as other abnormalities can first manifest themselves by a seizure. Brain activity is associated with electrical phenomena that can be recorded by the electroencephalogram. When it discloses the specific disarray of the normal pattern which indicates such a possibility, little question remains as to the proper decision from the standpoint of flying safety. Even in the presence of such underlying abnormalities, however, the electroencephalogram may remain normal. Examining the brain after it has been stressed may uncover a diagnostic electroencephalographic record. Forms of stress include sleep deprivation, hypoxia (subject breathes a mixture of 10% oxygen and 90% nitrogen for a given period of time), and partial occlusion manually, one side at a time, of the carotid artery in the neck, which supplies oxygenated blood to the brain.

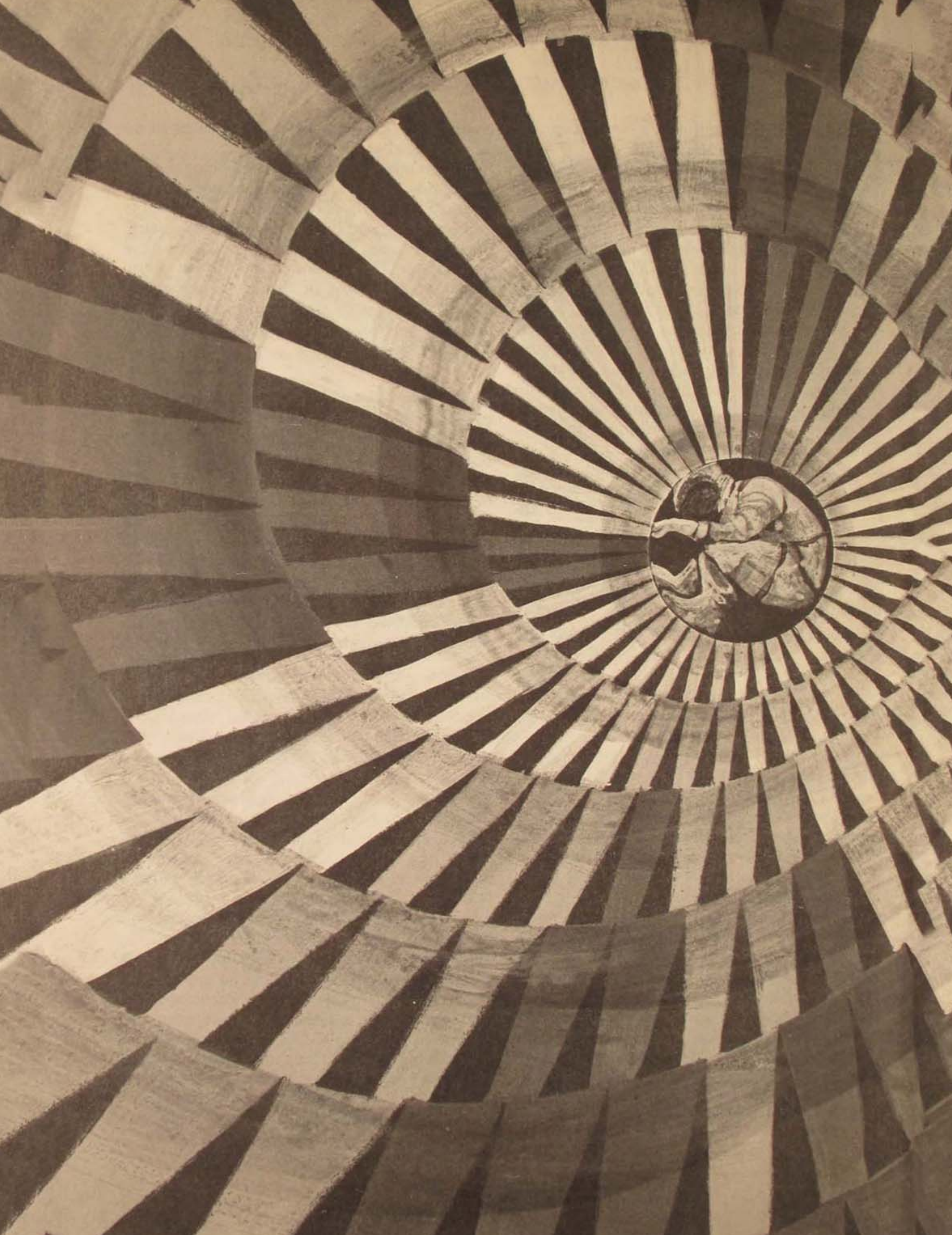
A normally functioning vestibular organ is essential to flying, particularly when visual orientation is not possible. The vestibular apparatus located in the inner ear is one of the organs involved in the maintenance of equilibrium and sense of balance in man. This organ perceives accelerative or decelerative changes and signals the direction of the gravitational attraction of the earth. A tilt of the head is registered as a change in gravitic relations, and appropriate reflexes are initiated to bring about certain changes in the neck and body musculature to maintain posture and produce adjustments for preservation of normal position of the eyes. There is also impartation to the brain of an awareness of the position of the head.

To determine the range of tolerance in normal individuals and to detect insidious abnormalities of the vestibular mechanism, this organ can be stressed in several ways and the response measured by recording and measuring the direction of the compensatory eye movements. In one technique, the subject is placed in a biaxial stimulator called a Coriolis chair, rotated in one plane, and then tilted on an additional axis.

Emotional stability and well-being as well as mental capacity are equally as important as physical health in the selection of astronauts and research test pilots. A detailed psychiatric interview is an integral part of the medical evaluation. The addition of psychometric testing to this facet of the examination also includes a form of stress, since some of the procedures require responses within a distinct period of time.

THE CITED EXAMPLES of examination under stress are characteristic of the Air Force approach to medical evaluation in a dynamic state. Newer and more revealing techniques now under development will require validation before they can be utilized as diagnostic tools. We have much to learn yet as to what the aerospace mission will demand of man's biologic tolerances. As our knowledge grows, the standards for acceptance of prospective test pilots and astronauts will become more specific and the details of the examination will become more refined.

Aerospace Medical Division, AFSC



TOXICOLOGY CONSIDERATION IN EXTENDED AEROSPACE FLIGHT

Dr. A. A. Thomas

16-27

We are living in an age of complex revolution in chemical technology, and we are daily reminded of its implications. We are becoming increasingly aware of the influence of this revolution on our everyday life and our health. At first, this awareness centered on air pollution because of some dramatic occurrences that emphasized its importance. Then came agricultural chemicals, pesticides, and insecticides. In a more subtle manner, they also found their way into our everyday life through the publicizing of the cranberry scare, and soon everybody was talking about "residuals" that may or may not be harmless when present in the food we eat.

Meanwhile, the pharmaceutical industry was pursuing the game of structural roulette, synthesizing entirely new drugs to tranquilize the ruffled soul of a public deeply worried about air pollution, pesticides, and the arms race. Then, of course, came thalidomide and more pointing of fingers and looking for scapegoats. The arguments became more heated, pro and con, and, as human nature dictates, a period of overcompensation began. Some thought that the "Silent Spring" was imminent, and others concluded that the internal combustion engines would have to go. This attitude, of course, had to give way to more constructive thinking and the realization that scientific effort should not be restricted to the search for new chemical compounds but also must include development of adequate safety and precautionary measures so that we shall be able to afford both the progress and the price for it.

The United States Air Force has been fully aware of the impact of new technology on the health and welfare of the people developing new missile and space systems. In 1961 an accelerated research program was started in the areas of toxicology, pharmacology, industrial hygiene, and occupational medicine, to provide the necessary understanding and suitable control measures for handling new propellants and other high-energy compounds by Air Force and contractor personnel. While this program initially was directed toward the protection of ground-based personnel, the rapid progress of the space age made it mandatory that an equal emphasis be placed on the health of aerospace crews confined to artificial atmospheric environments for extended periods. To expedite research in this area, unique facilities were established in 1963 at the Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio.

The purpose of this discussion is to delineate the chemical hazards affecting the health of aerospace crews manning future systems capable of long mission duration and to forecast the operational implications of toxic hazards on the design of such systems. To be more specific, we are projecting ourselves into the 1975–85 era when mission durations of 100 to 1000 days should be feasible.

the environment

The space cabin environment is designed to sustain man as best we can for a long period of isolation from earth. Everything is artificial. To create a microcosmos capable of supporting life, new chemicals and new chemical processes had to be developed and incorporated into the life-support system. Our main concerns are the chemical composition and purity of the atmosphere and the partial pressures of oxygen and inert gases.

If these parameters are changed from the familiar earth atmosphere, the human organism must either learn to live with these changes or perish. In other words, as soon as we change the ratio of oxygen to nitrogen, or substitute another inert gas, or omit the inert gas, we are prevailing upon the organism to accommodate in order to survive. This process is called adaptation. We know from biological experience that, in general, adaptation is possible only if it is gradual. We can adapt easily to a slight change, but adaptation to considerable change in the environment is possible only where the rate of change is slow. There is a price for adaptation. Although the organism can adapt to the new environment, if the old environment were suddenly reestablished the organism again would have to readapt to the original conditions. The real danger is that adaptation can be pushed so far that readaptation may become very difficult or incomplete. Plausibly, there may be a number of artificial atmospheres (using various partial pressures of ingredients) to which the crew on a 1000-day mission could adapt completely and upon return find themselves in the untenable position of depending on a higher percentage of one or more ingredients of that atmosphere or perhaps dependent on a lesser or greater total pressure than our earth atmosphere.

We have already produced concrete evidence that this situation can occur in animals exposed to oxygen-enriched atmospheres. These animals survive the initial toxic effects of oxygen and can live in such environment indefinitely. The price they pay for this adaptation, however, is that upon return to the normal earth atmosphere, they die from lack of oxygen because their lungs underwent adaptive morphologic changes, such as thickening of the gaseous exchange surfaces, to protect them from the excess of oxygen in the artificial atmosphere. However, they can be saved by "weaning" them back to normal conditions if the oxygen content of the artificial atmosphere is decreased gradually over a period of weeks. Although this process saves their lives, the readaptation is incomplete, since much of the normal lung structure is destroyed and replaced by connective tissue that is nonfunctional for the purpose of respiration. The animals, although appearing healthy, have decreased pulmonary function and thus represent incomplete readaptation. This response suggests the possibility of occupational diseases in future spacecrews.

contaminants

Contaminants, by definition, are either toxic or annoying materials which inadvertently find their way into the cabin environment and the life-support system. They can be gases, vapors, aerosols, dusts, or other particulate matter such as fibers, microorganisms, etc. They may constitute a toxic hazard primarily because of the recirculation of the atmosphere in a very limited cabin volume. For the purpose of this discussion we will disregard problems concerning ionized particles, dusts, and microbial contamination.

The sources of contamination are manifold and extremely hard to eliminate. Those contaminants of biological origin produced by the crew are controlled only in the waste disposal processes and by the oxygen reclamation systems. Since no such process operates with 100 percent efficiency, there will be a gradual accumulation of such contaminants on missions of long duration. Another major source is the air purification and disposal equipment, together with the chemicals used in the reactions, specific reaction by-products, and specific chemical processes. Finally, all materials used in the construction of the cabin and its maze of instrumentation contribute significantly by outgassing volatile materials that were used during manufacture or installation. This outgassing phenomenon is greatly enhanced in the cabin's reduced pressure.

Since all these sources continuously supply many different types of contaminants, the end result is a highly complex mixture of contaminants made up of minute quantities of primarily organic chemicals representing all major classification categories. They are generally referred to as trace contaminants.

toxic effects from trace contaminants

This article will not dwell on the toxicological characteristics of individual contaminants for two reasons. First, such information is readily available in the literature on those chemicals which have been extensively used in industry. Second, many of these trace contaminants have never posed a problem in industrial operations, and therefore no specific toxicological information is available. Rather, they should be regarded and classified according to groups possessing similar mechanisms of toxic action, irritation, or mere nuisance value.

The main reason trace contaminants must be taken seriously is the complexity of the mixture contaminating the atmosphere and the long mission duration, which constitutes a truly long-term continuous exposure. Continuous exposure per se seldom, if ever, occurs in anybody's life under normal earth conditions. The industrial worker, although exposed to certain toxic contaminants in the milieu of his job, is seldom exposed for more than 8 hours a day, 5 days a week. When he leaves his site of occupation, he is removed from the noxious atmosphere for the rest of the day or for the weekend. This allows a period of recuperation from any incipient damage to his health. In a continuous-exposure situation, there are no recuperative periods, and the increments of damage, however slight per 24-hour period, accumulate without opportunity for repair. This is often referred to as a "summation of interest" type of situation. There is a role for adaptation in this instance, too, but it is much more limited than physiological adaptation to an artificial atmosphere. Here, we are dealing not with one mode of toxic damage and one target organ but with many modes of action affecting every organ. Consequently, we should consider the deleterious effects of trace contaminants as a nonspecific toxic stress affecting the whole organism. Thus, as the exposure continues and damage mounts upon damage, eventually the proverbial straw that breaks the camel's back arrives.

The absence of recuperative periods poses another real danger to health. Beyond the fact that trace contaminants affect all vital organ functions, classes of contaminants having different target organs or modes of action can exert additive and even synergistic toxic effects. This compound mechanism is a real detriment to any potential adaptive response. For example, while adaptive processes can increase tolerance to pulmonary irritants, the end result is a decrease in the efficiency of pulmonary function, ventilation, and compliance of pulmonary tissues. This is a highly undesirable course of events in an artificial atmosphere. Poor lung ventilation will lead to atelectasia first and to emphysema in the long run. As a direct consequence, the pulmonary defense mechanisms are impaired, the residence time of toxic substances in the lung increases, resulting in more complete absorption and, hence, a more severe toxic effect. If, in addition, there are contaminants present which affect the cardiovascular system, the heavier load imposed on the heart by the pulmonary changes will establish the classic vicious circle of cardiopulmonary decompensation.

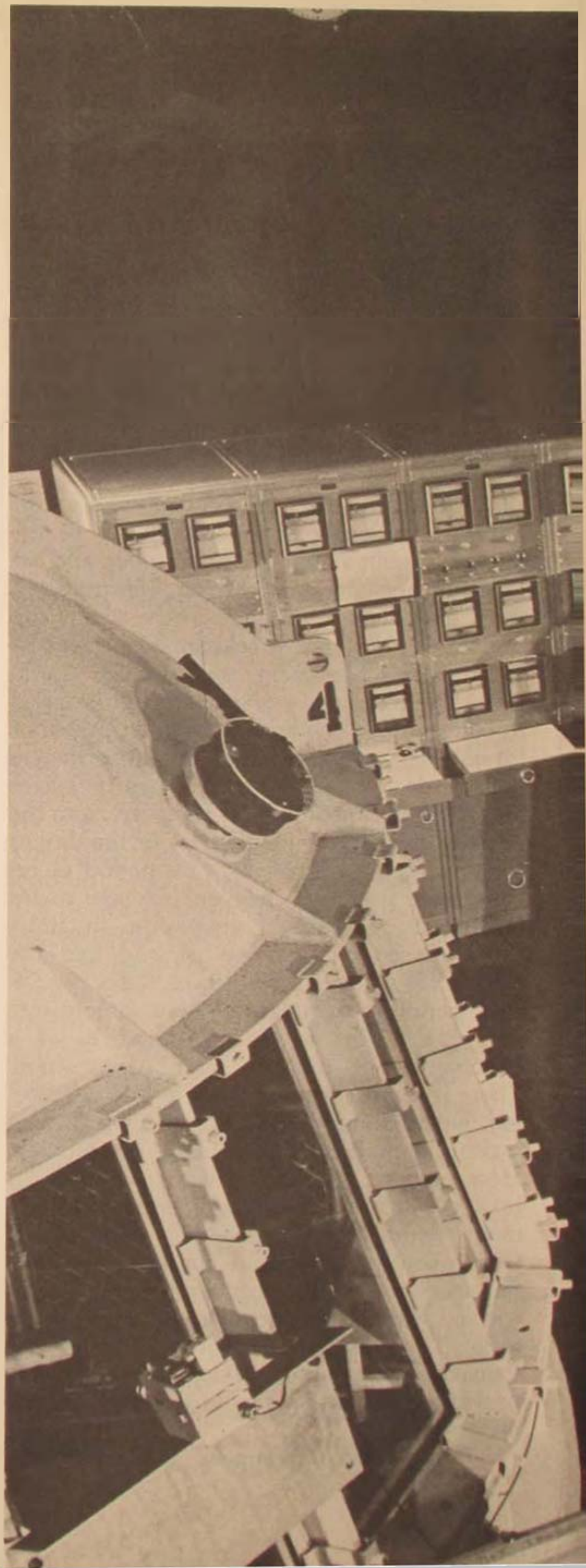
Similar additive and/or synergistic effects can be postulated for an infinite variation of mechanisms, target organs, and classes of contaminants. Many organic chemicals do have a depressive effect on the central nervous system (CNS). In their more subtle manifestation of toxicity, these affect only performance without causing overt clinical symptomatology or neurological deficit. It is quite easy to see how the presence of carbon monoxide as a contaminant could complicate the effects from CNS depressants. Any interference with oxygen transfer mechanism will lead to relative hypoxia in all tissues. If the CNS is already depressed, a relatively small decrease in tissue oxygen availability caused by carbon monoxide could have precipitous results.

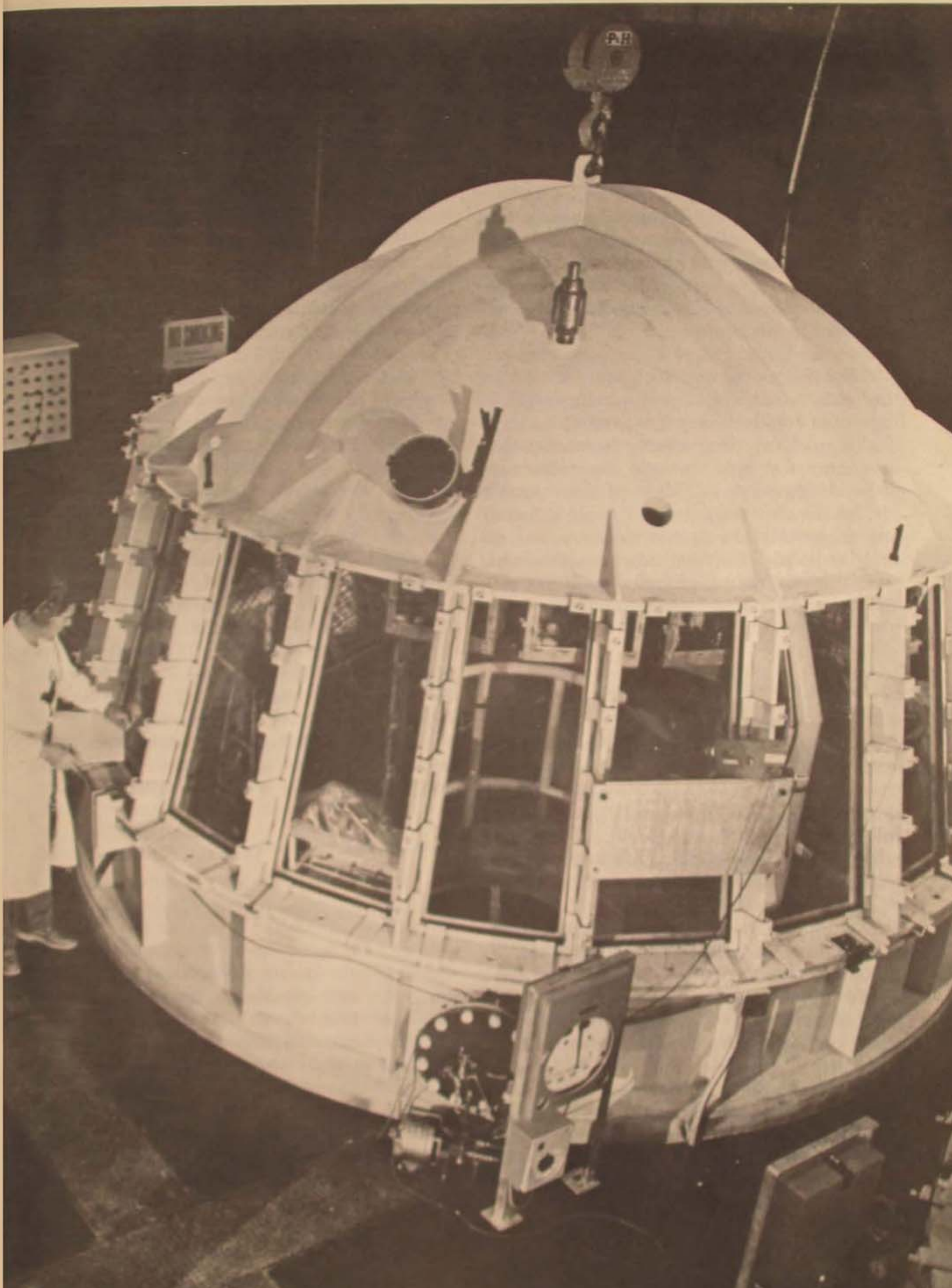
These few examples are cited to emphasize the serious consequences of continuous exposure to bizarre mixtures of trace contaminants. It is well to remember that the chemical stress is only one burden of life in a space cabin, but it could be enough of a burden to undermine the health of the crew in a long-

(Continued on page 22)

Altitude Chamber Facility

Cryogenic storage tank for liquid oxygen, 7500 gallons capacity, supplies gaseous oxygen (by conversion) for research on the toxicology of space cabin environments. . . . Altitude chambers (Thomas Domes) usually simulate the atmosphere at 27,000 feet, 5 psia pressure, with either pure oxygen or a mixture of 68 percent oxygen and 32 percent nitrogen, the flow adjustable from 24 to 100 cfm. Vertical airlock system allows access without changing the atmosphere inside. The control panel monitors and records pertinent data. . . . Clinical laboratory tests performed on blood drawn from animals under altitude conditions reveal biological response. Other tests include punch biopsies of liver and kidney tissues for electron microscopic evaluation of subcellular and ultrastructural changes. Test group typically includes 40 rats, 50 mice, 8 beagles, and 4 monkeys in a dome.





duration mission. Unfortunately, there are other stresses which also can act in an additive fashion. Weightlessness and resultant deconditioning affect the cardiovascular status. The dynamic stresses during re-entry require a great deal of physiological reserve in the crew. The heat stress during extravehicular activity could play havoc with an already unbalanced cellular energy metabolism caused by toxic action from some contaminants. Tolerance to radiation can be greatly reduced by contaminants that have a radiomimetic effect; i.e., act through the mechanism of free radical formation in the body. Ozone is a classic example.

For the sake of brevity, I will not consider the many other stresses which also play an important role in taxing the general status of health, such as toxic effects from microbial organisms and radiation and the entire area of psychological stress. Many of these stresses are inherent in the nature of space missions, and many of them cannot be controlled entirely or at all. The chemical stress is the most amenable to control, provided sufficient care and foresight are exercised during the design phase of the system.

philosophy of contaminant control

The design goal of zero contamination is desirable but probably unattainable within the time period with which we are dealing. Fortunately, there are very few toxic substances that would require the assignment of a zero tolerance limit. Still, this ideal goal should be adhered to as closely as possible in the initial design phase so that the sizing of air-purification and waste-disposal equipment, with the attendant power consumptive figures, will be taken into consideration by the engineers. In the process of prototype design and testing of life-support systems and subsystems, whatever contamination is functionally inherent in these units must be carefully identified and remedied if possible. But even before this stage, we should be certain that no materials were used in the construction and assembly processes which would impart an undue contaminant burden to the system. Only when engineering remedial action is unsatisfactory should we be concerned with setting mission-oriented tolerance limits for specific contaminants.

materials selection

This is an area where an ounce of prevention is worth a pound of cure. Fortunately, the crucial importance of material selection has recently been recognized, and standard testing procedures have been established for materials acceptability from the standpoints of both fire and toxic hazards. Thermogravimetric analysis, coupled with mass spectrometry, gas chromatography, and infrared spectroscopy where necessary, is used to identify volatile contaminants emanating from cabin materials. As a result, cabin construction materials are being catalogued for acceptability, and the engineers will have a suitable reference list for selecting or substituting materials for specific applications.

To complement the analytical screening effort, biological test methods are also employed in qualifying cabin materials. Small animals are exposed to the gas-off products from cabin materials in a recirculating life-support system to test for overt signs of toxicity and for chronic effects. To avoid unpredictable surprises from potential additive or synergistic effects between contaminants, these tests also include large mixtures of typical cabin materials for a specific system.

human tolerance limits

For control of the most common undesirable contaminants, tentative tolerance limits have been established by the ad hoc Committee on Air Standards of the Space Science Board. These are for preliminary engineering purposes and consider mission durations of 100 and 1000 days. Development of more definite limits requires extensive biological experimentation, which has already been initiated. The same is true in establishing physical limits for alert or abort situations. The importance of animal experimentation in the development of valid human tolerance limits cannot be overemphasized. Because of the many uncertainties and dangers of long-term continuous exposure, objective estimates of tolerance, adaptation, and readaptation must first be established in various animal species to facilitate extrapolation to man. Since many of the attending changes must be quantitated in tissues and at the subcellular level, the necessity for animal experimentation is quite obvious. In this respect the procedures required to declare a specific concentration of contaminant safe are closely related to those routinely employed in the safety evaluation of new drugs, food additives, pesticides, and insecticides.

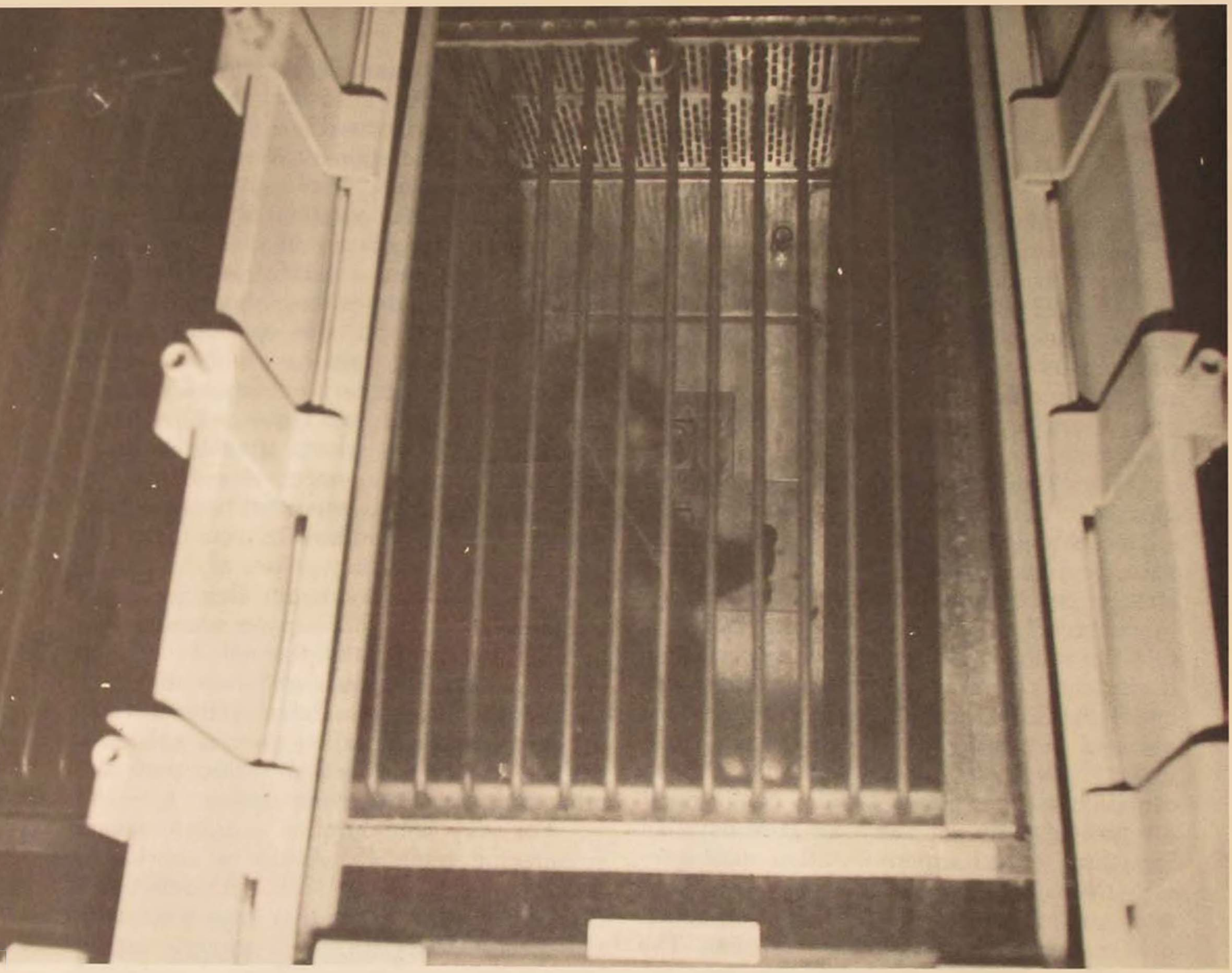
The validity of extrapolation from animal data to human has often been questioned by engineers and technical personnel from other than the biological area. Without going into lengthy polemics, suffice it to say that these procedures have been all worked out and that the safety record in marketing such new drugs and chemicals is both extensive and impressive. Besides the ethical considerations involved in experimentation with human volunteers, the difficulties in obtaining human experimental subjects for 100-day confinement are great enough, let alone for 1000 days! In any case, animal experimentation must precede the exposure of humans to either a simulated contaminant atmosphere or to an actual one occurring during a space mission. The area where human experimentation may become necessary is that of relatively short-duration continuous exposure for the purpose of verifying intactness of performance in an alert or abort situation.

in-flight control of contaminants in the cabin

Assuming that everything possible has been done to eliminate volatile contaminants during the design and construction phase, one still may find certain contaminants when all systems and subsystems become integrated into a functional spacecraft. In many instances systematic search for the origin of these contaminants will also reveal potential methods of control by slightly changing performance characteristics or efficiency of such air-purification devices as catalytic burners, filter flow rates, etc. If all this fails, as a last resort the leak rate of the cabin toward the vacuum of space can be increased at the expense of either mission duration or weight of stored oxygen supplies. A word of caution is in order here. Any such manipulations should be thoroughly tested for efficacy in space simulators on the ground, and a careful analytical survey of the cabin atmosphere should be made to insure that the shifts in operating parameters of certain systems have not led to the production of previously unencountered contaminants. Previous experience with a number of life-support system simulators shows that indeed this can occur very frequently. This type of testing is important because it can also reveal unexpected toxic hazards that might occur during emergency phases of the mission when the crew must attempt alternate methods of repair on the life-support system which have not been originally planned. As a matter of fact, a complete mode-of-failure analysis is an absolute necessity to define well in advance the consequences of failing parts or processes, with concomitant effects on other parts and other processes within the system.

For very long-duration missions, several engineering trade-offs should be considered. As our exploration of space progresses and carries us farther and farther away from earth, the spacecraft logistics and resupply aspects become more and more difficult. In relatively short-duration missions, increasing the leak rate of the cabin can decrease atmospheric contaminants to tolerable levels. This approach is not practical logistically when mission length requires resupply, because of the premium price on payload. At any rate, there must be sufficient oxygen reserve aboard to allow for complete dumping and repressurization of the cabin atmosphere in emergency situations, such as generation of noxious gases from fires or fire extinguishants and contaminants produced by malfunctioning life-support equipment.

Air-filtering and purification equipment must always have sufficient redundancy and capacity to allow for alternate modes of operation during repair or emergency periods. In-flight periodic maintenance will be an absolute



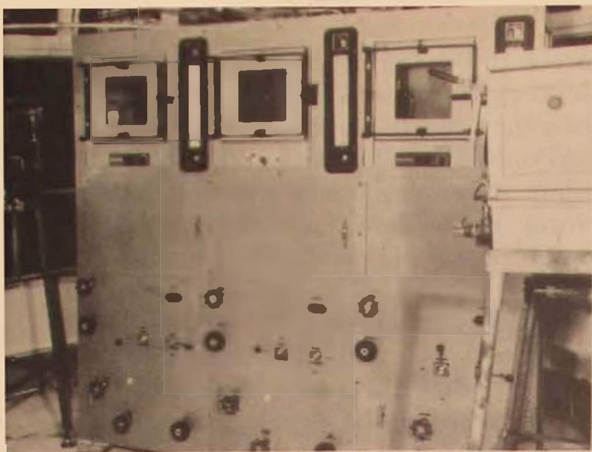
Trained subhuman primates used in experiments must show no clinical pathology changes after the exposure period if the test atmosphere and contaminant level are to be acceptable. To evaluate performance decrement, the animals' visual and audio reaction times are measured for comparison to their conditioned performance of the same continuous discrete psychomotor avoidance tests.

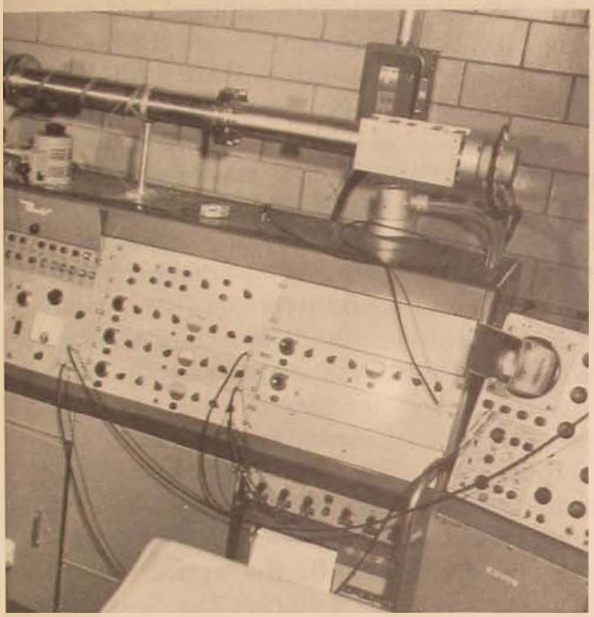
must in long-duration flights. Devices and media that can be regenerated to prolong their service life are preferable. But even regenerative devices have a limited useful life cycle. If too many spares are provided, they also represent an added weight penalty on takeoff.

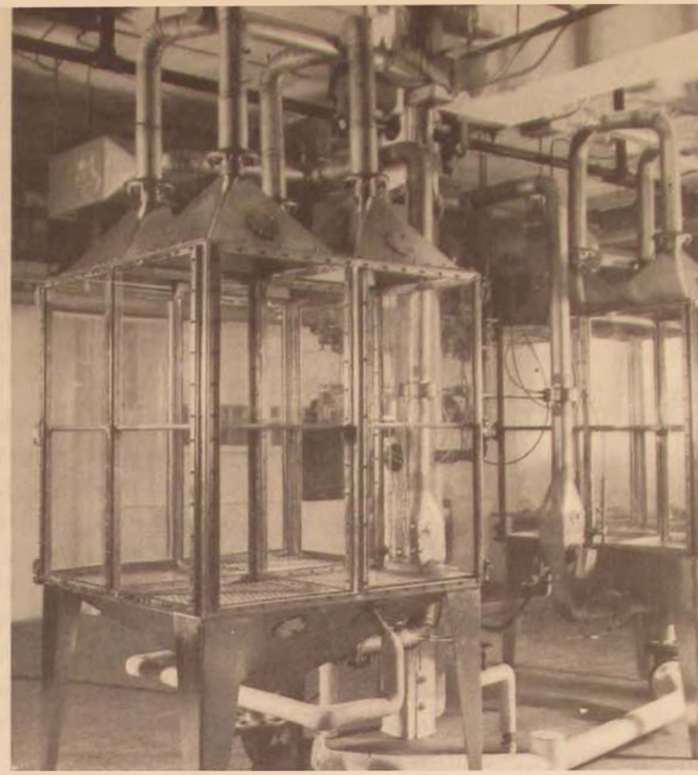
Extraterrestrial materials suitable for absorbent beds probably could be found on the moon and other planets or their satellites and might be processed into usable form with relatively little effort. This approach may also be useful for replenishment of media for waste disposal and trickling filters.

Extraterrestrial materials may also be found which will serve as energy sources for the operation of the life-support system. Other possible uses include shielding materials for extraterrestrial shelters and germination media for growing seedlings for dietary supplements.

The use of extraterrestrial material must be preceded by systematic physical/chemical and toxicological characterization so that no new contaminants are introduced into the spacecraft.







Materials tested for use in space cabins are heated to 155°F in an oven, and the gas-off products are recirculated into a closed-loop system within the dome. The dome remains on an open dynamic flow at 5 psia 100% oxygen, from which replenishment oxygen goes into the closed system. The effect on mice and rats helps in finding the range of acceptable materials. . . . Samples of contaminants in the cabin atmosphere are collected through multistage cryogenic trapping systems and analyzed by mass spectrometry, gas liquid chromotography, and infrared spectrometry. . . . Simpler chambers (right) are used in establishing tolerance levels for ground exposure to such toxic hazards as fuels and oxidizers, fire-fighting agents, engine oils and lubricants, deicers, and new chemicals used in aerospace activities. A steady concentration of test contaminant is maintained in the airflow to animals undergoing toxicity study.

toxicology research needed

The gaps in knowledge concerning response to very long-term continuous exposure to a mixture of contaminants and the effects of combined stress during such exposures must be closed in the next ten to fifteen years. Without this closure, extended aerospace flight would present unpredictable toxicological risks, and contamination of the cabin atmosphere could become one of the most serious limiting factors in the overall safety aspects of space flight. Mathematical models of chronic toxicity must be developed and tested in a systematic manner to evaluate the effect of absorption and clearance rates of toxic contaminants on specific target organs and on the entire organism. This will require the development of new methodology in assaying "half lives" for typical contaminant categories. To perform such studies, tagged contaminants should be used which embody radioisotopes that have as little radiobiological effect as possible. This will require the modification of existing exposure facilities to accommodate the use of low-activity radioactive materials.

As a next logical step, better methods must be found for the evaluation of nonspecific chemical stress. In conjunction with the development and testing of mathematical models, a statistically significant number of animals from each exposure group should be subjected to meaningful terminal stress tests to assess biological reserve. These terminal stress methods should approximate, both qualitatively and quantitatively, the combined stresses of the space mission. Special emphasis should be placed on the re-entry profile and the attendant thermal and biodynamic stress, to insure detection of subliminal biological decompensation resulting from the exposure to toxic chemicals. With such new tools as the dynamic escape simulator nearing completion, this type of terminal stress testing can be optimized and made quite realistic.

New instrumentation must also be developed, both in the biological monitoring area and for the generation and detection of contaminants. Various organ function tests are highly desirable during long-term continuous exposure. Pulmonary and cardiac function should be evaluated on a day-to-day basis, and improved psychopharmacological test methods are sorely needed to detect deterioration of higher mental functions and decision-making processes. By the judicious application of such function tests, the intactness of the integrated organic functions of the experimental animals can be ascertained. Very likely, many of these methods to be developed will be applicable to medical monitoring of the crew itself.

Contaminant generation equipment for animal exposures is still quite primitive, and few advances have been made in the past 50 years. To study highly complex mixtures one will need equipment that can generate, in various proportions, 50 to 100 contaminant species with great reliability for long time periods. The advantage of such equipment employing a fixed-ratio principle is obvious from the monitoring standpoint. Any one of the easy-to-monitor components can be selected for quality control purposes with assurance that the concentration of contaminants will be maintained at the intended level.

Contaminant detection and monitoring in the spacecraft require other approaches. Onboard high-resolution analytical capability can cope with the appearance of unexpected contaminants only if a sufficient number of different sensing principles is incorporated. While some form of readout capability must be aboard for quick interpretation of dynamic changes, the more detailed information can be transmitted back to the operational base for data processing and final identification.

Assuming that the proper mathematical models are successfully developed, a small special computer should be built to aid the medical monitoring personnel onboard and on the ground in decision-making. Since the contaminant profile of the atmosphere will be continually changing as a result of accumulation and removal of old contaminants and the appearance of new ones, the crew's tolerance will have to be computed repeatedly. Such computations should take into consideration the previously discussed phenomena of adaptation, tolerance, additive and synergistic effects on target organs, and the physiological reserve needed for the rest of the mission and re-entry. This computer should also be able to trade off increased contaminant levels with mission duration if such trade-offs are feasible and meaningful.

Much fundamental research must be carried out concurrently with the applied program. Once we start to delineate the deleterious effects of continuous exposure, approaches will become apparent for counteracting some of them. Probably periodic interruption of the exposure by respiratory protective devices or by special clean-atmosphere compartments can counteract the "summation of interest" type of damage mechanism. The optimum length of such recuperative periods must be determined experimentally and concurrently with the continuous-exposure studies. This will both save lead time and also shed further light on the nature and degree of adaptive cellular and subcellular mechanisms, if properly supported by electron microscopic studies of the ultrastructure and concurrent biochemical determination of energy metabolism in mitochondrial and microsomal preparations.

The latter area alone has a significant

impact on the entire field of safety evaluation of new drugs, cosmetics, food additives, pesticides, and agricultural chemicals. The morphological changes at the cellular and subcellular levels must be correlated with functional biochemistry in order to be meaningful. Indeed, the demarcation between adaptation, tolerance, and degeneration is a very thin line and must be described thoroughly and quantitated accurately.

spin-off benefits from space-cabin toxicology research

As has been demonstrated with other areas of the expanding space technology, toxicology research will have several major benefits in the area of medical research. The most prominent of these will apply to occupational medicine, industrial hygiene, air pollution, and the safety evaluation of new chemicals. The better understanding of biological responses to toxic agents in general and to chronic exposures in particular will have a revolutionary effect on concepts governing the control of occupational exposures and the development of protective methodology. The quantitative evaluation of residual toxic effects will have great impact not only on the protection of the industrial worker from the chemical environment but also on the medical-legal assessment of disabilities occurring as a result of lifetime chronic exposures. The developments in the biological and contaminant monitoring areas will undoubtedly find immediate applicability to clinical medicine and industrial hygiene. The tolerance limits in space-cabin atmosphere can be extrapolated easily and safely to shorter-duration continuous exposure, such as occurs in severe air pollution episodes, and will supply the basis for calculating community air standards. The development of a valid mathematical model alone will eliminate the guesswork in experimental planning and in selecting of dose rates for the safety evaluation of new chemicals. The relationship of changes between ultrastructure and biochemistry at the subcellular level will further increase the overall safety and validity in the evaluation of new drugs. In general, the entire area of toxicology and pharmacology will gain from almost every bit of new knowledge that is generated as the result of an intensive research program dedicated to the protection of the health of aerospace crews during extended missions.

Aerospace Medical Research Laboratories, AFSC

THE PHYSIOLOGICAL CLOCK ACROSS TIME ZONES AND BEYOND

Dr. Hubertus Strughold

SINCE the beginning of motor technology the mode and speed of travel have shown a revolutionary development. Before this technological time, back to the era of the caveman, man stayed in his local time zone with its regular cycle of day and night to which his activity and sleep cycle were adapted. The development of transcontinental and intercontinental surface transport vehicles within the past hundred years made it possible to travel through some four to five time zones within a week or fractions of a week. With the appearance of aircraft at the beginning of this century, a radical change took place. Subsonic and supersonic speeds have enabled man to cross half a dozen time zones within a fraction of a day. An even more radical change has been achieved with the orbital velocities of rocket-propelled spacecraft, which cross half a dozen time zones within fractions of one hour, making time zones meaningless for the spaceman. But, like the caveman, the spaceman requires a regular sequence of activity, rest, and sleep. This physiological rhythm is usually synchronized with the physical day-night cycle in the local time zone of man's habitat. Rapidly crossing the time zones, as in travel by air or moving beyond the realm of time zones as in space travel, poses problems of special medical, professional, and general human interest.

Before discussing this topic in detail, we have to familiarize ourselves with man's natural sleep and wakefulness cycle, regulated by his physiological clock.

The Nature of the Physiological Clock and Its Cycle Phases: Wakefulness and Sleep

The considerable progress made in our knowledge of the nature of sleep and wakefulness has been elaborated in detail in the classic book, *Sleep and Wakefulness*, by N. Kleitman, but I must confine myself to a few essential points.

During the state of wakefulness we are aware or conscious of the outside environment and of some processes inside our body via the exteroceptors and interoceptors, respectively. There are various levels of wakefulness described as alertness, attentiveness, and vigilance.

During sleep we are not aware of the outside world. There are also different stages in the depths of sleep—drowsiness as the first stage, light sleep (second stage), and deep sleep (fourth stage), with a transitional stage between the last two. Light sleep is the phase of dreams and rapid eye movements. Concerning the amount of sleep, in addition to the six to eight hours of nightly sleep many people enjoy a short afternoon nap. Furthermore, after a night with not enough sleep, sleep seizures occasionally occur, lasting only several seconds and therefore called "micro-sleep"; they can be the cause of auto accidents late at night. A deeper insight into the stages or levels of sleep and wakefulness has been gained by recording the electric activity of the brain.

During the state of wakefulness the electroencephalogram shows one dominant frequency of "brain waves" of about 9 to 13 oscillations per second and of several millivolts—the so-called alpha waves. During sleep their frequency decreases to 3 to 2 per second, with increased voltage—delta waves. A dream or nightmare causes bursts of more frequent and violent oscillations.

Wakefulness, characterized by mental and voluntary motoric activity, and restful sleep are the most conspicuous signs of the physiological day-night cycle, now called the circadian cycle (from *circa* and *dies* = about a day), (F. Halberg). Many more changes behind the visible scene are found in the activities of practically all other body organs. Their special functions can be recorded by electrical and biochemical methods.

During sleep, activity of the voluntary motoric muscles practically disappears except for some dozen reflex movements triggered by the so-called gravitational pressure points. The muscle tone is relaxed. Consequently, during sleep we observe a slowdown in metabolic rate, respiration, heart rate, and blood pressure.

In contrast, motoric and secretionary activity of the digestive system increases during the night; but the kidneys and urinary transport system are more active during the daytime. The blood, as a kind of mirror, reflects the picture of the overall activities in the form of day-night variations in its cellular and chemical constituents.

Of special significance is the hormone secretion of the endocrine glands because they play an important role in control of the wake and activity cycle. Adrenalin production by the medulla of the adrenal gland is at a maximum between 4 and 6 o'clock in the morning, anteceding the awakening by about two hours, thus mobilizing the body via the sympathicus for the events of the day. Minimum adrenalin production is at around 10 p.m. A similar pattern has been observed in the cortisone-producing adrenal cortex and in other endocrine glands. All these secretionary functions are coordinated by the pituitary gland or hypophysis. This "master gland" is closely connected by nerve fibers with the hypothalamus of the mesencephalon, or midbrain, the central station of the autonomic nervous system, which, with its sympathetic and parasympathetic division, controls all vegetative activities of the human body. Generally, during sleep the parasympathicus is dominant.

All these periodic variations on an organ, cellular, and molecular level, harmoniously integrated into a functional circadian system with the hypothalamus as the coordinating center and the hormones as the intermediary chemical agents but strongly influenced by the cerebral cortex, repeat themselves with a clock-like regularity within the temporal frame of 24 hours. This has led to the coining of the terms "metabolic clock" and "physiologic clock," the best-known indicator of which is the body's temperature, which shows a peak in late afternoon and a low in early morning.

All in all, the body's clock is actually a clock system composed of various subsystems with their own individual clock indicators. This clock system as a whole is predominantly a circadian one-wave system, but the subsystems show additionally intradian fluctuations in their activities in order to meet the needs of the whole body system at the right time.

The natural time signal *(Zeitgeber*—J. Aschoff) time cue or "synchronizer," for the phase setting of sleep and wakening within the circadian cycle is the change from darkness to light at sunrise and back to darkness at sunset. This refers to both the "light active" or diurnal and the "dark active" or nocturnal creatures.

The adult's physiological requirement for sleep is about 7 $\pm$ 1 hour every 24 hours, plus one or two catnaps for those people who are not under community, social, or professional pressure. As mentioned earlier, there are various stages in the depth of sleep—light sleep and deep sleep, with transitional stages between. As a measure of sleep, the concept that the amount of sleep is the product of the duration and the depth of sleep has been suggested (W. von Frey, 1930). Most people at the beginning of their night's sleep fall into a deep sleep for two to three hours, which is followed by a light sleep. Some people seldom enjoy a deep sleep; these light sleepers need more time than deep sleepers to get the same amount of sleep. But there is at present no unit for measuring the amount of sleep comparable to the calorie for measuring metabolic requirements. Be that as it may, within the time frame of 24 hours man needs a certain amount of sleep to restore the energies spent in physical and mental activities during the phase of wakefulness.

Stability and Changeability of the Clock's Circadian Cycle

The circadian cycle in man and numerous animals shows a certain degree of stability, which may be properly expressed by the term "cyclostasis" if "stasis" is used in the same sense as in "homeostasis" or the tendency of the body to keep the physical and chemical properties of the intercellular body fluid nearly constant (proposed by W. B. Cannon in his book, *The Wisdom of the Body*, 1929). If "homeostasis" means controlled internal environment, then "cyclostasis" means controlled internal rhythmicity.

The stability of the circadian cycle, or the cyclostatic nature of man, is demonstrated by the following facts:

(1) It is impossible to break this cycle by ignoring sleep completely over a number of days; this sleep loss would lead to neurotic disorders, as proven by numerous sleep-deprivation experiments. Also from history it is known that Napoleon I and Frederick the Great of Prussia tried to demonstrate that sleep is just a bad habit. After two nights without sleep they had to capitulate to Morpheus, the more powerful god of sleep and dreams. It took them several days to recover from their loss of sleep, to the delight of their generals.

(2) According to Kleitman's sleep studies in Mammoth Cave, Kentucky, the duration of the circadian rhythm can be shortened to 18 hours or extended to 28 hours by exposing the individual to artificial light-dark cycles; the physiological clock accepts these durations by adaptation. But going below this minimum or beyond this maximum is outside the clock's adaptability, and it continues to run at its routine optimum 24-hour cycle.

(3) The sleep and wakefulness cycle continues in its nearly circadian pattern in constant photic environments, as observed on inhabitants of the subpolar twilight zones and

on animals kept under similar constant conditions in the laboratory.

(4) The physiological circadian cycle can be shifted in reference to the physical one, but it requires a number of days for readjustment. This is a familiar problem in work shifts in certain industries, communication and transportation services, fire and police departments, hospitals, military services, astronomical observatories, on ships, etc. Individuals involved in these professional activities feel some inconvenience when they have to change the work time. There are, of course, individual differences in the sensitivity to a phase shift. Some people can sleep like a cat any time, any place, under any conditions, but the majority are more or less sensitive in this respect. This is even indicated by the public reactions to such a small time change as that to daylight saving time.

These four points definitely illustrate the basic cyclostatic nature of the human body in terms of a relative stability of its internal circadian cycle.

In all these examples of changes in work time, the individual stays in his home time zone. With the development of fast-moving surface vehicles and especially since the advent of the airplane, a new way of phase shifting of the day-night cycle is experienced by millions of people, that is, by time zone changes during travel, particularly by air.

the physiological clock in air travel

Within the higher range of subsonic speed and in supersonic speed, about half a dozen time zones are crossed in six hours or less. This exposes a traveler in a very short time to a day-night cycle different from that at the point of departure and consequently different from the physiological day-night cycle which dominates his body. This means a phase shift between the geographic and physiologic cycles. Flight in an easterly direction advances the cycle and in a westerly direction delays it.

This unaccustomed relation of the internal time of the traveler to the local geographic time is called desynchronization or desynchrony, and it may take him from several days to a week to get adapted to the local time at the termination of the trip, or until the two cycles, physical and physiological, are resynchronized.

As statistical studies in long-distance flights have shown, the majority of people are sensitive to this travel-produced phase shift and experience some discomfort for several days. They become hungry, get sleepy, or are wakeful at the wrong time with regard to the new local time. Their "head clock" and "stomach clock" and elimination system are confused. Such is, in brief, the picture of the circadian "phase shift syndrome."

After transcontinental flights in the U.S.A., this condition lasts from two to four days; after transatlantic flights, four to six days. After crossing twelve time zones, or a complete reversal of the day-night cycle, resynchronization may take ten to twelve days. As a general rule, most travelers adjust to a new circadian cycle at a rate of nearly one hour per day. Some people adjust more easily after eastbound flights, others after westbound flights, and some when returning to their home time zone with its familiar climate and social order. But no definite statements in this respect can be made at the present time. There are, of course, also some people who are not particularly sensitive to time disorientation.

It must be emphasized that the psychophysiologic effect of cycle desynchronization, or, more in line with medical language, desynchronosis, is not a pathologic condition; it is merely a time disharmony concerning what the body's physiological internal milieu expects from the physical and social external milieu at the new locale. But this time disharmony can be significant in many respects.

First, circadian cycle desynchronization can have some significance concerning political summit meetings, emergency sessions of the United Nations, international scientific congresses, the Olympic games, etc. During the first few days of such events the participants who had to cross a number of time zones may be temporarily in a somewhat handicapped position due to their desynchronotic condition.

The problem of circadian cycle desynchrony is especially important for those whose occupation involves time zone changes. Pilots of long-distance air routes and stewardesses as well are in this category. Too frequent shift of their circadian cycle causes fatigue and requires special attention; this is well recognized and taken care of by the pilot associations, the medical directors of the airlines, and the medical officers of the Air Force.

What can be done to avoid the state of desynchronization of the circadian cycle on a certain occasion which requires full alertness after long-distance flights? There are several ways to achieve this and to be synchronized with the local time at the destination of the journey at the right time.

First, if an individual has to attend an important meeting at a distant location he can preset his physiological clock by adopting several days before the trip a sleep and wakefulness pattern corresponding to the physical day-night cycle of the place in question. This is preflight adaptation or synchronization. When traveling in an easterly direction, one can do this by going to bed every evening one hour earlier, and in a westerly direction one hour later, beginning three to five days before departure.

Second, the individual can fly to the distant place several days in advance of a certain event or meeting; this is postflight local preadaptation.

Each of these two methods, preflight and postflight preadaptation, should be effective to keep the traveler alert during the day desired.

A traveler who cannot afford the time for preadaptation should know that the morning hours during the first days after long eastbound flights and the late afternoon hours after westbound flights are not the proper times for important discussions and decisions.

Finally, mild medication, taken at the proper time, might be helpful to accelerate, as a kind of biochemical synchronizer, the physiological adjustment to the new local time.

All this is of no concern to vacation travelers.

Furthermore, the higher-speed jets can also mitigate the problem of time zones and circadian rhythm in that they allow flight to a distant place and back in one day; for instance, from cities on the East Coast of the U.S.A. to the West Coast and return. In this case phase shift is an intradian matter and should cause no desynchronization symptoms, especially if the speed is supersonic, which makes possible even a round trip from Washington, D.C., to the capital cities of Europe within one day.

the physiological clock in space flight

Supersonic speed exceeding mach 5 is called hypersonic speed. This third aeronautical speed blends with the first astronautical or cosmic velocity (8 km/sec) which permits orbital flight. With this we enter a completely novel situation—the customary geographic day-night cycle is replaced by a cycle of short sunlight, short earth-shadow.

Within the relatively radiation-safe altitude range from 200 to 800 km below the inner Van Allen radiation belt, the orbital periods last from 80 to 130 minutes. About 30 percent of this time, depending upon the orbit's inclination, the spacecraft is in the earth shadow. The external photoscotic (light-shadow) period is not longer than one-tenth of the light-darkness cycle on earth.

But in this unearthly photic environment of near-earth space, with short, contrast-rich photic periodicities, orbiting astronauts in the arrangement of their sleep and activity regime have to follow the dictate or, better, the "tick-tock" of their internal clock. It has to be isochronous with their natural inborn circadian pattern, and preferably synchronous with their home time zone. (Isochronous: occurrence in equal time periods; synchronous: occurrence at the same time.)

In addition to the absence of a suitable external light-dark cycle, the absence of weight enters the life of the astronauts. Fortunately, sleeping under weightless conditions seems to be no problem. One of the reasons: no gravitational pressure points. Furthermore, weightlessness makes the parasympatheticus dominant, which conforms with the sleep-induced parasympathicotonia. All our astronauts and the Russian cosmonauts had a sound sleep when the radio noise level was kept in proper relation to the silence of space. With two astronauts on a space flight, it has been found practical for them to sleep at the same time, so that Space Center on earth can give both of them radio silence for sleep and still leave maximum time for communication with them (Berry). With a crew of more than two, a properly arranged shift in the sleep and activity cycle will be required.

All in all, nothing illustrates more clearly the built-in cyclostasis of the human body than space flight with its exotic photic environment.

On the moon, the physiological sleep and activity cycle will be completely independent of the physical or selenographic day-night cycle, which is 27 terrestrial days in length. This photic environment does not provide a "time cue" comparable to earth's sunrise and sunset within 24 hours. The selenonauts must arrange in the lunar station the sleep and activity regime that accords with their geocyclostatic nature. Fortunately, since the moon's low gravity (one-sixth of one g) would probably cause fewer sleep-interrupting body movements than on earth because of lighter pressure points, sleep might be more refreshing in the easeful arms of Luna, goddess of the moon.

On the most attractive postlunar astronautical target, the Red Planet, Mars, the day-night cycle is only 37 minutes longer than that on earth. Thus the temporal day-night alternation on Mars offers a time sequence familiar to terrestrial visitors for their sleep-activity cycle, and consequently there should be no difficulties in this respect on a Martian station.

In conclusion, the circadian cycle of the physiological clock, as an inborn property of the human body, is and will remain of medical and professional interest in air travel with reference to the global network of time zones, and beyond them it will play a vital role in the success of man's further conquest of space.

USAF School of Aerospace Medicine

Bibliography

Aschoff, J. "Zeitgeber der tierischen Tagesperiodic," *Naturwissenschaften*, 41: 49-56, 1954.

Berry, C. A., Coons, D. D., Catterson, A. D., and Kelly, G. F. *Gemini Mid-Program Conference*, Part I. Houston: NASA Manned Spacecraft Center, 1966.

Bünning, E. *Die Physiologische Uhr*. Berlin: Springer-Verlag, 1958, 1963.

Endres, G., and von Frey, W. "Ueber Schlaftiefe und Schlafmenge," *Zeitschrift für Biologie*, Vol. 90. Munich: J. F. Lehmanns Verlag, 1930.

Gazenko, O. G. "Medical Investigations of Spaceships Vostok and Voskhod" in Chap. XVIII, *Third International Symposium on Bioastronautics and the Exploration of Space*, ed. T. C. Bedwell, Jr., and H. Strughold. Brooks AFB, Texas: Aerospace Medical Division, 1965.

Halberg, F. "Circadian (about twenty-four hour) Rhythms in Experimental Medicine," *Proceedings of the Royal Society of Medicine* (1963), Vol. 56, pp. 253-60.

Halberg, F. "Physiologic Rhythms" in *Physiological Problems in Space Exploration*, ed. J. D. Hardy. Springfield, Illinois: Charles C. Thomas, 1964.

Hauty, G. T. "Psychological Problems of Space Flight," Chap. 25 in *Physics and Medicine of the Atmosphere and Space*, ed. O. O. Benson, Jr., and H. Strughold. New York: John Wiley & Sons, 1960.

Kleitman, N. *Sleep and Wakefulness*. Chicago: University of Chicago Press, 1939, 1963.

Luce, G. G., and Segal, L. *Sleep*. New York: Coward-McCann, Inc., 1966.

Oswald, I. *Sleep*. Baltimore: Penguin Books, 1966.

Parin, V. V., Volynkin, Yu. M., and Vassilyev, P. V. "Manned Space Flight," *COSPAR Symposium*, Florence, Italy, 1964.

Pittendrigh, C. S. "Perspective in the Study of Biological Clocks" in *Symposium on Perspectives in Marine Biology*. Berkeley: University of California Press, 1960, pp. 239-68.

Richter, C. P. *Biological Clocks in Medicine and Psychiatry*. Springfield, Illinois: Charles C. Thomas, 1965.

Strughold, H. "Physiological Day-Night Cycle after Global Flight," *Journal of Aviation Medicine*, 23: 464-73, 1952.

Strughold, H. "The Physiological Clock in Aeronautics and Astronautics," *Annals of The New York Academy of Sciences*, 134: 413-22, 1965.

Acknowledgment

The author wishes to acknowledge consultation with Colonel R. F. Fitch of Wilford Hall USAF Hospital, Lackland AFB, Texas, and Colonel William Douglas, Commander, USAF Hospital, Wiesbaden, Germany.

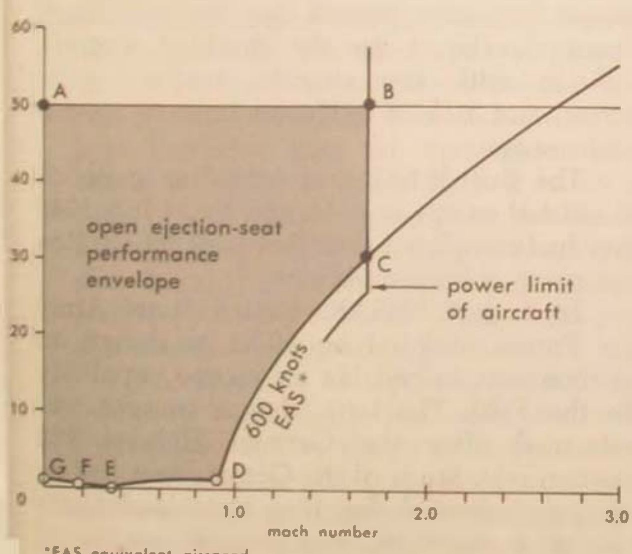
DEVELOPMENT OF AEROSPACE ESCAPE SYSTEMS

James W. Brinkley

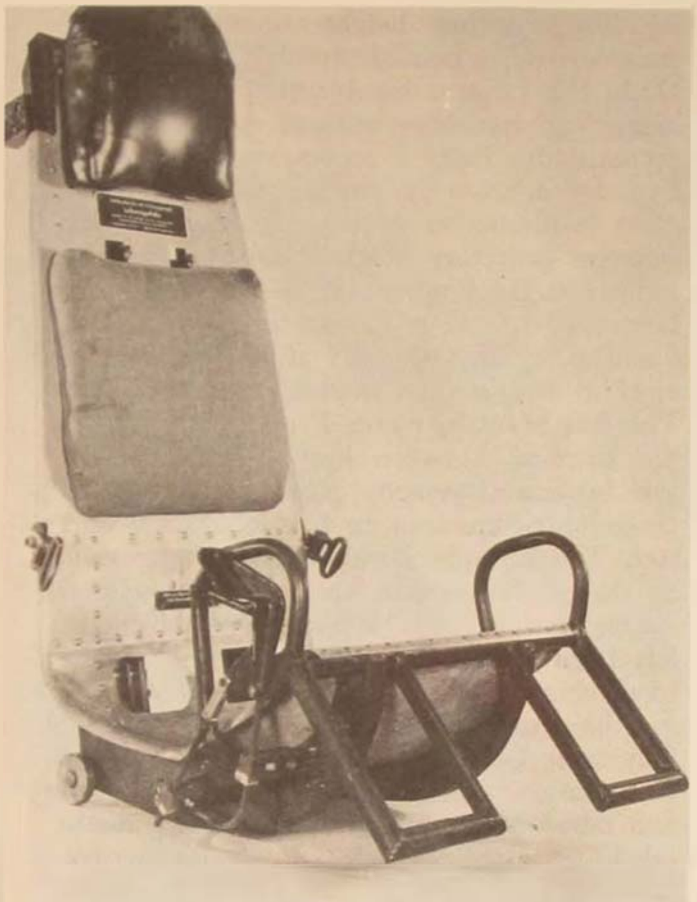
Two decades have passed since the first operational ejection seat was installed in a United States Air Force aircraft. Within these two decades the escape systems used by the Air Force have evolved from a relatively simple, ballistically catapulted crew seat to the explosively severed, rocket-propelled cockpit escape system of the F-111. This evolution has been marked by a progression of subsystem improvements, including the automatically opened lap belt, automatically actuated parachute, and seat/man separation devices. Each has significantly enhanced the efficacy of escape systems. The overall performance envelope of the escape system has been extended by the development of seat stabilization techniques, forcefully deployed parachutes, and methods of protection from windblast and altitude, such as the encapsulated seat.

Aerospace medical research has been an inherent part of the escape-system development effort. One need only consider the factors that limit the performance capability of a given escape system to recognize this relationship. Figure 1 illustrates a typical performance envelope for an open ejection seat assuming level flight and no sink rate. The performance limit from point A to point B is established by the requirement to provide altitude protection for the ejectee. The limit between points B and C is determined by the power capability of the aircraft. The ejectee's ability to withstand high dynamic pressures and rapid deceleration defines the limit from point C to D. The human tolerance to parachute-opening shock determines the limit of the envelope between D and E. Point E represents the highest velocity at ground-level air density at which the personnel parachute may be opened without injury to the parachutist. (In some escape systems the parachute opening is automatically retarded until the velocity decays below this limit.) The limit between D and E is caused by the time delay and resultant ejection trajectory loss until the ejectee has decelerated to a safe parachute-opening velocity. The trajectory height remains a critical parameter from point E through points F and G. In this range a combination of trajectory height and horizontal velocity determines the actual limits. Point F represents the airspeed that, for a given system, is considered sufficient to obtain an open parachute with the inherent trajectory height available. Point G represents the limit of the ejection trajectory height solely and is directly or indirectly influenced by the ejectee's ability to tolerate ejection acceleration without spinal injury. The line between points F and G represents the trade-off between the trajectory height and horizontal velocity parameters. None of these limits represent an insurmountable barrier. The altitude limit has been overcome by use of the pressure suit and the enclosed escape system. The dynamic pressure limit has been extended by enclosing the ejectee to eliminate windblast injury and by improving the drag characteristics of the escape system to reduce the magnitude of the rapid deceleration. Furthermore, current research and development efforts are disclosing methods to reduce the low-altitude escape barriers. Nevertheless, advances in aerospace-system performance and the concentration of fatalities outside of current escape-system performance envelopes continue to spotlight vividly the requirement for expansion of the escape envelope.

Figure 1. Typical escape-system performance



Determining the ability of the human to withstand a given environmental stress is basically the same problem that confronts the aerospace-vehicle designer when he must determine whether a vehicle subsystem can function within the environment. The vehicle designer may test the subsystem to failure numerous times, enabling him to describe with a relatively high degree of accuracy such factors as the performance decrement with each increase in stress, as well as the variability of the level of stress causing system failure. The point of human failure, however, may be the level of stress that will cause physical or psychological injury or even fatality, so of course destructive tests with a living human are impossible. Unfortunately, the human factors that limit the performance



The pilot ejection seat for the German Heinkel 162 was in production when World War II ended. A propulsive unit propelled both seat and pilot clear of the airplane; after manual release from the seat, the pilot parachuted to safety.

envelope of escape systems are indeed ones involving injury and fatality. Thus the aeromedical problem is a paradox in that the level of stress that will cause injury must be defined without deliberately causing injury in the process. To circumvent this situation, injury limits must be investigated by use of accident data, cadaver tests, operational experience, and laboratory tests to stress levels which provoke pain rather than injury. All these techniques are laden with problems that eliminate them as an individual solution. The purpose of this article is to review the development of aerospace escape systems from the aeromedical standpoint and describe recent advances that have made it possible to define more completely the human factors limiting the escape-system performance envelope. Performed within the current envelope limits, ejections have reached a success rate of 95 percent; however, the overall success rate is 88 percent.[1]

historical background

Early in World War II the German Air Force recognized the need for a method of assisted escape from disabled high-performance aircraft. By the end of the war they had developed and flight-tested the ejection seat, and it had been used approximately sixty times.

In 1943 the Allied forces began to consider seriously the requirement for an escape system. A study of accident reports conducted at that time by the United States Army indicated that 12.5 percent of all emergency bailouts accomplished in the preceding 12-month period had resulted in fatal injuries. Nonfatal injuries were experienced by 45.5 percent of the personnel involved in the bailouts. Of the aviators abandoning single-engine aircraft, approximately 24 percent had been fatally injured. The alarming nature of these statistics was emphasized when they were compared to parachute training records. These records revealed that less than 1 percent of personnel involved in parachute training exercises were killed, and 1.5 percent injured. Analysis of emergency bailout reports indicated that escape was complicated by the centrifugal forces developed by the disabled aircraft, collision with the aircraft structure after egress, and lack of sufficient time to accomplish escape.

The British began investigating methods of assisted escape in 1944, and by 24 July 1945 they had completed their first in-flight ejection test using a human subject.

In August 1945 the United States Army Air Forces initiated an effort to design an ejection seat to provide an escape capability for the F-80. The basic design concept was patterned after the German Heinkel 162 ejection seat. Study of the German seat and its catapult indicated that they were inadequate for use in the F-80. The ejection velocity of the seat did not provide sufficient clearance between the seat and the vertical stabilizer at the maximum airspeed of the F-80. Hence primary emphasis was given to the development of a new ballistic catapult.

The most fundamental problem in the design of an ejection catapult is in assuring that the ejection velocity is adequate to provide safe clearance between the seat trajectory and the aircraft tail surfaces. In a ballistic catapult, the velocity is limited by the length of the ejection stroke and the magnitude of the seat acceleration. Since the ejection stroke of a ballistically propelled seat is determined by the depth of the cockpit, the required seat velocity must be obtained by maximizing the catapult acceleration. This must be accomplished within the restrictions imposed by the capability of the human anatomy to withstand the acceleration without injury. The injury most commonly experienced during the catapult phase of the ejection sequence is compression fracture of the vertebrae of the spinal column, with associated damage to the surrounding muscle and ligamentous structures.

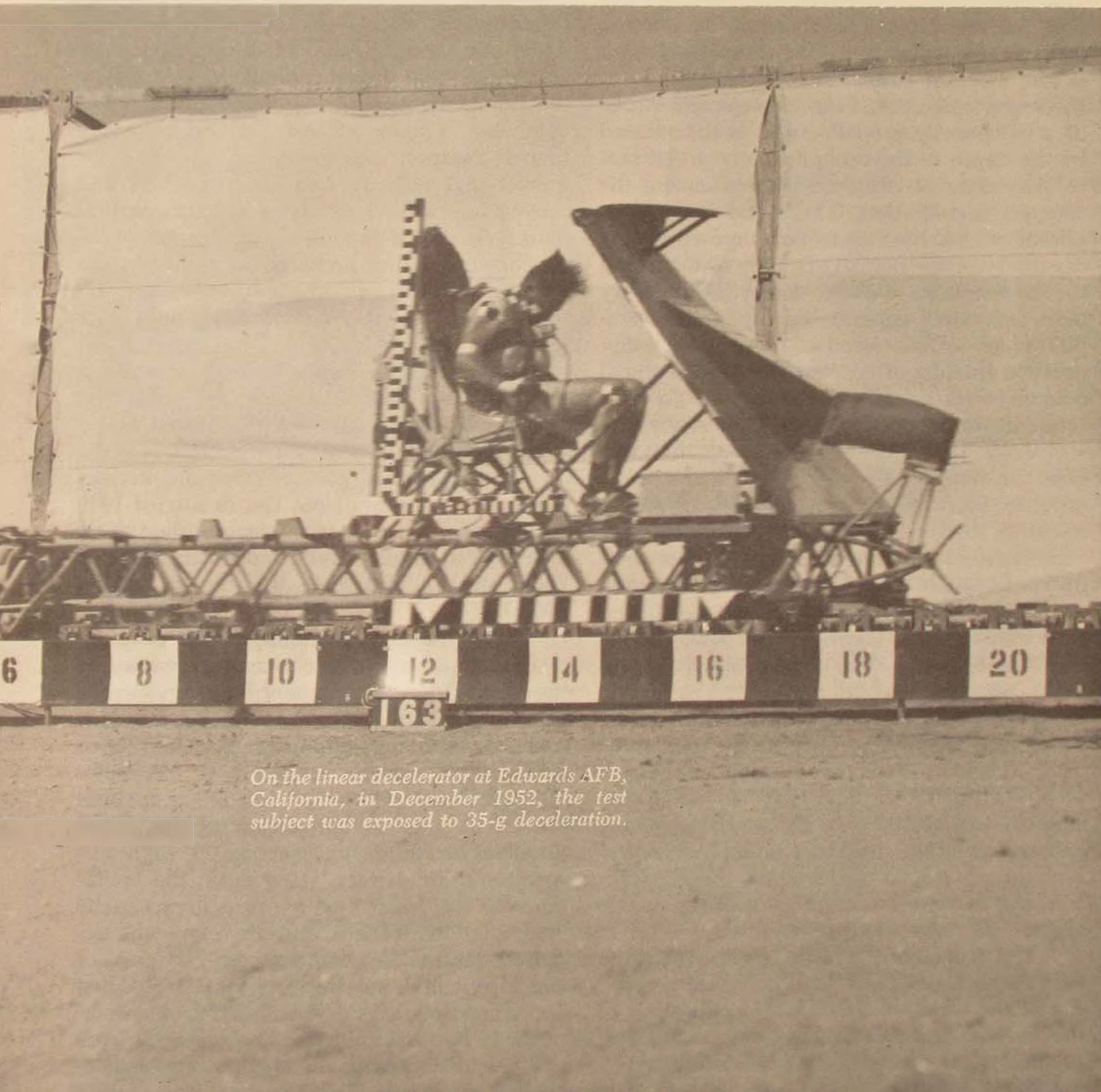
Until 1945 little effective research had been accomplished to determine man's tolerance to short-duration acceleration. German scientists had conducted numerous ejection experiments with human subjects,[2] but their instrumentation was considered inadequate, so that many of their conclusions were viewed with considerable skepticism by scientists in the United States.[3] The conclusions that were more seriously considered were based on data from tests of cadaver vertebrae under static load conditions. The data from these tests indicated that the vertebral segments would fail at 23 to 25 g. Since it is not possible to extrapolate directly to the dynamic loading situation, these data did not represent the answer to the catapult design problem, but they were a basic piece of the puzzle and a reasonable starting point.

The response of elastic systems to static versus dynamic loads had been studied by Frankland,[4] and so the rate of application of the acceleration was recognized as a critical parameter in optimizing the catapult acceleration. More specifically, from a theoretical standpoint it is possible to use the static tolerance limits only if the acceleration is applied so slowly that the loads within the elastic systems, in this case the human spine, do not dynamically overshoot the input loads, i.e., the seat acceleration. The experimental effort was oriented toward finding a workable tradeoff between the parameters of acceleration magnitude and acceleration onset rate. The experimental effort was conducted by the Army Air Forces Aero Medical Laboratory at Wright Field. Using catapults developed by the Frankford Arsenal, the laboratory exposed volunteer human subjects to progressively higher catapult accelerations until the required seat velocity had been reached and proved tolerable. Two of the subjects participating in the aeromedical experiments were concurrently being prepared to flight-test the ejection seat, an effort being managed by the Aircraft Laboratory and the Flight Test Division at Wright Field. The ejection-seat research and development effort reached a major milestone on 17 August 1946 when the first human ejection within the United States was completed from a P-61B aircraft.

The first operational ejection did not occur until three years later. On 29 August 1949 a successful ejection was accomplished from an F-86A at an airspeed of approximately 500 knots and an estimated altitude of 1000 to 2000 feet.

From the very beginning of the development of escape systems, human tolerance to the acceleration environment has been a major stumbling block. As soon as the acceleration criteria for the ejection catapult had been provided, it was recognized that the major human tolerance problem remaining to limit the useful range of the ejection seat was rapid deceleration following ejection at high airspeed and air density. Once again the limitations of the human body were found to be inadequately defined, and therefore the required limit of the escape-system performance envelope could not be established. The first approximation of the envelope was accomplished by ejecting human subjects from a flight-test aircraft. Ejections were accomplished at progressively higher airspeeds—up to 482 knots true airspeed at 9000 feet altitude —without injury to the subjects. In view of these tests the investigators concluded that ejection could be safely accomplished to approximately 600 knots equivalent airspeed (EAS). This capability appeared to be adequate for the high-performance aircraft of that time period.

In order to provide better estimates of human tolerance to the ejection-seat deceleration and windblast under more controlled conditions, the Aero Medical Laboratory con-



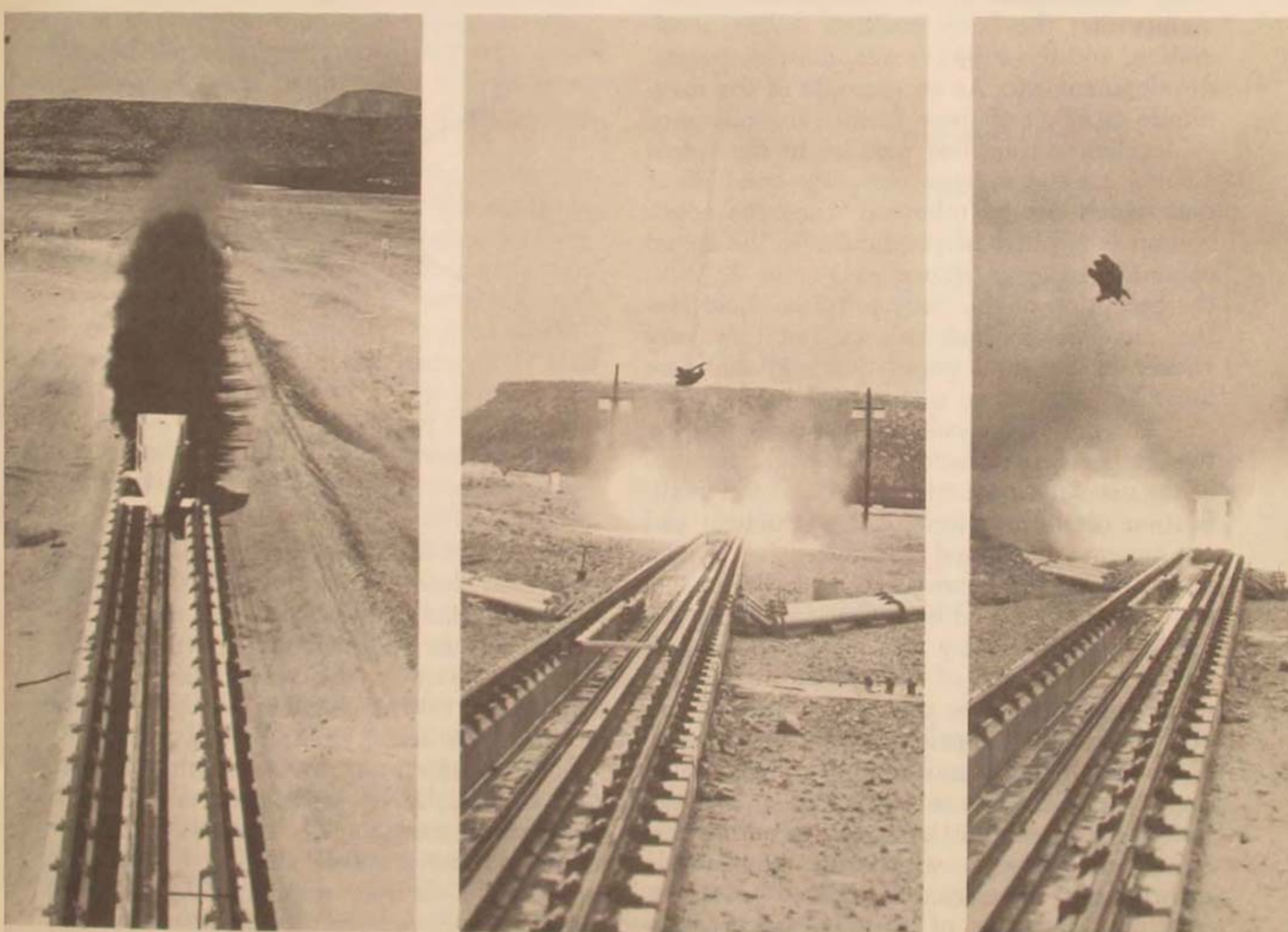
On the linear decelerator at Edwards AFB, California, in December 1952, the test subject was exposed to 35-g deceleration.

ducted a series of human experiments using rocket-sled techniques.[5] This extensive series of tests provided data that remain the basis for human tolerance criteria for rapid deceleration when the acceleration is applied chest to back or back to chest.

acceleration tolerance parameters

From the experimental evidence available and an understanding of the basic mechanics involved, it is now possible to identify the parameters that directly or indirectly determine if the ejectee will be injured by the ejection acceleration. These parameters are acceleration environment, acceleration modification, and imposed acceleration versus the ejectee's load-bearing ability. The most fundamental parameters in determining the potential for injury are the characteristics of the acceleration imposed at the interface between the subject and his environment and his ability to tolerate the acceleration. The characteristics of the acceleration are defined in terms of the acceleration-time function, i.e., they are defined primarily by the time to maximum acceleration, the duration of maximum acceleration, and the duration of the entire acceleration. From the earliest human testing, the rate of application of acceleration

To determine how best to help pilots escape from supersonic aircraft, a rocket sled carries dummy pilot at more than 500 miles per hour down a 12,000-foot test track at Hurricane Mesa, Utah.



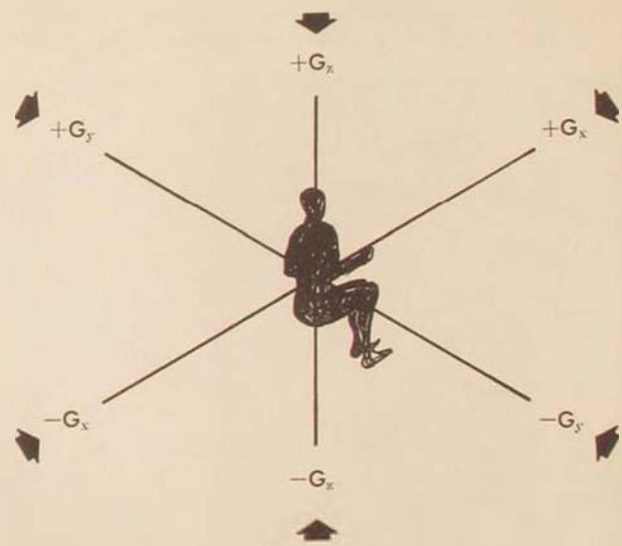
(the rate of onset) or the time period to the maximum acceleration level has been known, at least empirically, to have a direct effect on the tolerability of the acceleration environment. More specifically, higher acceleration levels have been observed to be more easily tolerated if the rate of onset of acceleration is reduced. In fact, as mentioned earlier, if the acceleration is increased gradually, it is feasible to reach an acceleration level equal to the static load that would cause injury. Conversely, if the acceleration is applied too rapidly, the acceleration within a mechanical system such as the human body may theoretically exceed the input acceleration by as much as a factor of two if the system is undamped.[6]

The ability of the human body to tolerate the acceleration is quite complex and is dependent upon factors such as position of the body with respect to the acceleration vector, maintaining the body position during acceleration, and the subject's age, musculoskeletal development, etc. As an example of the magnitude of effect of these factors, the tolerance to acceleration applied parallel to the spinal column ($+G_z$) is approximately one-half of that which can be tolerated when the acceleration is applied perpendicular to the spinal column ($+G_x$) as shown in Figure 2. With the exception of the body position, these factors are fixed in each subject, but they vary widely in the total population and therefore must be handled on a statistical basis.

The imposed acceleration is controlled by two rather broad factors: the characteristics of the acceleration environment and the modification of the acceleration by structure and equipment interposed between the human body and the environment. Each of the factors contains many variables within it. The acceleration produced by the ejection catapult varies as a function of the weight of the seat/man combination, the preignition temperature of the catapult propellant, and variations in the catapult propellant. The degree of acceleration modification is dependent on the deformation characteristics of the structure and equipment through which the acceleration environment is transmitted to the subject. The characteristics of structure and equipment may either amplify or attenuate the acceleration.

The ejection-seat cushion was the first piece of equipment known to modify the acceleration adversely.[7] The deformation of the seat cushion during ejection isolates the ejectee from his environment for a brief period, allowing the seat velocity initially to exceed significantly that of the ejectee. Once the seat cushion bottoms, the ejectee is rapidly accelerated until he and the seat reach the same velocity. In the process the acceleration

Figure 2. Acceleration terminology, arrows indicating direction of inertial responses



of the subject usually exceeds the acceleration he would have experienced had he been rigidly coupled to the seat. Other similar factors that might adversely modify the acceleration transmitted to the subject include elasticity of his restraint system, slackness of the restraint, and flexion of the seat structure.

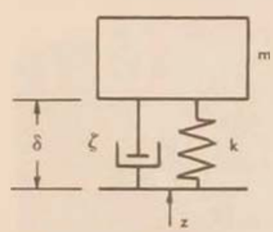
The acceleration environment may be modified beneficially by interposing acceleration-attenuating components, such as crushable foam, hydraulic shock absorbers, crushable honeycomb, air bag decelerators, etc. Such components have been used in escape systems of the B-58 and B-70 capsules and the F-111 crew escape module as well as the Project Mercury and Project Apollo vehicles.

human analog

Two difficult problems in the development of escape systems have been, first, the lack of data on the capability of the human being in the hostile environments sometimes encountered in emergency escape; and, second, the ambiguity and inconsistency of the data that have been made available to the escape-system designer. The first problem stems from the inherent difficulties in conducting human tolerance research and from the discontinuity of research emphasis on the escape-system development problem. The second problem developed initially out of the inconsistencies in the methodology used by the first investigators to describe the acceleration environment and the associated human response. This situation has been perpetuated by the slow pace of the research and by lack of a unifying methodology.

Within the last five to ten years there has been a gradual improvement in the methodology. The most significant advance has resulted from the use of analogs to describe the human response to mechanical environments, such as the short-duration acceleration associated with ejection. Since the response of the human body that results in injury is mechanical in nature (i.e., deformation of body tissue to the point of failure), the analog is a mechanical system composed of elements analogous to the mass, elasticity, and damping properties of the body. The response of the analog is describable by differential equations containing terms representing the positions of the mechanical elements with respect to time. Thus, by computation of the response of the analog elements for a given acceleration input, the response of the human body can be predicted. The accuracy of the analog may be determined by comparing the computed response of the analog with the measured response of the human body to noninjurious acceleration environments created in the laboratory and also by analysis of the environments known to have caused accidental injury.

The human response to short-duration accelerations applied parallel to the vertebral column ($+G_z$) is currently studied by use of a mechanical analog, since the critical mode of injury in this axis, compression fracture of the vertebrae, is a structural phenomenon. The simplest analog for this axis is a mechanical model composed of a mass, a spring, and a damper. The system elements are lumped-parameter elements, e.g., all the mass of the human body that acts upon the vertebrae to cause deformation is represented by the mass element. A diagram of the analogous model is shown in Figure 3. This model is used to predict the maximum deflection and associated force within the vertebral column for any given short-duration acceleration environment. The properties of the model elements



*dynamic response index

m = mass (lb-sec^2/in)

δ = deflection (in)

ζ = damping ratio

k = stiffness (lb/in)

z = acceleration input (in/sec^2)

$$^*\text{DRI} = \frac{\omega_n^2 \, \delta_{max}}{g}$$

ω_n^2 = natural frequency of the analog = k/m (radians/sec)

g = 386 in/sec^2

Figure 3. Spinal-injury model

have been derived from existing data. For instance, the spring stiffness has been determined from tests of cadaver vertebral segments, and the damping ratio has been calculated from measurements of mechanical impedance during vibration and impact of human subjects.[8]

Weber Seat Ejection Test

Development of an ejection seat for the supersonic F-102 that could be safely used at very low altitudes involved testing from a vehicle standing still on the ground. The Weber seat ejection test at Edwards AFB in January 1967 used a dummy (shown side view, front view, and after firing).

Study of the spinal-injury model provides a great deal of insight into the findings of earlier experimental evidence. It reveals rather simply that there is a physical basis for the observation that the acceleration level that may be safely tolerated is a function of the time required to reach the acceleration level. In this instance the experimental data can be used to verify the adequacy of the model. This verification provides additional confidence in the model's ability to predict the human response in environments that have not been as thoroughly investigated.

One of the greatest limitations of the method previously used to describe human tolerance to spinal injury was the oversimplification to fit the acceleration-time history of the environment in terms of a trapezoidal wave form. The trapezoidal wave form was selected because it fit the accelerations produced within the laboratory and, at least initially, the operationally encountered environment. Unfortunately, as escape systems became more complex, the acceleration environment became complex. With the advent of the escape capsule, the complexity of the acceleration environment reached a level that could not be handled by the method.

The acceleration environment of the escape capsule represents a major departure from the open ejection seat, since the ejectee remains within the capsule during parachute deployment, descent, and landing phases of the escape sequence. Because of variability of the descent velocity, oscillation of the capsule beneath the parachute, horizontal wind drift, and nature of the landing surface, the acceleration wave forms during landing impact are highly irregular and the direction of the acceleration vector unpredictable. It was this almost insurmountable problem that provided the greatest stimulus to the analog development. The human analog has not evolved to the point of sophistication that the problem of changing direction of the acceleration vector can be handled adequately, but the irregularity of the wave form is no longer a difficult problem. The limitation thus far is the lack of biological data to incorporate into the human analog.

operational verification

The human analog provides more than a basis for handling the complex acceleration profiles of the operational world; it provides a statistical method of predicting the injury potential of any given environment. Since the biologically important response of the analog can be measured in terms of a single parameter, such as the peak force within the system or the corresponding deflection of the system, the analog avoids the problem of relating the multiple descriptors of the environment, i.e., acceleration magnitude, pulse duration, time to peak acceleration, etc., which may vary individually or in combination. Using the analog, the analysis of environments known to cause injury can provide a correlation between the single human response parameter and the risk of injury associated with it.

Some insight into the probability-of-injury relationship can be seen from the cadaver test data that have been used to develop the stiffness characteristics of the spinal-injury model. As one might expect, the breaking strengths of the tested vertebral segments varied. The breaking strengths of these specimens can be statistically described. These values appear to be normally distributed about the mean value of the breaking force or deflection. Thus, for a given force or deflection there is a specific probability of failure. However, since these breaking strengths are obtained from research with cadaver material, the direct application of these data to the operational circumstance must be limited.

To provide correlation between the predictions of the model and the injuries being experienced operationally, an analytical effort has been in progress to collect data describing the accelerations produced by aircraft escape systems and to determine the spinal compression fracture rates associated with the use of each system. This proved to be no simple matter. Either instrumented ejections had not been accomplished or there had been so few instrumented ejections and the measurements so varying that they could not be described with any statistical confidence. However, a large body of data was found to exist from catapult qualification firings. These data were collected under controlled conditions and were sufficient in number to allow statistical analysis. Use of catapult qualification data has the potential failing of not being representative of the environment that causes the reported injury. The inherent variability of catapult performance due to preignition temperature of the propellant, the ejected weight, and the variability of the propellant make it virtually impossible to estimate the actual environment that caused the injury. Nevertheless, from the standpoint of controlling the design of catapults by use of the analog approach, use of the catapult qualification data provides an important advantage. Briefly, since the catapult performance data are usually the only comprehensive and statistically valid data collected during system development, it appears practical from a system design standpoint to relate the statistical distribution of qualification test results to the rate of operational injury. Conversely, although very interesting from a research standpoint, it did not appear practical to determine an absolute injury level and then attempt to relate this level to the probability of its occurrence operationally.

The relationships between the acceleration environment and the risk of injury that have been derived to date are given in Figure 4. The response parameter of the model has been nondimensionalized and expressed in terms of dynamic response index (DRI) values. The probability of injury determined from the cadaver data is indicated by the broken line. The operational escape-system data points have been obtained by calculating the DRI from an acceleration-time history representative of the escape system's mean catapult performance characteristics at nominal conditions of weight and temperature and then determining the actual spinal-injury rate associated with the system. Only compression fractures of the vertebral column that have been attributed to ejection acceleration, rather than landing impact, are used. Each data point represents the injury rate associated with at least 25 successful nonfatal ejections.

As might be expected, the operational system data points in Figure 4 are in most cases somewhat higher than would be predicted by the cadaver data. The more obvious reason for this difference would be that the intact living vertebral column embedded in the torso would almost certainly be stronger than cadaver segments. Since there are relatively few data points, it is not possible to describe a complete distribution of the DRI versus probability of injury. Nevertheless, the distribution should be similar to the distribution of the cadaver breaking strength.

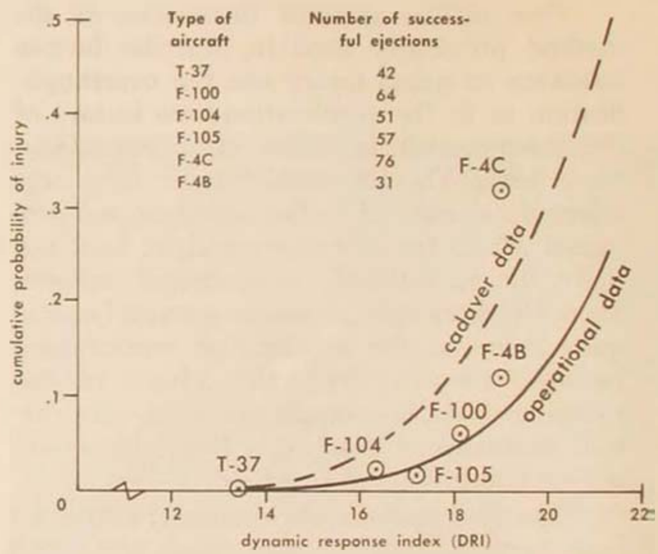


Figure 4. Probability of spinal injury predicted from cadaver data compared to operational experience

Such a predicted distribution is represented by the solid line in Figure 4. The points that represent the Navy F-4B and the Air Force F-4C ejection seats deviate from this prediction, the latter considerably. This can be partially explained by the fact that the seat of the F-4B and F-4C is so designed that the axis of the ejectee's spinal column is not aligned with the acceleration vector of the catapult. The spinal column may be misaligned as much as 10 to 16 degrees, so that during ejection the spinal column flexes forward, creating a greater load concentration on the anterior surfaces of the vertebrae, which results in a greater compression fracture potential.[9] The more deviant position of the F-4C point is caused by the poorer degree of restraint, a different survival kit–seat cushion configuration, and the operational use of the between-the-legs D-ring as the primary ejection actuation control. In the Navy F-4B the face curtain is used primarily rather than the D-ring. The face curtain provides head restraint that retards flexion of the torso and spinal column. Use of the D-ring exaggerates the tendency for flexion.

An additional source of variation in the data plotted in Figure 4 is the difference in the cushions used with the various ejection seats. Use of the modeling approach also permits depiction of the mechanical response characteristics of components between the ejectee and the acceleration source which might modify the imposed acceleration.[10] Recent ejection tests using the F-4 ejection seat have illustrated this point. In these tests the inertial response of the human subject was measured by placing force transducers between the seat and the subject. Figure 5 compares the measured force with the computed force which would have been measured had the subject been a rigid mass. Figure 6 compares the measured force and computed force when a seat cushion was placed between the seat pan and the subject.

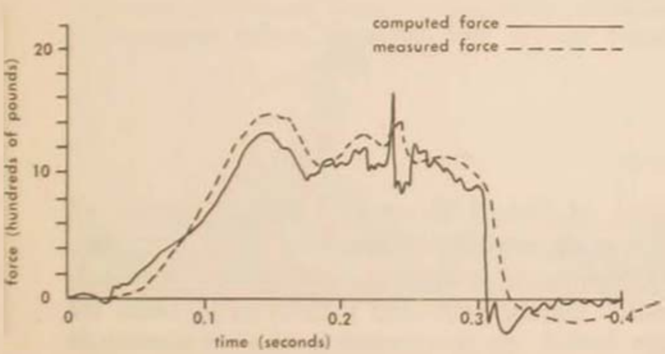


Figure 5. Comparison of computed and measured force with subject sitting on a rigid seat pan

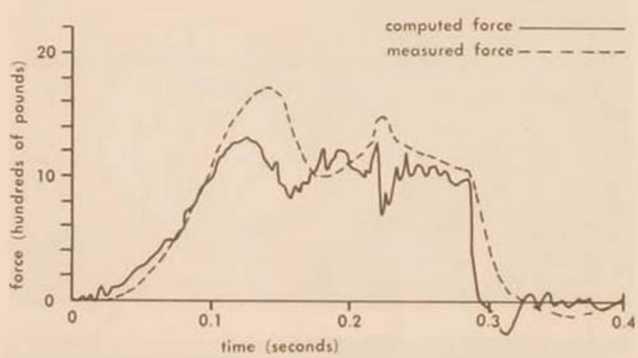


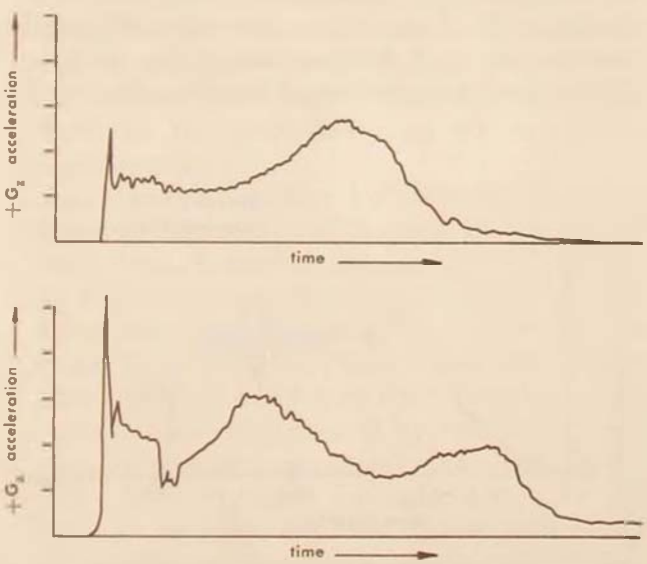
Figure 6. Comparison of computed and measured force with subject sitting on a seat cushion

Using the analog as a tool, the equipment designer finds it feasible to design the escape-system components quantitatively rather than use the former "cut and try" methods. Furthermore, in designing the seat cushion one might conceivably be able to determine analytically a reasonable trade-off between acceleration protection and crew comfort. These two requirements are currently considered to be antagonistic.

application of the analog

The F-111 crew escape module is a radical departure from previous escape systems. The crew module is an integral part of the forward fuselage of the aircraft, encompassing the pressurized cabin and forward portion of the wing glove. During ejection the crew module is severed from the aircraft fuselage by a shaped charge train and then propelled away from the aircraft by a solid-propellant rocket motor. After separation the module stabilization glove provides stability and aerodynamic lift. A parachute provides additional stabilization and deceleration of the module. The recovery parachute is forcibly deployed, and opening shock is minimized by reefing the parachute for 2.5 seconds. Landing impact on ground or water is attenuated by controlled gas expulsion from an impact-attenuation bag with blowout plugs. During development testing of the crew module it became apparent that the acceleration environment produced during the catapult phase of the escape sequence would be unlike that of previous egress systems. The acceleration data obtained in ejections from a high-speed rocket sled indicated that the acceleration experienced in the axis parallel to the vertebral column ($+G_z$) is significantly influenced by the airspeed and air density. The acceleration profiles shown in Figure 7 illustrate the effect. The first acceleration pulse, occurring in the initial 0.05-second period, was not apparent at all in either the development computer studies or wind-tunnel tests. The second, longer-duration pulse had been predicted; however, the magnitude appeared to be greater than

Figure 7. Comparison of acceleration of the F-111 crew escape module during ejection from a rocket sled at two equivalent airspeeds: 250 knots (above) and 450 knots (below)



anticipated. The first pulse, referred to as the "popgun" effect, represented a challenge to the traditional acceleration limit parameter, the rate of onset of acceleration. Specifications governing the procurement of previous escape systems limited the maximum allowable rate of onset in this direction to 300 g/sec. The rate of onset of the popgun pulse is approximately 1000 g/sec. Even though the popgun pulse exceeded established design limits, data from Air Force and contractor experimentation with human subjects during the develop-

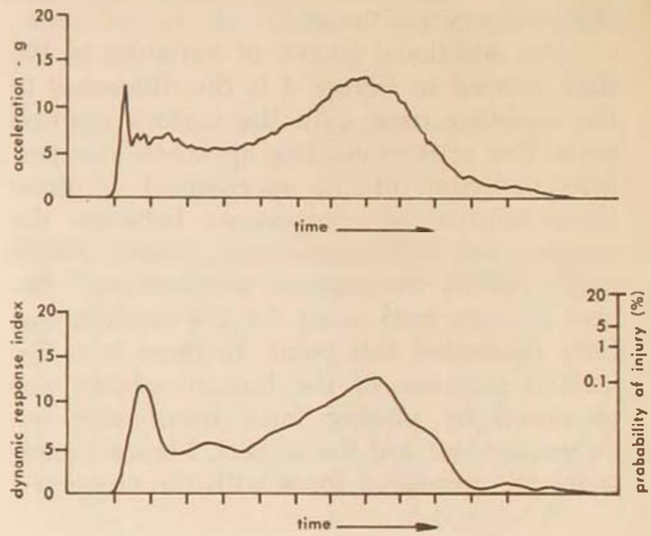
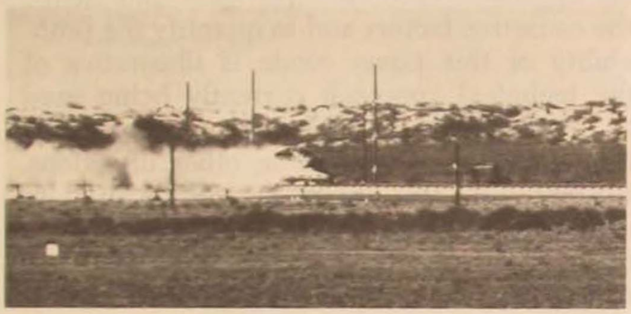
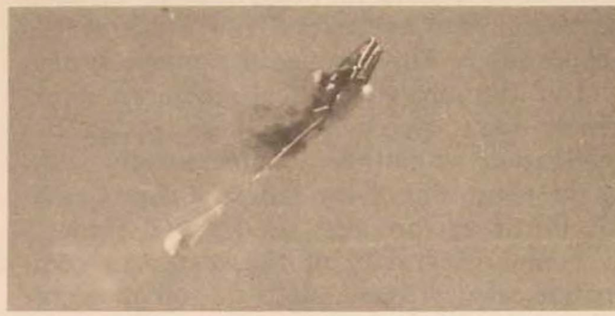


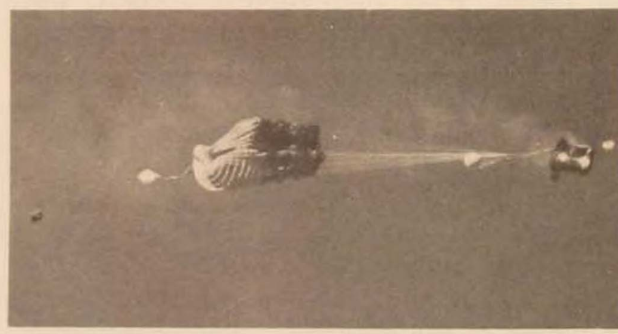
Figure 8. Acceleration recorded from F-111 crew escape module and computed analog response

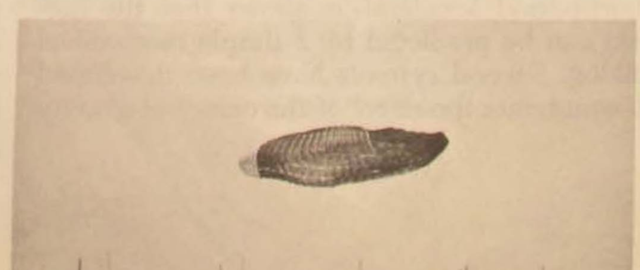
ment of the B-58 escape capsule indicated that such a pulse shape might be tolerable. Furthermore, analytical work with the spinal-injury analog provided a theoretical basis for this belief. At this point in the crew-module development program it became apparent that application of the analog might prove fruitful. The alternative was redesign of the escape system. With the acceleration-time history recorded from the track test ejection at 250 knots (equivalent airspeed) as the input function, the DRI-time history was computed. The computation results are shown in Figure 8. Assuming that use of the spinal analog provides a reasonable prediction of the response of the vertebral column, these results show that the inertial responses within the human

The F-111 escape module is put through its paces at Holloman high-speed test track.









do not correspond proportionately to the acceleration input function. They reveal that the time duration of the popgun pulse is so brief in terms of the dynamic response characteristics of the analog that the response is significantly reduced. The spinal-injury analog has since been more thoroughly explored and has been incorporated into the design guidance for the F-111 crew escape module as well as all future escape-system development efforts.

The modeling approach is also being applied to the problem of describing the influence of the motion of the ejectee's center of gravity upon escape-system trajectories. When the rocket catapult was introduced, its purpose was to extend the length of the ejection acceleration stroke beyond the limits of the cockpit depth. This enabled the escape system to clear the aircraft vertical stabilizer at extremely high speeds without increasing the acceleration magnitude. Unfortunately, without the constraint of the rails, the rocket catapult thrust vector must be directed through the center of gravity of the seat/man combination, else adverse pitch or roll moments will result. With high-impulse rockets, the condition results in rotation of the seat during rocket burning. This unstable condition increases the possibility of seat/man/parachute interference and limits the trajectory height at low airspeeds.

It is difficult to design for the center of gravity of the seat/man combination in the operational circumstance, since its position is not fixed. First, the center of gravity varies as a function of the anthropometric characteristics of the ejectee. Second, the weight and position of equipment worn by the crewman will add to the overall variability. Finally, during the catapult firing the human body will slump and the equipment will be displaced, so that the target for the thrust vector, the seat/man center of gravity, becomes a moving target. Laboratory study of the motion of the center of gravity of the human body during short-period acceleration shows that the motion can be predicted by a simple mechanical analog. Several systems have been developed to counteract the effect of the center-of-gravity eccentricity. The simplest concept employs a bridle and drag line that introduce opposing moments. A more complex system involves the use of a gyro-controlled vernier rocket assembly.[11]

For two reasons this discussion of aeromedical efforts to support the development of aerospace escape systems has concentrated largely on defining spinal-injury limits. First, spinal injury has traditionally concerned potential users of escape systems because that risk has been associated with the use of escape systems ever since their inception. Second, the technical approach used to investigate and define the causative factors and to quantify the probability of this injury mode is illustrative of the technical approach currently being used to investigate human tolerance to short-duration acceleration applied in other directions. Furthermore, this approach will be used to define more completely man's response to other environmental hazards associated with emergency escape, such as windblast, parachute-opening shock, angular motion, and the combination of such stresses as are still inadequately understood. The increased performance capability of advanced aircraft demands that these definitions be provided if injury and fatality rates are to be maintained at or below current levels.

In the past the development of each new escape system has disclosed the inadequacies of our knowledge of the human being. As a result much of our research has been committed to solving these problems as they have appeared. Hopefully the lesson has been learned. Additional emphasis is being placed on the problems of advanced systems. The need to develop operational escape systems for space vehicles adds urgency to this requirement. A more comprehensive evaluation of the probability of injury or fatality must be provided and related to the likelihood of occurrence of a given stress, so that the basic feasibility of space escape systems may be determined. The analog provides a powerful tool in this task, but the fundamental biological properties that limit man's capability *must* be more precisely defined by an increased research effort if the analog is to be maximally useful.

Aerospace Medical Research Laboratories

Notes

1. R. H. Shannon and C. H. Sawyer, "Man/Seat/Chute Interference in USAF Ejections," *SAFE Engineering*, Vol. 1, No. 4, October/November 1967.

2. S. Ruff, "Brief Acceleration: Less Than One Second," *German Aviation Medicine in World War II*, Chap. IV-C, Vol. I, U.S. Government Printing Office, Washington, D.C., 1950.

3. D. T. Watts, A. B. Mendelson, H. N. Hunter, A. T. Kornfield, and J. R. Poppen, "Tolerance to Vertical Acceleration Required for Seat Ejection," *Aviation Medicine*, December 1947.

4. J. M. Frankland, *Effects of Impact on Simple Elastic Structure*, Navy Department, David Taylor Model Basin, Washington, D.C., Report 481, April 1942.

5. J. P. Stapp, *Human Exposures to Linear Deceleration*, AF Technical Report No. 5915, Part 1, June 1949, and Part 2, December 1951.

6. Frankland, *op. cit.*

7. F. Latham, "A Study in Body Ballistics: Seat Ejection," *Proceedings of the Royal Society*, B, Vol. 147, 1957.

8. R. R. Coermann, *The Mechanical Impedance of the Human Body in Sitting and Standing Positions at Low Frequencies*, ASD Technical Report 61-492, Aerospace Medical Research Laboratories, September 1961. The sources of data and modeling techniques have been more thoroughly described by E. L. Stech and P. R. Payne in *Dynamic Models of the Human Body*, AMRL-TR-66-157, in press.

9. G. C. Mohr, J. W. Brinkley, L. E. Kazarian, and W. W. Millard, "Variations of Spinal Alignment in Egress Systems and Their Effect," to be published in *Aerospace Medicine*.

10. P. R. Payne, *Personnel Restraint and Support System Dynamics*, AMRL-TR-65-127, October 1965.

11. H. R. Moy, B. Nichols, Jr., and R. G. McIntyre, "A Rotation and Trajectory Control System for Rocket Catapult Ejection Seats," *SAFE Engineering*, Vol. 1, No. 1, March/April 1967.

POST-VIETNAM ROLE OF THE MILITARY IN FOREIGN POLICY

General Maxwell D. Taylor, USA (Ret)

In keeping with our intense concern about Asia in general and Southeast Asia in particular, it has occurred to me that it might be of interest to reflect on the condition of the armed forces after termination of the Vietnam conflict and the effect of that conflict on the role of the armed forces in foreign policy. A unique requirement is placed upon the military profession to anticipate change in time and to adapt thereto the conduct of its primary business, national security. The importance of quick perception and adaptation derives from the vital nature of national security and the disasters which may ensue from gross error in adjusting to its evolving needs. Unhappily, the timely anticipation of change is not easy because of the many variables which enter into the national security equation. National security is both a state of mind and a power relationship based upon the international distribution of resources of all kinds, upon attitudes and policies of governments, upon personalities of leaders, upon economic cycles, and upon the ebb and flow of ideologies. National security is affected by human emotions and motives arising from greed, fear, and fervor. Finally, in its narrowly military connotations, it is affected by changes in strategy, tactics, and weaponry.

It is with these thoughts in mind that I have undertaken to identify some of the changes which appear to be taking place in these broad fields bearing upon foreign policy and national security and then draw some conclusions with regard to the probable or possible effects on the role of the armed forces.

To start from fundamentals, let us first remind ourselves that the role of the armed forces as presently stated in official literature is to support and defend the Constitution of the United States against all enemies, foreign and domestic; to insure by timely and effective military action the security of the United States, its possessions, and areas vital to its interest; to uphold and enhance the national policies and interests of the United States; and, finally, to safeguard the internal security of the United States. In short, the armed forces exist to defend our form of government and the constitutional principles upon which it stands, to guarantee our physical security and the safety of our material possessions, and, in general, to advance our national interests wherever found.

I would call your attention to at least two characteristics of this mission. The first is that the mission is not solely the responsibility of the armed forces. In its overseas aspects, the mission that I have described is a reasonably complete statement of the goals of our entire foreign policy, supported by the totality of our national power, of which the armed forces are merely the military component. As such, they must work in combination with other components—political, diplomatic, economic, moral, and psychological—in order to carry out the foreign policy objectives of our government.

The second characteristic I would mention is the round-the-clock aspect of the military mission in foreign policy. There was a time when most people considered the armed forces an institution of importance only in time of war. There is an old English saying that the soldier in time of peace is like a chimney in summer. I can recall when, shortly after World War I, I returned as a second lieutenant to visit my old grandfather, a Civil War veteran, that I had great difficulty in explaining to the old gentleman really how I was earning my pay. He could not understand what an army did when there was no shooting war in progress. And I must say his questioning attitude was justified by the conditions faced by the armed forces between World Wars I and II.

In that period we had solemnly outlawed war as an instrument of policy; we were branding our munitions makers as "merchants of death," and it was taking ambitious second lieutenants nearly twenty years to become a captain. Today, this isolation of the armed forces from the realities of life in time of peace is a thing of the past. It is a hard fact of the present that the armed forces are on duty around the clock, and in a sense they never enjoy holidays or Sundays. But if most of our citizens recognize a continuing peacetime role for the armed forces, I think that many would still make a sharp distinction between their role as discharged in peace and in war. In spite of the teachings of Clausewitz as to the kindred nature of war and policy, many of us still feel that the transition to war in some way abrogates the peacetime roles, alters the relations of a citizen to his government, and surrenders the conduct of war and large parts of the related foreign policy into the hands of the military.

In World War I, the French political leaders liked to quote Talleyrand to the effect that war is too serious a business to be left to the military—a fact which indicated that, in the view of these French leaders, most people considered that the soldiers were, or perhaps should be, in charge in time of war. I would say that most of the officers of my generation would have been inclined to agree with this concept and to have labeled as political interference the intervention of civilian authority in time of war—in any field other than the broadest aspects of foreign policy. Also, all the officers in this same era were taught in the military schools that the mission of the armed forces in time of war was the destruction of the armed forces of the enemy. That destruction equated to the military victory for which General MacArthur proclaimed there is no substitute.

I have mentioned these past concepts because I feel that significant changes are occurring which bear importantly upon them and upon the future role of the armed forces.

In pursuing this subject, for completeness I would like to review the means and methods available to the armed forces in performing their role in foreign policy. Then I shall discuss the new factors arising which bear upon the choice of means and methods and, hence, upon the role of the armed forces in the support of foreign policy.

The armed forces exert their influence through various forms of military force, either potential or actual, derived from the men, weapons, organization, and discipline which are their primary sources of strength. This military force in its various configurations provides a means by which the leaders of government may bend the will and influence the conduct of adversaries in conformity with the requirements of the national interest as interpreted at a given time and place. To these leaders falls the choice of methods in using this military force. Even without an exercise of choice, the

The second series of General Thomas D. White Lectures began at Air University on 29 February 1968, the subject area for this year being Asia. General Maxwell D. Taylor was the distinguished speaker, and his presentation has been adapted for inclusion in this issue of the Review.

The Editor

mere existence of the armed forces contributes to the support of foreign policy, serving as a mute Big Stick that adds persuasiveness either to quiet talk or to noisy threats. But if mere force in-being does not suffice, the civilian leaders may then call the armed forces into action at varying levels of controlled violence.

In limited war, the armed forces may be used to impose limited damage and limited loss on the enemy, to obtain concessions that are likely to be something less than vital to either party. In total war, they may undertake to render the enemy helpless and defenseless by the destruction of his armed forces, of his leaders, of his government, of his economy, and even of his entire people. Following victory, they may then be called upon to occupy conquered territory and to join in repairing the damages of war to which they have contributed. All such actions take place within and as a part of foreign policy in its broadest meaning, not as a substitute or replacement for that policy. Clausewitz made this point long ago, and I think it is still valid.

In addition to the military means and methods available to the armed forces, there are also nonmilitary ways for them to support foreign policy. They do so by participating in peace-keeping operations, generally under international control, as in the Congo or in the Western Hemisphere as the agent of the Organization of American States. Through the administration of military aid programs, they exert an important influence in the field of foreign relations. I have often thought that our military school system, in accepting thousands of foreign officers and soldiers for instruction, is perhaps the most effective single instrument of foreign policy for broadly influencing foreign attitudes toward the United States.

The performance of the armed forces in civic action is well known. That term, I believe, was coined at the end of the Korean War, when in a relatively short time the armed forces of the United States, later assisted by those of Korea, quickly brought aid to the devastated countryside and performed miracles of quick restoration, doing things impossible in the short run for the long-term programs of economic aid.

So much, then, for the means and methods of the armed forces in support of foreign policy. Now let me move to the subject which I think is the most pertinent to the theme of this presentation. What new factors are arising which bear upon the choice of means and methods in the future?

I WOULD single out three factors which have arisen or are arising and which unquestionably will affect the future role of the armed forces in foreign policy. The first is the fear of World War III, which is a primary preoccupation of the political leaders of all nations. The second is the multipolar distribution of power which has followed the disruption of the Sino-Soviet bloc. The third is the aftermath of the experience of the Vietnam war, with its many lessons which, if understood and heeded, are sure to affect our future use of military power.

First, there are the effects of the general fear of World War III. This fear dates back to the use of nuclear weapons in World War II and expresses itself today in many ways. One is the emphasis on the deterrent role of the armed forces as the primary justification for their existence. The fear of World War III has made all responsible leaders cautious and inclined to examine their every move in relation to the possibility of World War III.

It is a curious thing, however, in considering the deterrent effect of the armed forces, that, in a sense, we can undermine this effectiveness by talking too much about it. The more one stresses the purely deterrent role of the armed forces, the less convincing that deterrent tends to become. This paradox arises from the nature of the elements which make for effective deterrence. Deterrence requires strong armed forces in-being, directed by resolute leaders clearly ready to use them and served by a command and control system which will assure getting their orders to the right place at the right time. Thus, the unquestioned will and the clear capability to use force become the strongest guarantee of not having to use it at all. Any suggestion that it is only for deterrence and somehow only for show and never for use works in a contrary way on the effectiveness of deterrence. Thus, it is not enough to talk a good game of deterrence; it is quiet, unruffled readiness to perform that really counts.

So, then, my first point regarding this fear of World War III is to note the increasing emphasis on the deterrent role of the armed forces. Growing out of this same concern is a tendency toward greater and more detailed civilian control of the armed forces. This tendency feeds on the fear that World War III will happen through mistake, through the error of a field commander, or through some other form of military miscalculation and is encouraged by the efficiency of our telecommunications which allows authorities in Washington to communicate almost instantaneously with commanders in any quarter of the globe.

Historical examples of the past prompt our civilian leaders to feel that they should assume a greater responsibility for intervening in military affairs. The example of General MacArthur as a field commander who changed the objective of an entire war in midstream is a case in point often cited in justification of the need of greater civilian control.

President Kennedy was greatly impressed by Barbara Tuchman's book, *The Guns of August*, which, as he interpreted it, exposed the pre-1914 generals to the charge of having made mobilization plans so rigid that political leaders in the critical days of 1914 were deprived of all options in making decisions affecting the destinies of their nations. The President was inclined to attribute to the generals the fault for this—a criticism which led me to fight back as best I could, maintaining that it was the politicians at fault, because they never should have let the generals plan without political guidance. At any rate, this feeling of the need for options is very much on the minds of our civilian leaders today, who do not want to find themselves boxed into a corner by military imperatives in a time of crisis. We can expect them to insist on maintaining options and alternatives, and to demand greater flexibility in military planning.

Next, there is the trend toward gradualism in the use of military force, which also arises from the fear of World War III. This trend has been encouraged by our experience in the Cuban missile crisis, which is often cited as a successful example of the use of restrained, graduated force. Although our government did not get all that it might have wanted in this confrontation with the U.S.S.R., it got all that was essential—and without World War III. That success, as interpreted by many observers, resulted from the fact that we remained in constant communication with Moscow, that we moved carefully, slowly, explaining what we were doing and why we were doing it, at the same time preserving a posture of unquestionable determination to see the thing through. This experience encouraged the gradualism which has characterized our strategy in Vietnam and which has often been disparaged by military critics. I shall return to this point later.

The second new factor which bears upon the future role of the armed forces in foreign policy is the fragmentation of the Sino-Soviet bloc. We should remind ourselves from time to time how the world looked to us ten years ago during the eyeball-to-eyeball confrontation of the Western and the Sino-Soviet blocs, when the great and overriding fear was of general nuclear war. Since then, the growing split between the Soviet Union and Red China, beginning with the withdrawal of the Soviet technicians from China in 1960, has drastically changed the political balance of power throughout the world. That split may well be recorded by historians as the most significant political event of the postwar period.

One result of it has been the growing possibility of a Soviet–U.S. détente, a prospect which some of us may regard as premature and perhaps illusory. It has also resulted in replacement of the former bipolarity of the power confrontation by a multipolar distribution of power and the creation of new foci of power in many quarters of the world. Consequently, we now have to concern ourselves with parts of the world which in the past were considered neuter in a strategic sense. Our experiences in Cuba, the Dominican Republic, the Middle East, Laos, and now in Vietnam remind us that multipolarity —while reducing the danger of a great nuclear war—carries with it challenges which are new and in some ways more difficult to cope with than the grim simplicity of the former confrontation with the Sino-Soviet bloc.

Let us now consider the third factor which has arisen since World War II which bears upon the role of the armed forces in foreign policy. It is the Vietnam experience, which is a case study of the consequences of the multipolarity to which I have alluded. It is hard at this point in time to draw all the lessons of Vietnam; even to attempt to do so is to invite debate, since anyone who seeks to identify lessons undertakes to interpret and to assess praise or blame for motives and actions. But at least we can say without fear of contradiction that our experience with the so-called "war of liberation" technique in Vietnam will have a bearing on the future participation of the armed forces in support of foreign policy. It is a challenge which I personally believe to be serious, in spite of efforts in some quarters to depreciate the sincerity of Lin Piao in describing how the "war of liberation" technique would, in the future, be the favorite device for the expansion of militant Communism. He emphasized in his famous speech on the subject that after the successful application of this technique in South Vietnam it would be applied not only in Asia but in Latin America and Africa as well. Further, he went on to explain why the Communist leaders had concluded that the "war of liberation" should be the preferred technique. He pointed out that general nuclear war was universal suicide and that, since even limited nonnuclear war could so easily expand to general nuclear war, limited war also is too dangerous. Hence, the "war of liberation," which tunnels under the conventional defenses of a country, was to be the preferred way for expanding Communism.

This feeling by the Communists that limited war is too dangerous for indulgence in is very interesting, since it parallels up to a point our own thought on this matter. We also believe that general nuclear war must be deterred at all costs. But, at least prior to Vietnam, we had not been inclined to reject limited war as a form of military force which might be used in the national interest under certain circumstances. However, current events in Vietnam are causing us to reexamine our views on this subject. President James Perkins of Cornell, in a recent article, has posed the problem very clearly. He points out the great difficulty in rallying this country behind a foreign issue involving the use of armed force which does not provide an identified enemy posing a clear threat to our homeland or to the vital interests of long-time friends. As many of our citizens view the situation, Vietnam does not meet these criteria —hence their dissatisfaction with our growing involvement. For the future, Dr. Perkins concluded that

> We now have to give more attention to the public understanding, to the importance of international support and cooperation, and to the need for increased development assistance as a more effective way of forestalling the circumstances that invite aggression. In the end we may feel as restrained in invocation of limited deterrence as we earlier did in the application of massive retaliation.

One finds much in the Vietnam experience to justify these views of Dr. Perkins.

Because of the tendency to move cautiously to avoid the risk of World War III, as a matter of deliberate policy we have exercised extreme prudence in applying military pressures in Vietnam. But however praiseworthy this restraint may be from some aspects, this slow application of military force is antithetical to the American disposition. It requires too much time and patience to obtain results. And we are finding in Vietnam, as in former episodes of our history, that these are national virtues in short supply.

A perceptive British critic, *The Economist*, observes that what the Americans may run out of is not material resources to continue to prosecute the war but patient public support for the whole idea of limited war. As long as the Vietnam experience is fresh in our minds, it is safe to say that the United States for a long time will be slow to engage in new military adventures far from home where the national interest is not more easily discerned than in the present Southeast Asian involvement.

That leaves us, of course, with the question of how to cope with a "war of liberation." Can we make no military response between a Lebanon-scale demonstration and a massive intervention in force to resist this threat? It is true that we can hope to anticipate situations where "wars of liberation" may occur and by nonmilitary civil means attempt to change the local conditions and eliminate the causes of political disintegration. But anticipation, of course, does not answer the entire question. We cannot afford to lose the deterrent effect of our forces in discouraging small aggressions. This is a point to which I will refer later.

Another point which is arising from the Vietnam experience is our growing resistance as a people to the role of world policeman which seems to be thrust upon us. We did not seek it, we do not want it, we do not like it. But, at the same time, our conscience reminds us of our responsibility to contribute in accordance with our means to the maintenance of worldwide peace and stability. But not wishing this task, we are inclined to look about in the hope of finding some way out of our predicament. Can't someone else take over?

At the same time that we are looking for outside help, we are experiencing a growing disillusionment with the capabilities of international organizations. We have tried to get the United Nations to help us in Vietnam, and we have been rejected. We have seen the great difficulty of peace-keeping efforts on the part of international bodies in Africa and the Middle East. So as we look at the problems of the emerging nations, we are at a loss to decide how to cope with the many focal points of unrest. We do not want to be the world policeman, but there seems to be no one else to do the job.

The dilemma urges us to greater wisdom and selectivity in deciding where our true interests lie in the worldwide scene. We find ourselves asking whether we have interpreted correctly our national interests in Vietnam and whether we are prepared to do better in choosing our course when similar situations arise in the future. The means taken to assure better selectivity are likely to react on the role of the armed forces in their support of the ultimate decision.

Another derivative of our Vietnam experience is the realization of the tremendous importance of the home front in support of foreign policy. We are learning how different it is, as Dr. Perkins has mentioned, to rally our people behind a distant cause which has no clear relationship with our immediate interests. We are seeing the effects of the misgivings of our people with regard to our growing involvement in Vietnam and to our apparent assumption of the role of gendarme of the universe. These misgivings among our people provide us with a forceful reminder of the essentiality of the support of the home front if we are to continue to use our military strength effectively in support of foreign policy —particularly if the scene of action is far from home. It is not an exaggeration to say that the outcome in Vietnam will be influenced as much by the attitude of the home front as by the conduct of our men who are fighting the battles.

Apart from other factors, our difficulties in closing ranks in support of this undeclared war are compounded by the competition for resources between the requirements of Vietnam and our domestic programs—by racial issues purporting to find some linkage between the Vietnam war and racial discrimination, by conflicts between liberals and conservatives, by contention between the executive and legislative branches of government, and then by just plain politicking with the Vietnam issue. This division at home has been furthered by the behavior of the publicity media. Free from any form of censorship in Vietnam which would be normal under conditions of war, they have reported the situation in such volume and profusion as to create much of the confusion that exists in the minds of those of us who depend upon press, television, and radio for our information. In the aftermath, we are going to have to think very hard about the proper role of these media as an influence upon the outcome of foreign policy.

I come now to the end of the discussion of the new factors bearing upon the role of the armed forces in their participation in foreign policy. I would now like to speculate a bit—though speculation is always dangerous—as to possible changes in the role of the armed forces which these factors may produce.

I WOULD NOT expect any significant change in the formal statement of the roles and missions of the armed forces which I cited at the start. That mission is stated in broad terms which seem adequate to continue to guide the armed forces in their support of foreign policy. But without any change in the stated role of the armed forces, I would certainly expect the trend towards increased civilian control over military operations to be a phenomenon which is here to stay. I think it is here to stay because the reasons for it which I enumerated are likely to remain valid for a long time to come.

If in making this statement I may have distressed some of my military friends, I now bring them compensating good tidings. In my judgment, the armed forces in the future will have the opportunity to participate to a much greater degree than ever before in the formulation of foreign policy. Just as Talleyrand said that war is too serious a thing to be left to the military, I would say that the deterrence of war and the maintenance of peace are matters too serious to be left either to the military or to the civilians, but must be the result of an integrated effort of all parties. I see signs which encourage me to believe that our civilian leaders accept this fact and can be expected to act in consonance with it.

To illustrate this point, I should like to mention something that may or may not be generally known. President Kennedy, following the disastrous Bay of Pigs affair, took a significant step in recognizing the need for greater military participation in foreign policy formulation. On 27 May 1961 he called in person upon the Joint Chiefs of Staff at the Pentagon and discussed their relation to him. He reminded them of their duties as the advisers to the Commander in Chief and expressed the hope that their advice would always come to him directly and unfiltered. He also stated explicitly his view that this advice of the Chiefs could not and should not be purely military, since most of the problems with which he was concerned were shot through with political, economic, and psychological factors as well as military, and that he as President must take all factors into account. While he expected the Chiefs to present the military factor without fear or hesitation, he wanted them to know that he regarded them as more than military specialists and looked to them to help him in fitting military requirements into the overall context of any situation because he recognized that the most difficult problem in government is to combine all assets in an integrated, effective pattern. This verbal statement to the Chiefs was recorded in National Security Action Memorandum 55 of June 1961. To anyone not familiar with it, I suggest it would make interesting reading.

President Johnson has also acknowledged the growing importance of the military contribution to foreign policy. He did so in the decisions contained in National Security Action Memorandum 341 of March 1966. This is the document which charged the Secretary of State, as the agent of the President, with the overall direction of all interdepartmental activities overseas and directed him to set up a series of interdepartmental committees to help him carry out this new mandate. The most important of these committees is called the Senior Interdepartmental Group, chaired by the Under Secretary of State and including as a member the Chairman of the Joint Chiefs of Staff. At the level of the Assistant Secretary of State, National Security Action Memorandum 341 directed the establishment of Interdepartmental Regional Groups, chaired by an Assistant Secretary of State and including a representative of the Joint Chiefs of Staff.

Thus, for the first time, the Joint Chiefs organization has been fitted by executive authority into the planning and implementation process of foreign affairs, and the military voice has been given a forum in which it can be heard and its influence exercised in an environment conducive to effective integrated action.

This new place at the national council table offers a great opportunity to the armed forces and should end the myth that the military voice is not being heard at the top level of government. I often have occasion to chuckle as I read some of the Washington columnists. It seems to me that one morning one of them produces a column which proves conclusively that President Johnson has sold out to the military; the next day I read a column that is just as convincing in proving that the Joint Chiefs of Staff are being ignored and the civilians are making all the military decisions. It seems to me that the number of articles on both sides of the issue are so nearly equal that it suggests we are striking not a bad balance in Washington in accommodating the role of the military in the formulation of policy.

Now let us give some thought to the future size of the armed forces and the effect of that size on their role in foreign policy. It is possible to make a good case for the need for larger armed forces after Vietnam and an equally good case that they should be smaller. In favor of bigger forces, one can point to the increased needs of deterrence in a world of multipolar power where there will be many calls to many parts of the world requiring strong, highly mobile, ready forces. Furthermore, the reluctance to call up reserve forces to meet the needs of Vietnam has made us uncertain of their availability in future emergencies. Thus, there is the question in our contingency planning whether we can safely count on the reserves in the future. The question is heightened by the civil unrest at home which may require the retention of the National Guard in its state role and its exclusion from overseas missions. Such considerations as these argue for larger regular forces in-being in the post-Vietnam period.

But if it is possible to make the case for an increased establishment, I can also make a strong case for the opposite view. At least I can point to tendencies which will have the effect of reducing the armed forces.

The first obvious one is that after every war there is an immediate move to reduce military spending; and, because of the high cost and unpopularity of Vietnam, I would expect this urge to be even stronger than in the past. Furthermore, the needs of our domestic programs which have been delayed or set aside by the requirements of Vietnam will demand attention and provide added arguments for a reduction in military spending.

Monetary policy may also contribute to a cutback of military spending and of all overseas activities and thus work at odds with our foreign policy objectives. Some economists are convinced that the continuation of a fixed exchange rate will eventually make it impossible for the U.S. to finance overseas activities at past levels without serious domestic consequences. They argue that as we run out of gold we must bring our balance of payments into equilibrium or pay our overseas accounts with dollars saved by deflationary austerities at home. The alternatives to this unattractive prospect would be to raise the dollar price of gold, to supplement gold by some form of international currency such as the special drawing rights which are now being considered, or to adopt a flexible exchange rate independent of gold. All these measures raise objections of varying degrees of seriousness which make unlikely the early adoption of any one of them.

In the meantime, we may run the risk of having the present monetary policy impose restrictions on foreign policy which will work against our genuine national interests. Thus, in the final analysis, we will have fiscal, economic, and domestic reasons for limiting our overseas commitments after Vietnam. In combination, these factors are likely to exert a depressive effect on the size of the forces which the Congress will be willing to support.

There is considerable uncertainty as to the combined effect of these various factors with regard to the composition and strength of the post-Vietnam armed forces. But if I were asked to guess, I would expect that we will have smaller forces, at least in the immediate post-Vietnam period, characterized by greater emphasis on quality, mobility, and professionalism. There is likely to be every effort to do away with the draft and to depend entirely upon volunteers to maintain the armed forces, but with greater expenditures in pay of personnel. This reduction in size may be offset by a reduction in overseas responsibilities, because one consequence of our Vietnam experience is certainly going to be a review of all worldwide commitments with military implications.

Let me mention one last aspect of the role of the armed forces in support of foreign policy which we seldom think about but which is of tremendous importance. It is the need for the armed forces to do their part in assuring the support of the home front for the foreign policy of our government. I revert to our experience in Vietnam and the great difficulty we are having in aligning our people solidly behind that policy. But having said that the armed forces should do something about the home front, I recognize the very real difficulty of suggesting practical measures. I do think that we can help by word and deed in setting forth to our fellow citizens the legitimacy of the military role in a democratic society and the indispensability of military power as a part of national power in support of our foreign policy.

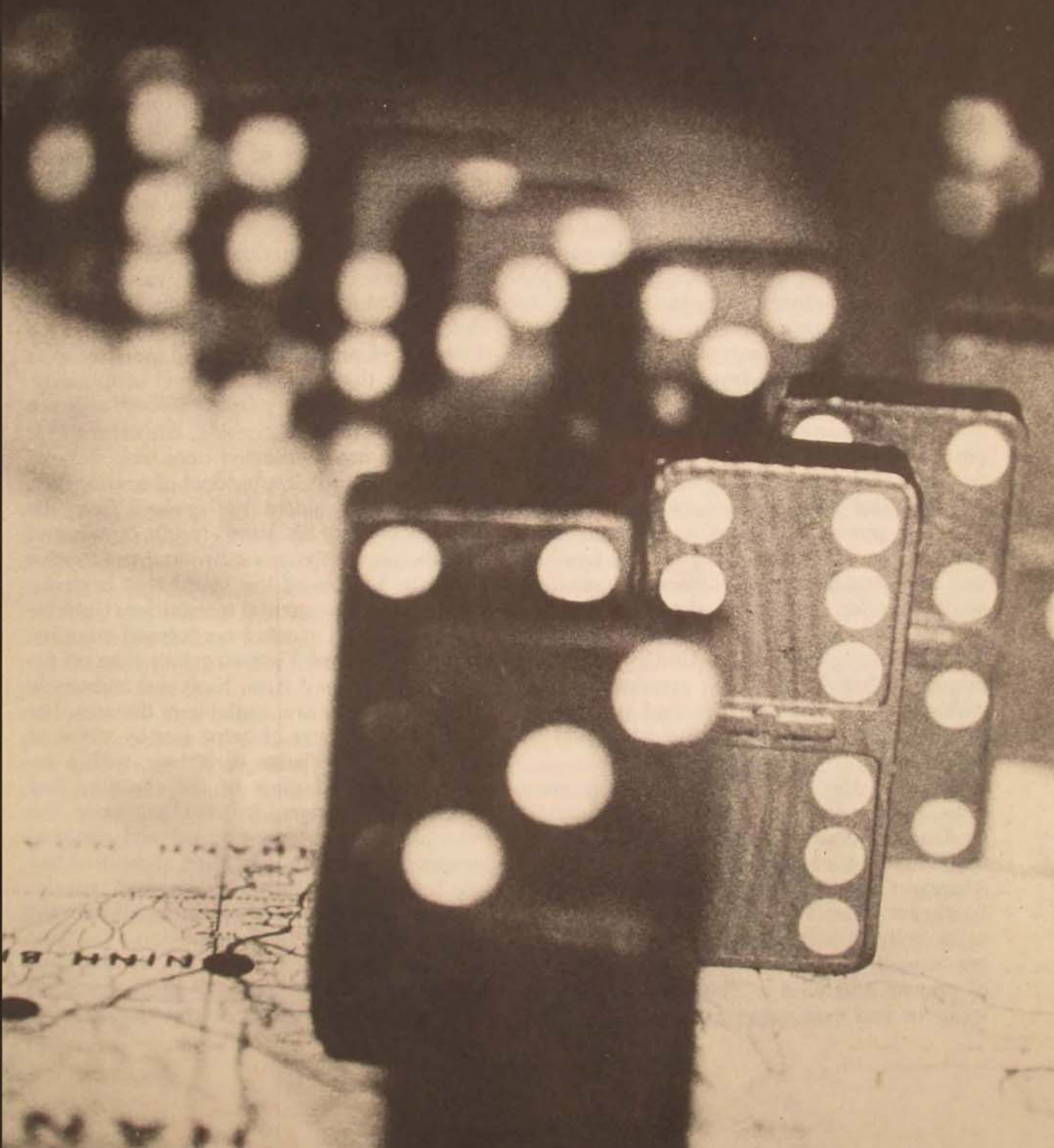
In so doing, we must show that we of the military have a sincere respect for the responsibilities of our civilian leaders and understand the supporting role of the military to that leadership. We must demonstrate in our behavior that we do not think exclusively in terms of force in solving the world's problems, that we can and do act not just from the military interest but from the national interest. Such a posture, faithfully sustained, will go far, I believe, in convincing our citizens that the military voice speaks with a competence and a responsibility which deserve close attention in the councils of government. Respect for the character and competence of the armed forces is one part—and a most important part—of respect for the competence of government and for the soundness of its policies.

Arlington, Virginia

VIETNAM

OUR WORLD WAR II LEGACY

MAJOR JOHN F. McMAHON, JR.



IN these trying times when the frustrations and pent-up emotions concerning the course of the war in Vietnam exacerbate relations among Government officials, politicians, academicians, friends, neighbors, and families, it is essential that we in the military profession not lose sight of the fact that a basic consistency in the objective and stakes involved in Vietnam has existed since the Administration of President Truman. Our present involvement in Vietnam stems from decisions made in the aftermath of the Second World War, not from incidents in the Gulf of Tonkin. The scope of that great war left the United States with political and moral commitments in Asia as well as on the continent of Europe. The conclusion of the Second World War was really the beginning of a protracted struggle on behalf of two diametrically opposed ideologies for the "minds and hearts" of the peoples of the world. The United States became the champion of national independence, and in this role she was compelled to accept the concomitant role of the guarantor of the freedom of independent states from intrusion by unwelcome "aggressors."

In the course of evolving United States postwar policy, the concept of containment was broached, entertained, and applied. The freedom and independence of less fortunate and less powerful nations became essential bulwarks to the maintenance of U.S. freedom and independence. U.S. policies, of necessity, were founded on calculations of national interest as well as international morality. Containment allowed the United States to prevent what had to be prevented while making possible constructive and progressive trends toward a world order which would be conducive to free societies.

Within the U.S., though, postwar reactions in the form of insular or isolationist tendencies became noticeable. National commitments to such organizations as the North Atlantic Treaty Organization (NATO) and Southeast Asia Treaty Organization (SEATO) supposedly dispelled any notions of our turning inward, i.e., returning to the bankruptcy of prewar isolationism. The advent of atomic weapons had cast numerous unfamiliar shadows on the international scene. The role to be played by these weapons in the newly evolved policy of containment was cloaked in continuous searching debate. More than ever before, war now presented itself as sterile and brutal, yet the adversary insisted upon warfare as a means to achieving a Communist-dominated society. For the moment, war as an instrument to be used in direct confrontation with the adversary was considered unthinkable. However, war waged on a limited basis and without causing the adversaries to confront one another became an accepted tactic in achieving the overthrow of non-Communist societies. Under the labels of "just" wars or wars of "national liberation," the Communists sought to neutralize the effect of atomic and nuclear weapons while relying on guerrilla techniques which were to be known as "unconventional" in later references to the conflict in Vietnam. For war to be condoned or utilized as a means to an end, the United States was compelled to rationalize the questions of political utility and morality so as to provide that war, at any level of intensity, would serve a major purpose in both spheres.

In view of the foregoing, our concern for Vietnam is not predicated upon any singular proposition, nor is it a product of irrationality. The U.S. involvement has evolved from the desire to prevent disastrous results in Asia and to make possible constructive and progressive trends in an area of the world that is straining for advancement and recognition. Unfortunately, time and events have focused attention on the territory of Vietnam rather than on the whole of Southeast Asia. New and immensely promising trends are available in the area, but these are in danger of being lost by virtue of our lack of knowledge of history, with a resultant narrowed view of the meaning and purpose of Vietnam. By dwelling upon the postulations of the uninformed and the misinformed, we are in danger of abdicating our role in Asia through being panicked into defending a position which excludes all relevant factors other than Vietnam.

The route from Tokyo Bay to the Gulf of Tonkin has by no means been serene or without frustration. Our current mood con-

General Van Tien Dung, Vietminh leader of truce talks at Trung Gia, after the fall of Dien Bien Phu in May 1954

cerning Vietnam is highly suggestive of the prevailing mood in 1951–52 concerning Korea. Up to that period, no war in U.S. history had created such a disturbance of conscience and national resolve. The indecisiveness of the situation had caused the American people to become frustrated with the course of the war and the mounting casualty lists. The American people felt that the United States had carried the economic and military burdens for world peace throughout the Second World War, and now in the early 1950's, a twilight of "no war—no peace," they found themselves engaged in a most searching and bitter national debate on the foreign policy of the postwar years.

The debate, ranging over a wide area of postwar foreign policy, had emotional roots and overtones deriving from the sweep of American history in the Far East and from the tensions and cross-currents of the Cold War. The Korean War was considered an aberration by many Americans. American disenchantment came even in the face of the harshness and arrogance of the Communist aggression in Korea.

On the other hand, Vietnam presented an entirely different problem. The decision to become irrevocably committed in Vietnam was a product of nearly fifteen years' concern and policy development. Although the U.S. commitment proceeded very subtly, the public was well aware that the national interest dictated a continuing U.S. presence in Asia. It was hoped that those agencies which possessed the capability to combat insurgency operations would be sufficient to thwart Communist aims. This hope rapidly dissolved, however, as the Communists escalated their efforts to a level akin to open warfare. It became apparent that the U.S. was faced with the possibility of a major and quite disastrous shift in the balance of power in Asia if Vietnam were to be ignored. Thus, in February 1965, the decision was made to continue to pursue U.S. national interests in Asia by meeting the stepped-up Communist aggression in Vietnam. In essence, U.S. policy relative to Southeast Asia had not changed since the introduction of the containment policy in 1946 and its application to Berlin in 1948 and Korea in 1950.

It should be apparent that our involvement in Vietnam is symptomatic of our commitment to foster and preserve freedom and independence in Southeast Asia, and in Asia as a whole. Not only the peace and security of Asia but also the future of the world would be in serious jeopardy if the U.S. were to lose interest in places such as Korea or Southeast Asia (Indochina). It was this determination to keep Asia free that caused the U.S., French, and British delegates in the United Nations Assembly, on 28 January 1952, to issue a joint warning against Chinese Communist aggression in Southeast Asia. The three nations declared that any attempt at aggression would "be a matter of direct and grave concern which would require the most urgent and earnest consideration by the United Nations."[1] On the eve of the Korean armistice in July 1953, Britain joined France and the United States in a statement declaring that the Indochina struggle "is essential to the free world."[2]

These two policy statements by the three Western powers left little doubt as to the position these nations took in regard to the threat of Communist aggression in Southeast Asia. The Korean War had been a very unstabilizing factor in Asia. The Chinese Communist armies had joined battle with the Western powers, and for a time it looked as though the United Nations forces were going to be driven out of Korea. The situation was reversed, however, by early May 1951, and a stalemate occurred which was to last until the armistice was signed on 26 July 1953.

If it could be said that there was a "winner" in this "strange" war, then the fact that Communist China had shown her prowess and forced the Western powers to negotiate a settlement was sufficient to qualify the former as having gained at least a greater prestige among the Asian nations. United States policy did not "surrender" Korea. On the contrary, the real damage had been done on 25 June 1950, when the North Korean attack began. The Eisenhower Administration was faced with an irreconcilable situation—the heavy expense involved in manpower and resources to unite a country that had been divided since 1945.

With the conclusion of the Korean War, the stability of Southeast Asia remained as uncertain as ever. The grim issue of Indochina became readily apparent after the truce. Would the Chinese Communist troops, released from the Korean fighting, be used against the French in Indochina? Was there to be a second Communist aggression on another Asian country? These and other questions caused intense concern within the Eisenhower Administration. How could the promises of no war, balanced budgets, tax cuts, and a better life for all be fulfilled if war erupted again in the Far East?

In an attempt to deter this possibility, Secretary of State Dulles used the occasion of an address to the American Legion convention on 2 September 1953 to warn:

> The Chinese Communist regime should realize that such a second aggression could not occur without grave consequences which might not be confined to Indochina. I say this soberly in the interests of peace and in the hope of preventing another aggressor miscalculation.[3]

President Eisenhower had added his voice to the increasing concern over the war in Indochina when a month earlier, speaking in Seattle, he stressed the need to hold Indochina as the key to Southeast Asia.[4]

The United States had by this time become deeply involved in supporting French military operations in Indochina. When the Eisenhower Administration took office, the United States was giving more aid to the anti-Communist forces in Indochina than the aid received by the pro-Communist forces from Red China. Economic and military aid totaling $785 million had been allocated during fiscal 1954, and a planned $1.13 billion was provided for Indochina in the fiscal 1955 budget. In February 1954 it was announced that additional B-26 bombers were being sent to the French in Indochina and that the United States Military Assistance Advisory Group of some 400 personnel was being joined by 200 "volunteer" technicians sent to service the nearly two hundred fighting aircraft the United States had supplied. "Without engaging in combat," writes Merlo Pusey, "these men notably enhanced the striking power of the French air force and demonstrated the eagerness of the Eisenhower administration to give all the help it could short of actual participation in the war."[5]

In September 1953 the ill-fated Navarre plan was announced (named after the French commander in Indochina, General Henri-Eugene Navarre). The purpose of this French-developed plan was to intensify the prosecution of the war in order to break up and destroy the regular enemy forces. An additional sum of $385 million in U.S. aid for supplies and equipment was included in the plan. The French were to train and direct the establishment of a strong Vietnamese army. This plan was never fulfilled; by March 1954 it had collapsed, and the military situation in Indochina was nearing the danger point of a French defeat. Chinese Communist aid to the Vietminh was increasing in volume, and France was fast approaching a domestic political crisis as a result of a public demand, similar to that raised by Americans during the Korean War, calling for an end to the fighting.[6]

The increasing participation of the United States in the Indochina war, based on the policy that Indochina was the key to Southeast Asia, created some alarm in Congress. The question of intervention arose in many quarters. The excitement was partially alleviated on 10 February 1954, when the President said that he was "bitterly opposed to ever getting the United States involved in a hot war in that region"; that he could not "conceive of a greater tragedy for America than to get heavily involved . . . in an all-out war" in Indochina.[7]

Nevertheless, the subject of intervention remained very much the talk of official Washington. On 19 March Secretary Dulles tried to dampen the talk of intervention further when he stated that the "New Look" policy of deterrent or retaliatory action had no application to Indochina, where there had been no "open" aggression. President Eisenhower had intimated two days earlier that Southeast Asia lay "on the fringe or the periphery of our interests." In all respects it looked as if the importance of Indochina in U.S. policy was being downgraded and the idea of intervention completely discouraged.

With the arrival of General Paul Ely, French Army Chief of Staff, on 20 March 1954, the tone of official comment underwent an abrupt transformation. President Eisenhower, at his 24 March press conference, viewed Southeast Asia as being "of the most transcendent importance" to the United States and the free world. Secretary Dulles "after consultations with Congressional leaders of both parties, and after having advised our principal allies" revealed the Administration's feelings concerning the Indochina crisis in an address to the Overseas Press Club of America on 29 March 1954:

> Under the conditions of today, the imposition on Southeast Asia of the political system of Communist Russia and its Chinese Communist ally by whatever means would be a grave threat to the whole free community. The United States feels that the possibility should not be passively accepted, but should be met by united action. This might have serious risks, but these risks are far less than would face us a few years from now if we dare not be resolute today.[8]

What had caused this sudden return to viewing Indochina as the "key to Southeast Asia"?

General Ely had come to Washington with desperate news. He frankly told American officials that Indochina was lost if the United States did not intervene decisively.[9] On the same day, Marquis Childs, in an interview with René Pleven, the French Minister of Defense, was told that the French needed "an additional one thousand bombers and at least three more paratroop divisions" to bring about a victory in Indochina; that France could not provide them—only the United States could provide such a sizable force.[10] The in-

Colonel Marcel Lennuyeux, French representative to the negotiations at Trung Gia, about 25 miles north of Hanoi tervention requested by General Ely involved an air strike against the Communist forces beleaguering Dien Bien Phu.

The impact of General Ely's request had been electric. The Pentagon advised that an air strike by itself would be wholly inadequate. General Matthew B. Ridgway, Army Chief of Staff, was thoroughly opposed to the air strike principle because he believed ground troops sooner or later would have to be committed. To him intervention would have been a "tragic adventure."[11] General Nathan Twining, Chief of Staff of the Air Force, and Admiral Robert Carney, Chief of Naval Operations, both leaned somewhat toward the Ridgway view. Only Admiral Arthur Radford, Chairman of the Joint Chiefs of Staff, strongly supported an air strike.

Secretary Dulles, in turn, insisted that the United States should not allow itself to be drawn into the war in any manner that would make it appear as an ally of French colonialism. Therefore, if the French would promise Vietnam independence, then Dulles would favor intervention with air power. Lastly President Eisenhower insisted that it would exceed his constitutional powers to enter the Indochina war without Congressional consent. However, American interests in the Pacific would be deeply affected by the loss of Indochina to Communist forces, so both Eisenhower and Dulles sought a way to bring United States power to bear in Indochina which would be both militarily effective and politically acceptable.

On 4 April 1954 President Eisenhower, Secretary Dulles, and Admiral Radford met in the President's study upstairs at the White House to discuss the crisis in Indochina. The threat of imminent French military disaster confronted the President with the difficult question of whether the United States should intervene with its own armed forces to halt the Communists in Indochina as it had in Korea. The final decision was made: If a collective defense in Indochina could be managed, the United States would participate in the fighting.[12]

The decision to participate had been based on three conditions: (1) that the French would agree to see the finish of the war; (2) that the French government would take steps to grant full independence to Vietnam, Laos, and Cambodia; and (3) that Britain, Australia, and New Zealand would join in collective defense. The plan was never effected. France did not have the will to mobilize all its own resources and fight for victory. The British opposed the American plan both politically and militarily; they preferred to await the outcome of the imminent Indochina conference at Geneva and not implement a plan that would imperil the diplomatic negotiations.[13]

On the other hand, the British military opposed intervention on the grounds that an air strike would not be enough. They held that an immediate, large increment of ground forces would be necessary to prevent a rout in the Hanoi-Haiphong area in the north. They declared that ground forces were not available in numbers necessary unless the United States was prepared to take three or four divisions out of Korea at once. Since two divisions had already been removed from Korea for economy purposes by the Eisenhower Administration, this added withdrawal would have exposed South Korea if a general war started.[14]

While the debate concerning intervention continued in this country, the French made two last desperate pleas for air support, the last request being made in late April. By this time the situation at Dien Bien Phu had so deteriorated that both Dulles and Radford ruled out an air strike. Now the question of initial intervention with ground troops was added to the Administration's dilemma.

No less an authority than Vice President Nixon, in an off-the-record statement that very quickly found its way into the newspapers, warned that the United States "as the leader of the free world cannot afford further retreat in Asia" and might even have to send "troops" there.[15] Admiral Radford, the champion of intervention throughout the Indochina crisis, in a speech on 15 April also called for measures to prevent the loss of Indochina to the Communists.[16] They were firm believers in the "falling dominoes" concept, which was first described by Eisenhower on 7 April 1954:

> You have a row of dominoes set up, you knock over the first one and what will happen to the last one is the certainty that it will go over very quickly. So you could have a beginning of a disintegration that would have the most profound influences.[17]

Indochina was the first domino, and if it fell, the next to collapse might be Burma, Thailand, Malaya, and Indonesia. It was believed that the "falling dominoes" could even topple into America's island defense chain of Japan, Formosa, the Philippines, and then southward, threatening Australia and New Zealand.

The sharp division among the Joint Chiefs of Staff concerning intervention in Indochina became known to the President in one of the National Security Council meetings. He managed to have General Ridgway make his own presentation at a later Council meeting. In his memoirs General Ridgway related how with charts, tables, and figures compiled from an on-the-spot evaluation of the Indochina situation by a team of Army experts —engineers, signal and communications specialists, medical officers, and experienced combat leaders who knew how to evaluate terrain in terms of battle tactics—he documented his argument that intervention with air and naval power would inevitably be followed by the necessity for American ground troops. He estimated that seven or eight divisions would have to be committed; and under the then existent manpower conditions, the United States military structure would have been far out of balance, thus leaving the U.S.S.R. an opportunity to strike, possibly in Western Europe or South Korea, as the British military chiefs had reckoned.[18]

Following abandonment of the intervention idea by the National Security Council, a directive was issued by the Secretary of Defense forbidding the service chiefs, the civilian secretaries, and assistant secretaries from writing any newspaper or magazine articles. It looked as if General Ridgway's presentation had caused President Eisenhower to direct a strategic retreat from the advanced position of intervention to one of seeking a *modus vivendi* in the Indochina situation.

Many people assumed that diplomatic frustration with the British and the French was the controlling reason for the decision to abandon the idea of intervention in Indochina. However, the impact of the military thinking of the British chiefs of staff as well as the powerful argument presented by General Ridgway more than likely settled the question in the President's mind. There was little doubt that the United States would have had to supply the preponderance of men and equipment even if France and England joined in a collective effort.[19] Given the low state of its ground forces, the United States could not have successfully undertaken a ground war in Indochina without increasing its mobilization base.

On 7 May 1954, Dien Bien Phu was captured by the Vietminh forces. Free world forces had retreated reluctantly from another confrontation in Asia. The prospect of a new Korea, with higher defense spending, higher taxes, and revived economic controls had caused many Americans to look with dread upon the prospect of intervention. The retrenchment of the initial two years of the Eisenhower Administration had left the United States without a versatile and flexible military establishment. Yet, even as prudence dictated that the United States refrain from unilateral involvement in Southeast Asia, the fundamental policy of guaranteeing the freedom and independence of nations in Asia remained viable. In the words of some observers, military involvement in Southeast Asia in 1954, although justified, "would be the wrong war, at the wrong place, at the wrong time."[20]

Southeast Asia continued to concern United States policy-makers throughout the late 1950s and into the early 1960s. With the shift in emphasis from massive-retaliation to limited-war strategy in the 1960s, the national strategy was reoriented towards conventional limited war. The ever present concern for Indochina became of increasing importance in the early 1960s with the increase of insurgent activity in South Vietnam. By late 1964 it was apparent that the U.S. would have to become more markedly involved in Vietnam if the concern expressed in earlier years for the freedom and independence of Asia as a whole was to be quieted. In line with the basic premises of the three preceding Presidents, President Johnson in 1965 was compelled to implement the policy decision to intervene: a decision reaffirmed in 1954 but not implemented by Eisenhower.

Where the Eisenhower Administration had withheld implementation because of the lack of a proper mix of military forces, President Johnson's Administration acted on the basis that possession of a requisite military capability now afforded the U.S. the opportunity to prevent a North Vietnamese takeover of South Vietnam. It was decided that nothing less than major military measures could possibly hope to stem and reverse the tide which had been rising since 1950.

When one ponders the historical development of our military participation in Southeast Asia, particularly in Vietnam, it is rather obvious that without U.S. military involvement "at the right place and at the right time" Chinese Communist and North Vietnamese domination would have occurred throughout Southeast Asia to the point where a greater conflict under worse circumstances could have resulted. Our presence in Vietnam is historical, inevitable, and an inspiration to the free people of Asia, as well as to the world. History will judge us as to our success or failure in coping with our most significant legacy from World War II.

Hq United States Air Force

Notes

1. *New York Times*, 29 January 1952.
2. *Ibid.*, 15 July 1953.
3. *New York Times*, 3 September 1953; also United States Department of State *Bulletin*, XXIX (14 September 1953), p. 342.
4. *New York Times*, 5 August 1953.
5. Merlo J. Pusey, *Eisenhower the President* (New York: The Macmillan Company, 1956), p. 147.
6. Miriam S. Farley, *United States Relations with Southeast Asia: With Special Reference to Indochina, 1950–1955* (New York: American Institute of Pacific Relations, 1955), p. 7.
7. Report of President Eisenhower's news conference, *New York Times*, 11 February 1954.
8. John Foster Dulles, "Indo-China and the Chinese Communist Regime," *Vital Speeches*, XX (15 April 1954), p. 387.
9. Chalmers M. Roberts, "The Day We Didn't Go to War," *The Reporter*, XI (15 September 1954), pp. 31–35. The events of the next few weeks following General Ely's visit are recorded in this article by Mr. Roberts. The author based his article on facts and circumstantial evidence. It is the only account of this period that has been widely acclaimed as substantially correct.
10. Marquis Childs, *The Ragged Edge: The Diary of a Crisis* (Garden City, New York: Doubleday & Co., 1955), p. 95. This interview would seem to lend credence to Chalmers Roberts's account of the Indochina crisis.
11. Matthew B. Ridgway, *Soldier* (New York: Harper & Brothers, 1956), p. 277.
12. Robert J. Donovan, *Eisenhower: The Inside Story* (New York: Harper & Brothers, 1956), p. 261.
13. Roscoe Drummond and Gaston Coblentz, *Duel at the Brink* (Garden City, New York: Doubleday & Co., 1960), pp. 117–18.
14. Childs, pp. 130–31.
15. *New York Times*, 17 and 18 April 1954.
16. Roberts, p. 32; Childs, p. 159; *New York Times*, 16 April 1954.
17. *New York Times*, 8 April 1954.
18. Childs, pp. 154–57; Ridgway, pp. 276–77.
19. Childs, p. 95.
20. James M. Gavin, *War and Peace in the Space Age* (New York: Harper & Brothers, 1958), p. 217. This same argument was as prevalent throughout the Pentagon in 1954 as it was in 1951.

STRATEGIC STABILITY

Amoretta M. Hoeber

Since the end of the United States monopoly of nuclear weapons four years after World War II, the definition of strategic stability has revolved primarily around the development of a relation of mutual deterrence between the United States and the Union of Soviet Socialist Republics. Strategic stability is neither simple nor static, but it can be viewed broadly as the result of effective deterrence.

stability as two-sided deterrence

Although no one has accurately measured deterrent balance, it is clear that a small deterrent may be effective against a larger one, provided the smaller deterrent can threaten the infliction of an unacceptable level of damage. This depends not only on an assessment by each opponent of the other's subjective evaluation of unacceptable damage but also on the offensive capabilities of the small deterrent relative to possible defensive capabilities of the opponent.

Deterrence in the nuclear age has been thought of as prevention of the opponent's use of nuclear weapons through the threat of retaliation, but deterrence can be more fully defined as the maintenance of such a posture that the opponent is not tempted to take any action which significantly impinges on his adversary's vital interests. The concept of deterrence is aimed, then, not only against the use of nuclear weapons but also against the use of the threat of nuclear weapons in vital circumstances.

Throughout history, the major military mode of achieving deterrence has been to build a military force large enough to establish the credibility of threatened punishment if vital interests are impinged upon. If deterrence is adequate, vital interests will not be challenged, and stability will be established and maintained. The problems arise in determining the kind and amount of forces that will achieve the desired deterrence. Two opposite views of the forces that will achieve deterrence and thus promote stability are the disarmament view and the massive retaliation doctrine.[1] An understanding of the assumptions, aims, and limitations of these two views is important in evaluating the current U.S. deliberate, selective, controlled (DSC) response policy.

Would a disarmed world be stable?

First is the hypothetical instance of an unarmed world. The assumption that arms make war, that weapons are tension-*inducing* rather than tension-*reflecting*, results in the conviction that stability is possible only in a disarmed world. The extreme of this view is the advocacy of general and complete disarmament (GCD). Less extreme is the advocacy of arms limitation by agreement, either as a progressive lowering of force levels or force growth rates or as the abolition of a type of force, usually new, such as anti-ballistic-missile (ABM) defense. (The proposition that stability may be inversely proportional to the destructive potentials of weapons results in opposition to technological advances; if weapons are destabilizing in themselves, it is argued, then not only more but also better weapons are more destabilizing.)

It has never been demonstrated that either general and complete disarmament or arms limitation produces a stable condition. It is not clear why, if GCD were stable, development and production of weapons ever occurred. But more important is the question of stability if an agreement for arms reduction or limitation at various levels were effected. Reductions in the current force levels—for example, to the small number of offensive weapons advocated in the minimum deterrence doctrine—could be destabilizing if technological advances in missile kill capabilities or large-scale violation of the agreement made one side more certain of its destructive power. Stability depends on both sides. No sources of conflict would be eliminated simply by an agreement between the United States and the Soviet Union to disarm, and the destabilizing potentials of third powers would be enhanced. The disarmament proposed is of nations, not of the world, and hence is neither general nor complete. For these and other reasons, it is very difficult to postulate how the end state of GCD could be reached.

the threat of massive destruction

At the opposite pole is the doctrine of massive retaliation, which held sway during the fifties. The objective of containment of the Soviet Union was asserted to be more important than the avoidance of nuclear war. Massive retaliation was based on the central strategic concept of a short, extremely destructive war and depended on the potential use of strategic nuclear weapons against population as the sole threatened retaliatory punishment to deter all aggressions, large or small, against the United States or its allies. Hence, it was thought that the United States needed only to maintain its clear superiority in offensive nuclear forces and threaten to use them. Stability was sought from the one-sided imposition of terror.

As the Soviet Union acquired a significant deterrent threat, the use of terror became balanced in a "mutual suicide pact," in the sense that any transgression would result in the catastrophic war. The major defect of this "pact" was that it was simply not credible, certainly not with respect to minor transgressions.[2] The massive retaliation strategy fixed the form of military reaction, leaving no options open to the deterring power. It was a policy geared to meet the one improbable type of warfare, but it was weak in its ability to meet the more probable types of threats. Its aim was to deter nuclear attack on major interests, and, being organized for this, it raised the question of defining what aggressions against which interests could be considered sufficiently "major." It forced a choice of either yielding to local small aggression or applying the threatened massive nuclear destruction; and the ultimate threat is neither credible nor usable as punishment for less than ultimate cause. Hence, depending on massive retaliation encouraged destabilizing "nibbling" aggressions. It also left the terrifying prospect of accidental or unintended war, including not only war as a result of a "short circuit" or the act of a berserk general but also war as the outcome of miscalculation of intent or the misreading of enemy actions.

a third view—the current DSC policy

The fact that massive retaliation might be disproportionate to the most likely threats led the United States to broaden its options. The resultant concept of deliberate, selective, controlled response enhances stability in ways that massive retaliation did not. One of its major contributions to stability was that its development required, first, more precise definitions of what it is desirable to deter, in terms of both the full spectrum of conflict and the definition of our vital interests.

It is clear, of course, that it is desirable to deter general nuclear war. This aim has so far been achieved; not only have nuclear weapons not been used since World War II but there has been no strategic use of forces, although an increased alert such as that during the Cuban crisis could possibly be considered a type of strategic use.* On the other hand, the effectiveness of deterrence of general nuclear war is not static; the fact that it has worked so far does not ensure against its failure in the future. The deterrent balance needs constant reappraisal. The current U.S. mode of deterring general nuclear war is by maintaining a strategic nuclear force sufficient to make credible a threat of "assured destruction"; that is, certain destruction of something of such value to the enemy that its loss would be unacceptable. In this assured-destruction mode, the force must be of sufficient magnitude to retain credibility even in a second-strike position; that is, even if deterrence fails and the enemy strikes first, using some or all of his first-strike weapons in a counterforce role, to limit damage to himself by destroying some of our offensive weapons before they could be used. This posture is based on the view that strategic stability exists when each side deems the second-strike retaliatory capability of the other to be as claimed—survivable, reliable, and effective.

It is also clear that the United States has not been and does not hope to be able to deter (as distinguished from oppose) small, local guerrilla wars through the threat of assured destruction. This is so for two reasons. First, the threat of assured destruction is incommensurate with the scope of guerrilla warfare; and, second, guerrilla war appears as either civil war, which we may have no right to deter, or war by proxy, which always appears too ambiguous to deter by threatening either the guerrilla forces or the apparently supporting country.

Between these two extremes on the spectrum of conflict are small nuclear attacks, conventional aggressions that might threaten escalation, and various conventional attacks which, regardless of scale, might be contrary to U.S. interest. Implementation of the DSC policy has included building up conventional forces as well as further development of tactical nuclear weapons, with a view not only to their deterrence capabilities at the middle levels of the spectrum of conflict but also to their counteroffensive potentials if deterrence fails. This has amounted to a reappraisal of the utility of nuclear forces for deterring as well as opposing transgressions of various intensities against less-than-major vital national interests. The development of small nuclear weapons created a wider range of retaliatory options. The belief that tactical nuclear weapons are destabilizing because of escalation possibilities overlooks the differences between a small nuclear attack on overwhelming military forces and a strategic attack on population, as well as the difference between defensive use of nuclear weapons—initially perhaps on one's own soil—and offensive use of such weapons. It is not clear that escalation is inevitable, and it does seem clear that a capability to oppose aggression at lower conflict levels increases the protection of vital interests and hence increases stability.

The evaluation of vital interests interacts dynamically with both the world situation and the changing leadership of the major powers. There is general agreement that the forced conversion of any European nation today to alignment with the Communist bloc would be against the U.S. vital interest. However, despite the post-World War II strategic superiority of the U.S., at that time we allowed the U.S.S.R. to make satellites of the eastern European nations. The U.S.S.R.'s maintenance by conventional military means of the alignment of Communist bloc countries was not viewed as sufficiently contrary to U.S. vital interests to provoke reaction to the 1956 Hungarian uprising, and the same inaction would probably result today. Use of nuclear weapons by the Soviet Union for the purpose of retaining power, however, might bring a different reaction.

Strategic stability, then, is a dynamic balance, dependent on the two-sided effectiveness of deterrence in achieving its pur-

*The use of strategic weapons in a tactical mode should be viewed as a change in weapon mission, not a change from a tactical conflict into a strategic one.

poses. This balance should be constantly re-examined; the alternatives in both assured-destruction and damage-limiting capabilities need to be considered with a view to their contributions to stability.

There are several alternative postures of the strategic offensive force (SOF). Currently, the SOF has been given a dual mission: the primary mission of deterrence through assured second-strike destruction capabilities and the secondary mission of limiting damage through counterforce capabilities, should deterrence fail and the opportunity for counterforce use remain. The U.S. assured-destruction requirement has been approached in two ways: first, through building a force numerically large enough so that a counterforce attack by a smaller Soviet missile force could not destroy enough of our SOF to lower the retaliatory damage to the Soviet Union to a level acceptable to them; and second, through development of various protections for the SOF to accomplish the same survival goal as would numerical increases.

Passive protections are stabilizing because they increase the deterrent value of a given missile force through introduction of factors of uncertainty into the enemy's calculations of the effectiveness of his offensive forces in degrading the U.S. SOF. The current deterrent policy of "win second strike" becomes sounder with the increasing probability of survival of the U.S. SOF. Stability is also increased by various active defensive modes, which introduce an additional measure of uncertainty of the outcome of an attack.

role of ABM systems in strategic stability

One of the principal dynamics of the process of maintaining strategic stability is technological progress. As is well known, technology has had and is having a significant effect on the role of the bomber. A more important recent trend is the development of feasible defense against missiles. Damage limiting has, until recently, been the secondary mission of the missile portion of the SOF. But the counterforce role of the SOF is an indirect method of damage limiting, and, since it requires use of the SOF, the stabilizing effects, if any, can only become applicable with the use of the SOF on enemy forces, that is, after deterrence has failed; and at that point in a second strike there may not be significant enemy forces remaining on the ground. Anti-ballistic-missile defense can be a direct protection for both the SOF and the population, and its effect on the stability of deterrence is by virtue of its existence, not its use;[3] i.e., its effect on stability is not dependent on deterrence failure.

Anti-ballistic-missile defense increases the effectiveness of deterrence through injecting uncertainty into the enemy's calculations about the result of use of his forces. In the pre-ABM world, with the two major countries —the United States and the Soviet Union— both possessing large numbers of offensive missiles, the outcome of scenarios where deterrence fails could be predicted with considerable reliability. The introduction of an ABM system on either or both sides alters the picture.

Predictions of assured-destruction capability in the face of any defense can no longer be as accurate. The assured-destruction potential of the SOF is replaced by an "uncertainty of outcome." An attack against a target without defenses involves some uncertainty about its being killed, but, with each additional shot, the uncertainty of kill decreases in a predictable way; thus, forces can be programmed so that the uncertainty of kill of any set of targets can be lowered to an acceptable degree. With a defense of the target, the predictability of assured destruction is no longer as simple, since the outcome of an attack would depend on the interaction of the offensive and the defensive systems, and the effectiveness of neither the offensive countermeasures nor the defensive capabilities can be predicted with high accuracy. The effectiveness of penetration aids to counter a defensive system ought always to be treated as uncertain, since it is to some extent dependent on doctrine. Each side would have to rely on available intelligence about the performance characteristics and operating doctrines of the other side's defensive system, and this information could hardly be regarded as 100 percent complete. But even if one had 100 percent intelligence, tactics are subject to alteration between the time of intelligence collection and of conflict—indeed, even during an engagement.

Consequently, with deployment of a defensive system, assessment of the capability to threaten a defended target becomes more complex. An additional element of risk is introduced into the use of the deterrent in either first or second strike. The additional risk of uncertainty of the outcome of an attack presumably results in less likelihood of an attack (on either protected SOF or protected cities), and stability is increased.*

The historical Soviet emphasis on strategic defense has led to a beginning of some deployment of an ABM system. General Talensky states the Russian argument that such a system would be not only efficient but also stabilizing:

> It is said that the international strategic situation cannot be stable where both sides simultaneously strive for deterrence through nuclear rocket power and the creation of defensive anti-missile systems. I cannot agree with this view. . . . From the viewpoint of strategy, powerful deterrent forces and an effective anti-missile defense system, when taken together, substantially increase the stability of mutual deterrence.[4]

The argument that the most effective means of countering the U.S.S.R. defensive potential is an increase of offensive forces, either in number or sophistication, overlooks the basic fact that deterrence depends on the Soviets' assessment of our military power (versus their own defensive capabilities); and they may not regard the effectiveness of our military power—at any level—as so certain. It is always possible that they may be correct, but this is somewhat beside the point. The important point here is that, with a balanced offense-defense, they will retain the same degree of certainty of their assured-destruction capabilities as against an offense-only U.S. posture, while we, if we rely on an offense-only posture, cannot establish the same certainty for our own forces.

It is this situation of certainty versus uncertainty which is destabilizing. The country whose destruction potentials are uncertain will be under a great deal of pressure to do something to establish certainty again. If this is attempted through an increase of offense, it is not clear that certainty can ever really be achieved in the same sense as that allowed before ballistic missile defense (BMD). And it seems logical that a large increase in offensive forces by the uncertain side would provoke a reaction and, hence, would spiral both sides into the very arms race they are attempting to control or avoid.

On the other hand, introduction of BMD on both sides not only restabilizes the situation but results in a greater stability than that of the pre-BMD standoff by reducing the importance of the counterforce role of offensive forces. In an SOF-only confrontation, the damage-limiting role of the SOF can be applicable only if a significant number of the opponent's forces are caught on the ground. Hence, there is a definite premium on time, which tends to result in a preference for pre-emption. This preference does not exist where damage limiting is predominantly self-protective. Thus, BMD lowers the overall probability of deterrence failure through the addition of uncertainty on both sides and also tends to decrease the probability of a large-scale pre-emptive attack. This contribution of BMD to stability is overlooked in the argument that the protection which an ABM system would afford to the population in the event of an all-out war would not be significant. The effects of BMD on stability and on the level of fatalities are two entirely different measures of its value, and its impact on the first is not dependent on its effectiveness in terms of the second. Although technological advances with a view toward negating BMD would probably con-

*The planned U.S. thin deployment of Nike-X (the Sentinel ABM system), with its announced capability against the Chinese, alters the picture between the U.S. and China but only marginally affects the U.S.–Soviet relationship, since it "would in effect be no adequate shield at all against a Soviet attack." (R. S. McNamara, quoted in *The New York Times*, 19 September 1967) It must be noted, however, that the planned thin deployment may provide a growth capability for rapid expansion to meet a Soviet threat at some later time. It is the potential capability of the system which affects the U.S.–U.S.S.R. relationship.

tinue to be pursued, it seems unlikely that an increase in numbers of offensive weapons would appear attractive, since the marginal effectiveness of the additional missiles would be highly uncertain.

A deliberate all-out nuclear war, however, may be the least likely scenario. Thus a further stabilizing result of an effective ABM system is important: the potential lessening of the effect of military demonstrations; accidental, inadvertent, or unauthorized "psychotic commander" attacks; and wars of miscalculation. These need not necessarily lead to holocaust, since an effective defense would allow time to assess the situation, and the possibilities of political settlement are always enhanced by an increment of time.

The value of an ABM system is also, to some extent, an emotional one, dependent on personal and national views of the value of damage limiting per se, especially with respect to human lives. If it could be assumed with certainty that the possibility of future conflicts involving the use of strategic nuclear weapons were zero, then there would, perhaps, be less of an argument for damage-limiting measures. But this assumption cannot be made for the reason, among others, discussed next.

n-sided stability

A factor that must enter into calculations of strategic stability in the future is the impact of external influences—basically, the *n*th-country problem. While possession of nuclear weapons and crude delivery systems (bombers or missiles) does not vault an *n*th country into great-power status, the earlier belief that actions of peripheral countries could not alter the strategic balance can no longer be held valid. Proliferation of nuclear weapons has occurred and will probably continue for many political and strategic reasons, ranging from prestige to traditional enmity, over which the major powers are not likely to have much control. One motivation has been the change in the nature of alliances. In historical deterrence postures, before the advent of nuclear weapons, a major factor in the balance of power was the constant struggle for favorable alliances, despite the continuing debate over whether alliance treaties were mere scraps of paper. It is hard to see how alliances could play the same sort of role in a nuclear strategic balance, one reason being the shortness of time in a strategic nuclear exchange for diplomatic maneuvering to establish alliance support. But more important is the difference in degree of risk involved. Before nuclear weapons, a country could discharge its alliance obligations with much less risk of its own destruction than at present. Hence, the degree of alliance commitment becomes more questionable. The questioning of commitments of nuclear guarantees has clearly been one motivation for development of independent nuclear forces in France and Communist China.

The assumption that any level of nuclear-weapon possession acts to close the gap between an *n*th country and the superpowers has some validity if the superpowers cannot effectively deny penetration to unsophisticated weapons. This establishes a clear case for some BMD deployment, as was recognized by Secretary McNamara,[5] since it is likely that *n*th-country attacks could be effectively interdicted for the foreseeable future. The argument that a large offensive military force will dampen the ambitions of *n*th countries overlooks the fact that even a small nuclear force when targeted countervalue may be an adequate deterrent against a larger, offense-only force. Certainly the damage to an *n*th country resulting from retaliation would be greater than the damage any *n*th country is likely to be able to inflict for some time, but this remains true whether the *n*th country is allowed penetration or not. The combination of urban and SOF protection could probably deny both counterforce and countervalue roles to an *n*th country. Thus, effects of the actual use of *n*th-country nuclear power would be degraded, and the political threat value of such a force would be diminished.

It is not clear that introduction of BMD would discourage proliferation, for *n*th countries might still have strong local, regional, and prestige motivations for acquiring nuclear forces. The deployment of defenses would, however, deny the effectiveness of *n*th-country power against the protected countries and would strengthen the credibility of nuclear guarantees, particularly to those countries which might consider themselves threatened by *n*th countries. In these ways, BMD would reduce the range of possible destabilizing acts by *n*th countries.

Stability, then, is the dynamic situation of mutual deterrence—"mutual" not necessarily confined to pairs. Deterrence depends on the interaction resulting from constant reappraisals by both sides of the changing technical and political framework within which conflicts are to be adjusted. The important question is what basic policy is to be followed: who is to be deterred, from what are they to be deterred, and by what threats are they to be deterred? These questions must be viewed within the context of the simultaneous evaluations of all opponents, since deterrence is a relation whose maintenance is dependent on the state of mind of all parties.

Falls Church, Virginia

Notes

1. A detailed analysis of these and other schools of thought concerning nuclear weapons has been made by John H. Morse and W. R. Van Cleave in *Problems Posed by Conflicting Views Concerning Nuclear Weapons* (Menlo Park, California: Stanford Research Institute, August 1965).

2. For a discussion of the credibility of disproportionate responses, see Thornton Read, *Military Policy in a Changing Political Context* (Princeton, New Jersey: Center of International Studies, December 1964). For detailed analyses of the massive deterrence policy and its limitations, see Robert Strausz-Hupé, *et al.*, *A Forward Strategy for America* (New York: Harper and Brothers, 1961), and General Maxwell D. Taylor, USA (Ret), *The Uncertain Trumpet* (New York: Harper and Brothers, 1959).

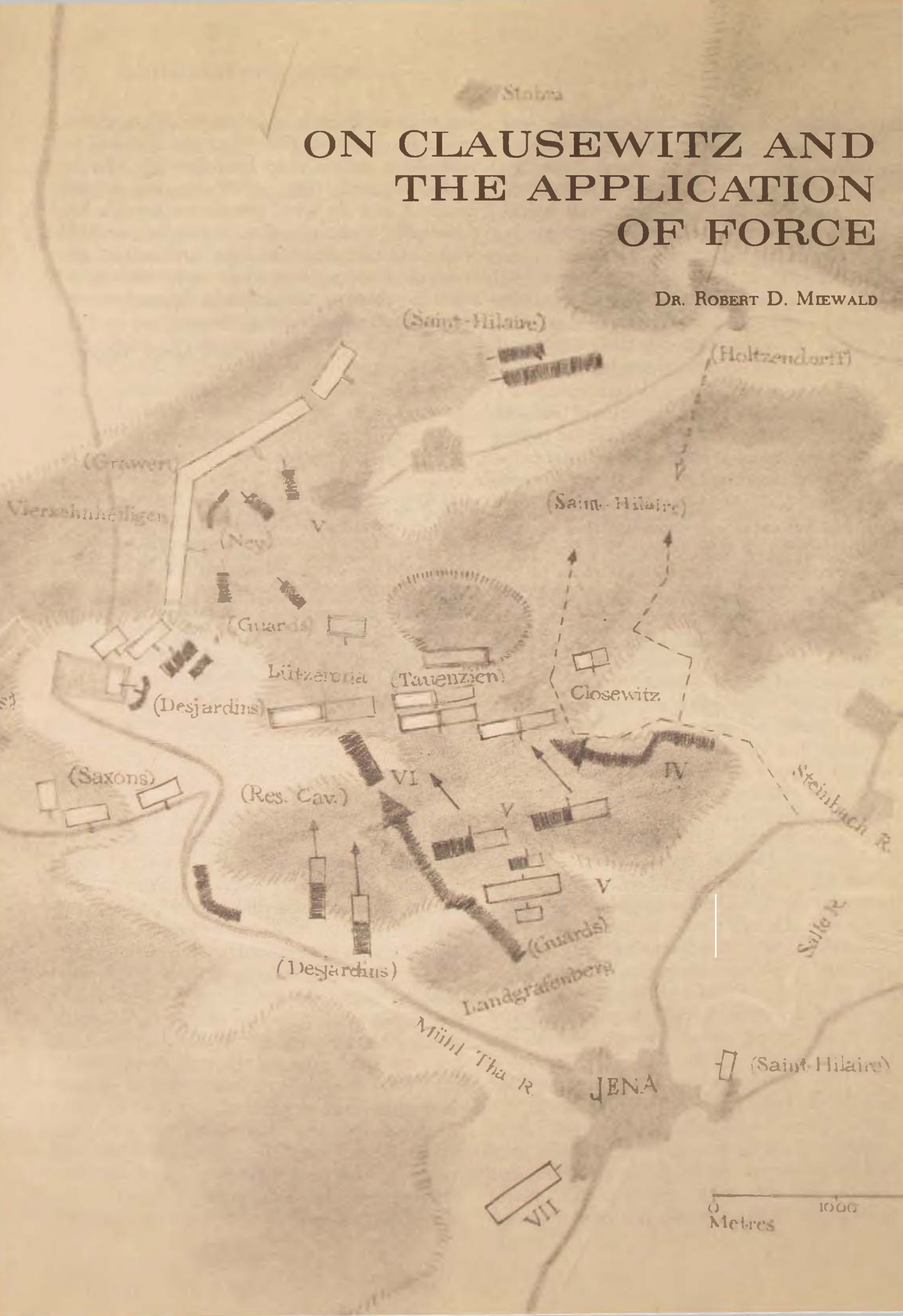
3. Richard B. Foster has developed several of these concepts in *The Impact of Ballistic Missile Defense on Arms Control Prospects* (Menlo Park, California: Stanford Research Institute, June 1966) and in other papers.

4. Major General N. Talensky, "Anti-Missile Systems and Disarmament," *International Affairs*, October 1964, pp. 15–19, reprinted in *Bulletin of the Atomic Scientists*, February 1965.

5. *New York Times*, 19 September 1967.

ON CLAUSEWITZ AND THE APPLICATION OF FORCE

DR. ROBERT D. MIEWALD



THE departure of Secretary of Defense Robert S. McNamara from the Pentagon, after a remarkable seven years in office, will produce appraisals of his performance from all manner of analysts. In the nature of such things, much of the criticism will be about as productive as the kibitzing of Sisyphus' technique of rolling stones; it will fail to ask the basic questions of whether the Department of Defense is in fact a manageable organization and whether any one man or any one team could impose comprehensive administrative reforms within such a mammoth complex. But certainly two fields of study are obligated to make a mighty effort to overcome any parochial distortions in order to put the McNamara phenomenon into broader perspective. For students of the art and science of administration and students of military affairs, the Secretary has symbolized a revolution, the dimensions of which we can still only dimly perceive.

This business of placing men and events in perspective would be much easier if there were an identifiable discipline called military administration. To be sure, one does come across that term in the literature, but the idea is seldom backed up with substance; there is not a truly harmonious blending of the knowledge of civilian and military experts about administrative problems. Despite the periodic calls for a separate science of military administration, the great void still exists. How, then, do we assess the contributions made by such a pioneering military administrator as McNamara? How do we respond to the insinuation that his regime was administratively correct and militarily deficient? Perhaps there is a worthy substitute for a venerable scholarly tradition in the writings of Karl von Clausewitz. Certainly there are few who would dispute this Prussian's premier position among theorists, if not philosophers, of war. What is not so often recognized is that Clausewitz had a great deal to say about the management of the large organization. Indeed, much of *On War* is—to use the modern sociological phrases—a dissertation on the problems of decision-making in the nonprogrammed situation. In my opinion, Clausewitz is the most provocative and realistic of nineteenth century commentators on administrative matters.

Therefore, I shall attempt here to view the McNamara administration of the Department of Defense from the Clausewitzian perspective. The attempt seems all the more timely because of the apparent rehabilitation of the reputation of Clausewitz by modern strategists. That popular diversion among students of war which determines after the fact "what Clausewitz really meant" has taken an abrupt change in direction. No longer is he seen as the prophet of *Krieg an sich*, as the intellectual force behind the military excesses of several generations of European officers. We are now informed by such knowledgeable authors as Herman Wolk and Wesley Posvar that limited warfare is Clausewitzian warfare.[1] Such an evaluation follows naturally from an emphasis upon his most famous dictum: War is the continuation of politics by other means. But one dictum does not a theory of warfare make: any war, limited or otherwise, has to be executed, has to be administered; and it thus becomes necessary to take into account all that Clausewitz had to say about the actual conduct of war.

By its nature, limited war presents a large number of administrative problems. Essentially, it entails the application of an appropriately tailored military response. Such delicate application of force demands much forbearance and restraint; it involves careful measurement and calculation. In contrast, traditional warfare, at least since Napoleon, has been shot through with nonadministrative factors; it has been more in the nature of an emotional crusade against an inherently evil enemy who must be destroyed. At the other extreme, all-out nuclear war, in its operational phases, does not require prolonged administrative consideration, its essence being a one-time, highly nonroutine response.

Our present experience with limited warfare seems to bear out this point about the administrative character of such conflict. Vietnam is surely our most bureaucratic war. Our goal there is not a victory parade through the enemy's capital; instead, it is a matter of applying the right amount of persuasive power. Indeed, as Amrom Katz of RAND has pointed out, success in Vietnam, in the absence of a front line, is measured by that lifeblood of any hardy bureaucracy—a deluge of statistics. Kill ratios, defection rates, and other esoteric items are the pale substitutes for captured colors and famous victories. Of course, this bureaucratization of war is often difficult for participants and observers to appreciate. To a man in mortal fear for his life or to worried parents at home, administrative restraint may appear to be inexplicable. In the heat of passion, injunctions against "going all the way" are hard to follow. But bureaucracy, by definition, is the denial of passion.

Limited war is bureaucratic war, but Clausewitz is no friend of a rigid military bureaucracy. His counsel cannot be comforting to anyone who craves stability and predictability in the administrative environment. In contrast to Jomini, his more rationalistic contemporary, Clausewitz plunged into the investigation of the characteristic irrationality of war. What he accomplished was a breathtakingly stark view of the nature of war, a view so revealing that it must shake one's confidence in the predictability of that activity. Clausewitz stripped war of all its baroque adornment, of the polite assumptions with which the bureaucrats of the eighteenth century had surrounded the subject. He concentrated on the pure essence: war is the application of violence.

It is not easy to accept this fundamental premise and still insist that the engines of war can be operated according to rational calculation. "There is no human affair," wrote Clausewitz, "which stands so constantly and so generally in close connection with chance as War," for it is largely an act of primitive emotion.[2] A realization that war deals with the effect of violence upon human beings, both friend and foe, demands that the student of military administration consider those dark elements which even today are not quite explained away by the most sophisticated theory of psychology. By striking at the heart of the matter, Clausewitz, as he well knew, vastly increased the area of the unknown and thus decreased the sphere of operation for a thoroughly bureaucratized military unit. But he could not bring himself to defy the imponderability of violence by producing a handy, "by-the-numbers" manual of rules and regulations.

Such scrutiny of the violence unleashed by war exposed so much uncertainty that a fundamental characteristic of bureaucratic behavior—dealing with reality in terms of easily manageable but artificially constructed categories—was no longer possible. For Clausewitz, warfare was an interconnected mass of individual events, and an overly rigid set of guidelines for action would prevent the commander from assimilating several unique cases. Therefore, if the military profession was instructed by Clausewitz as to the violent nature of war, it was also forced to recognize the innumerable variables that could come into play in the application of force. He did not allow the rational student of war to ignore all the immaterial moral forces that could determine the outcome of an encounter no matter how well the tangible contingencies had been provided for.

For the administrator, civilian or military, Chapter 7 of Book I is the core of *On War;* this potent antidote to excessive rationalization in warfare deserves to be appended to all formal administrative codes. Here Clausewitz identified all those intangible factors which could make a mockery of the best-laid plans as "friction":

> Friction is the only conception which in a general way corresponds to that which distinguishes real War from War on paper. The military machine, the Army and all belonging to it, is in fact simple, and appears on this account easy to manage. But let us reflect that no part of it is in one piece, that it is composed entirely of individuals, each of which keeps up its own friction in all directions. Theoretically all sounds very well. . . . But it is not so in reality, and all that is exaggerated and false in such a conception manifests itself at once in War. The battalion always remains composed of a number of men, of whom, if chance so wills, the most insignificant is able to occasion delay and even irregularity.[3]

Clausewitz then summed up his definition of friction in one of his most graphic descriptions, a description valid not only for the officer but for any administrator who must react quickly in an uncertain environment:

> Activity in War is movement in a resistant medium. Just as a man immersed in water is unable to perform with ease and regularity the most natural and simplest movement, that of walking, so in War, with ordinary powers, one cannot keep even the line of mediocrity.[4]

Because of this friction, Clausewitz had little faith in principles of war or their expounders. Nor was he excited by the possibility of discovering some theoretical lubricant for improvement of the connection between the will of the commander and the action of the soldier on the line. Too many imponderable and intangible factors would inevitably disrupt this vital connection, this link between policy making and policy execution. Such administrative theory as he presents, therefore, is not an imposing edifice composed of enduring principles. Theory could only furnish the commander with an understanding of the unpredictable nature of war; it could not illuminate all the unknown factors before they occurred.

Had Clausewitz continued in this vein, he might eventually have reached the extreme statement of administrative helplessness described by Tolstoy in *War and Peace*. But Clausewitz was too much of a soldier to admit that his profession was fit only for the provision of presiding officers over meaningless chaos. He found hope in the form of a special type of decision-maker, namely, the commander with genius. He suggested that a commander who was unfettered by predetermined rules and who possessed the gift of the *coup d'oeil*, combined with a sense of resolution, could cut through the fog of uncertainty that envelops the scene of combat. In other words, he valued the heroic and, consequently, nonbureaucratic leader. A bureaucracy, being the haven of ordinary men with ordinary minds, could not respond quickly or resolutely enough to make sense out of the disorder and confusion which result from the application of violence. The decisive element in war could be provided by that sphere of the mind outside the purely rational domain of science, by that "field of genius, which raises itself above rules."[5]

It is probable, then, that Clausewitz would not be altogether comfortable with recent trends in the Office of the Secretary of Defense, even among those experts who are engaged in the conduct of a Clausewitzian war. The systems analysts and other staff aides to the executive, whose function, so it is often said, is only to sharpen the intuition of the decision-maker, would not have been enthusiastically embraced by a man for whom intuition, sharpened or otherwise, was the most basic ingredient of military success. Time after time Clausewitz denounced those who, through their obsession with "time and space, and a few lines and angles," would turn warfare into a matter of geometrical precision.[6] He reserved his harshest censure for the theorists of warfare who desired to make it a science by taking into consideration only those elements which were quantifiable and leaving out the incalculable, although crucial, factors. In describing the practitioners of this common bureaucratic failure, he wrote:

> They strive after determinate quantities, whilst in War all is undetermined, and the calculation has always to be made with varying quantities.
>
> They direct the attention only upon material forces, while the whole military action is penetrated throughout by intelligent forces and their effects.
>
> They only pay regard to activity on one side, whilst War is a constant state of reciprocal action, the effects of which are mutual.[7]

In short, Clausewitz placed himself in opposition to the tendencies toward the routinization, the bureaucratization of the application of force. In doing so, he was only emphasizing the military reality which all successful officers, before and after him, have recognized to one degree or another. As has been argued elsewhere, Jomini and Clausewitz were not diametrically opposed on the issue of rationality in war.[8] Their differences were a matter of emphasis: Jomini denied any attempt to create a geometry of war, and Clausewitz, for all his pessimism, did not give up the search for sources of stability in military administration. Neither these Napoleonic commentators nor their successors were willing to reduce armed conflict to a series of determinable patterns.

Clausewitz's writings, dramatic as they are, must be seen within this mainstream of military thinking on administrative problems. In the long tradition of military managerial doctrine, he centered his analysis on the inevitability of what Amitai Etzioni has identified as the "organizational dilemma": the constant tension between the rational and nonrational factors within the organization.[9] Thus, Clausewitz could suggest formal measures for increasing the degree of reliability of response within the military machine. He was not willing, however, to allow any military manager to forget the existence of friction, of that unexpected happening which would cause the plan to fail. This organizational dilemma is the theoretical center around which Clausewitzian administrative doctrine revolves.

Returning to the problem at hand, it would appear that the recent developments in the Department of Defense have been on the rationalistic side of the equation. A concern with the quantifiable may have led to an underestimation of the intangible; and this, in turn, may have resulted in the lack of communication between civilian and military experts which has been so often publicized. Certainly one can sympathize with systems analysts who have rejected this flimsy stuff called intuition when it is patently nothing more than the fustian prejudices of a veteran campaigner. Even Clausewitz would have rejected the notion that time-serving somehow imparted that genius needed for command. But by devaluing this intangible element, civilian leadership perhaps has also overlooked that dark but fruitful view of the world which characterizes the intelligent military perception of man in the environment of conflict.

Therefore, the present discussion is not meant to be taken as an attack on the administrative reforms instituted by Secretary McNamara or on the concept of limited warfare. The reasonable citizen must surely pray that the Department of Defense can be managed and that, for the sake of the survival of the planet, limited war can remain limited. Clausewitz did not deny the possibility of such warfare, but his impressions of the turbulent environment of violence must provide a strong warning to anyone who supposes that its implementation follows automatically. And therein lies the greatest value of a thorough reading of Clausewitz: he tried to delineate the realm of the possible in war by repudiating those who would minimize the great difficulty of the administration of force. It might thus be helpful if his most famous words concerning the relationship between politics and war could always be followed by yet another pregnant Clausewitz dictum: "In War everything is simple, but the simplest thing is difficult."[10]

Long Beach, California

Notes

1. Herman S. Wolk, "The New American Military," *Air Force and Space Digest*, April 1966, p. 87; Wesley Posvar, "The Political Environment for Military Planning," *Air Force and Space Digest*, December 1966, p. 45.
2. Karl von Clausewitz, *On War*, Vol. I, trans. J. J. Graham (London: Kegan Paul, Trench, Trübner and Company, 1908), p. 19.
3. *Ibid.*, p. 78.
4. *Ibid.*, p. 79.
5. *Ibid.*, p. 100.
6. *Ibid.*, p. 167.
7. *Ibid.*, p. 99.
8. Robert D. Miewald, "Military Managers," *Military Review*, July 1967, pp. 40–45.
9. Amitai Etzioni, *Modern Organizations* (Englewood Cliffs: Prentice-Hall, 1964), p. 41.
10. Clausewitz, p. 77.

SYSTEM MANAGEMENT AND LOGISTICS

Major Graham W. Rider

IN an earlier issue of *Air University Review*, I defined logistics as the creation and sustained support of combat forces and weapons.[1] How this task is accomplished was explained in terms of three kinds of logistics: strategic logistics—determining the structure required to accomplish national objectives; support logistics—acquiring the assets needed for the structure; and operational logistics—distributing and applying those assets in direct support of the combat forces and weapons. I pointed to possible organizational problems within the Department of Defense, particularly within the Air Force, as reflections of our general misunderstanding of logistics.

There is no easy way to resolve organizational problems, especially in an organization with the massive size and complexity of the Air Force logistic operation. Further, it is hardly possible to analyze Air Force logistics if a suitable framework for the analysis is not available. However, such a framework does exist in the theory and management of systems, which is the modern approach to management of formal organizations.[2] The purpose of this article is to propose a system concept that might serve as a suitable framework for analysis and possible improvement of Air Force logistics.

the system management concept

We in the Air Force tend to think of systems in terms of weapon systems or command and control systems, and when we think of managing such systems, the system program director or system support manager comes to mind. These, however, are rather special examples of the system management concept. Johnson, Kast, and Rosenzweig of the University of Washington, pioneers of this modern theory, define a system as "an array of components designed to accomplish a particular objective according to plan."[3]

This definition is significant in that an array indicates interrelated functions, that the system has a purpose, and that inputs to the system must be acted upon according to a plan. In that way the authors explain their definition. It follows that to manage according to this concept the manager must see his organization as a system of interrelated and interfunctioning parts. The system reacts to its inputs in a manner calculated to enable it to accomplish its objective or objectives.

The human body is a system, but it is also composed of subsystems, like the nervous system and the digestive system. So, too, can organizations be thought of as systems composed of subsystems. However, organizations rarely function as smoothly as does the human body, so management must consider "the means for interrelating and coordinating these various subsystems."[4]

We can distinguish between closed physical systems and open living systems. An open system, like the human body, lives by exchanging materials with its environment. It imports, converts, and exports materials in order to live. On the other hand, closed physical systems are self-sufficient and need not exchange materials with their environment in order to live.[5]

In traditional organization theory, organizations have generally been thought of as closed physical systems. It has been assumed that problems which the organization encountered would be solved with reference to the internal or hierarchical structure. Essentially, traditional theory has not considered inputs from and outputs to the organization's environment to be significant except as they affected the internal structure of the organization. The relationship which the organization has with its environment, for the most part, has been ignored.

Those who specialize in logistics have long been aware of the impact of such inputs as national objectives, the state of the economy, and capabilities of the defense industry. They are especially aware of the output demands made by their customers, the using commands. If our present logistic structure is based upon traditional theory, then it is the gross impact of these inputs and outputs, these environmental forces, which is creating the current demand for a better concept of logistics management. The better concept may well be system management.

The Air Force is not alone with this problem. Private industry is experiencing similar difficulties but apparently has discovered a solution through viewing the firm as a marketing system. Admittedly, this viewpoint is new, but it appears to be successful. In the past, civilian management has borrowed ideas from the military to solve its problems. Perhaps the Air Force can reciprocate by applying the marketing-system concept to the management of logistics. The concept is certainly worthy of our consideration.

the firm as a marketing system

Not too long ago the average American firm was oriented to either sales or production; marketing was not considered to be a major function. In fact, the American Marketing Association defined marketing as "those activities which direct the flow of goods and services from production to consumption."[6]

Thomas A. Staudt and Donald A. Taylor of the Marketing Department of Michigan State University were not satisfied with this definition. Their empirical research in the business world convinced them that the firm is an integrated production-marketing system. They say that:

> . . . for managerial purposes, there is no other appropriate way to conceive of a firm except as a market entity . . . we recognize the firm as a means-end system. It has resources and it seeks market ends. In fact, we can think of the firm as a target-seeking mechanism, continuously striving to adapt and adjust itself to the attainment of its end purposes.[7]

Their managerial concept reads quite well, but to thoroughly understand it, further illumination is required. A system model of the firm shows the firm as a marketing system (Figure 1).[8] The model can be understood by starting at the upper left with corporate objectives. These objectives are affected by external inputs from the firm's environment: for example, government regulations, investor demand, and social pressures. The corporate objectives are also affected by the firm's marketing objectives and marketing knowledge, which might be expressed as sales volume, profit, or some other criteria such as percent of market. Of course, marketing objectives affect the internal operation of the entire system. They, combined with corporate objectives and market knowledge, enable the firm to select a market.

Market selection is a critical component of the market system. For example, an electronics firm may choose to produce components only or to produce finished units of equipment. If its choice is the former, then its product offerings may be limited and specialized, as in the production of transistors. On the other hand, the firm may choose to offer a line of components which might include resistors, capacitors, inductors, and so forth. What the system may offer is affected by inputs from the rest of the firm, such as manufacturing capability or new discoveries from the research department. Thus, we see the interrelationships between three components in the system array: market selection, product offerings, and rest-of-firm. An important point to remember is that the rest-of-firm, shown in Figure 1 as a rectangle, is environmental to the marketing system. It provides inputs and consequently acts as a constraint upon the system.

The next step in the system is to develop marketing strategies. We consider four strategies in this model. First, the product strategy reflects the mix of product offerings. Let us assume that the firm's strategy is to offer an integrated line of electronic components. Second, the distribution strategy considers not only transportation but also alternatives in warehousing, wholesaling, retailing, and direct selling to customers. We might assume that the electronics firm chooses to direct sell only to industrial customers, will centrally warehouse its products, and will use air transportation to fill orders expeditiously.

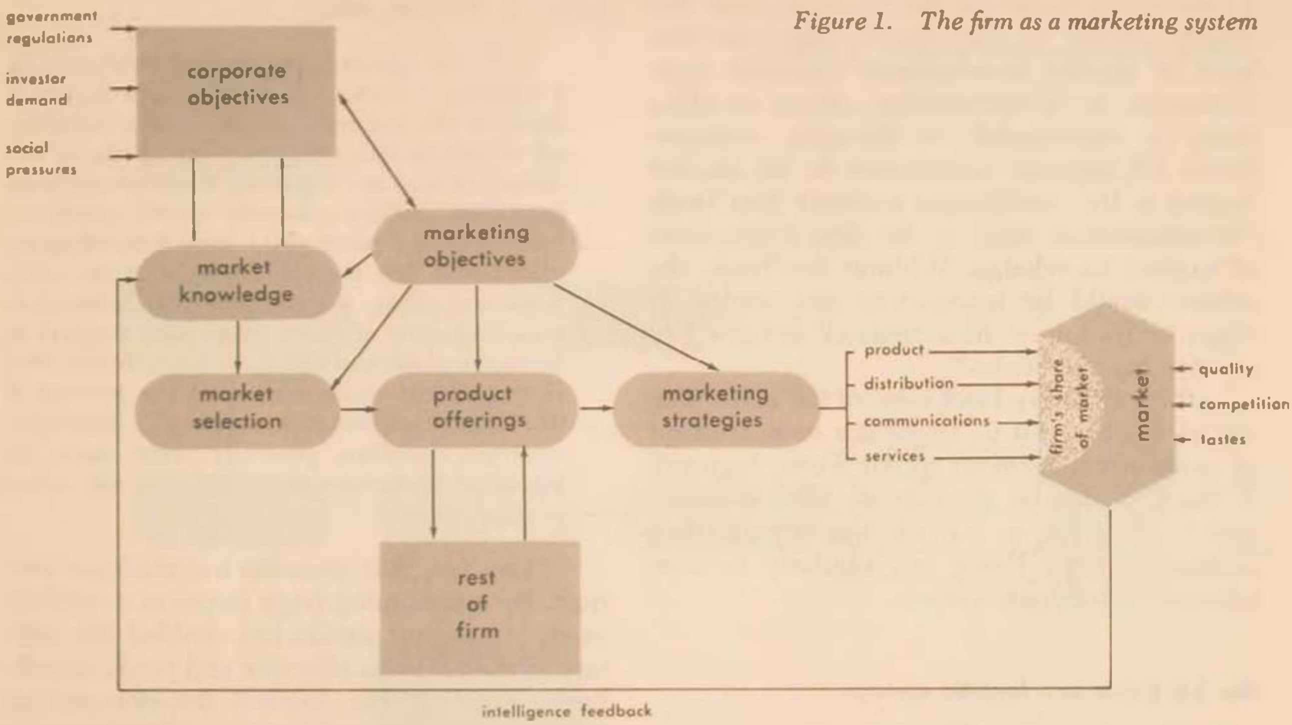


Figure 1. The firm as a marketing system

The third strategy, communications, provides product information to persons within the system as well as to customers. However, the strategy primarily involves choosing an appropriate mix of advertising messages and the media through which they may be carried to potential customers. Based upon the other strategies, the electronics firm would probably limit its advertising to trade and professional journals.

Fourth, the services strategy for this electronics firm would probably involve pricing and guarantees as well as engineering assistance to customers using the products. The quality of its products would determine the range of alternatives which the company might enjoy for this strategy.

Finally, in the market the firm receives inputs from still other environmental forces, a form of exchange for the firm's outputs. The forces (shown in the model) may take the form of quality improvement demands from customers, or of competitive actions by other firms, or, conceivably, of changing customer tastes. Of supreme importance to the market system is the intelligence network that feeds this information back to the firm in the form of market knowledge. Without feedback, the system would be incomplete and unable to react to its inputs in a manner designed to achieve its objectives.[9]

With this very brief view of the marketing model in mind, let us apply the same concept of system management to Air Force logistics. If the firm can be thought of, from a managerial viewpoint, as a marketing system, then perhaps the Air Force can similarly be considered as a logistic system.

the Air Force as a logistic system

There is a rational basis for this consideration. The current Air Force mission is to provide trained and equipped combat forces to the unified commands.[10] Therefore, our overall mission is primarily logistical, and it provides the basic justification for viewing the Air Force as a logistic system. A model of the logistic system designed to accomplish that purpose is shown in Figure 2.[11] Certainly, there are basic similarities between the models in Figures 1 and 2, but there are significant differences as well.

We shall investigate these relationships in the same way we analyzed the first model, by starting with objectives. As with corporate objectives, national objectives are also affected by environmental inputs. Foreign policy, military intelligence, and economic constraints are shown, but there may be many others which from time to time will affect national objectives. Both operational and logistic objectives are based upon national objectives.

Notice that operations and logistics overlap in the determination of military strategy. This has not always been true. In previous wars, logistic objectives have preceded operations objectives because of the necessity for first building up a logistic base. Historian James A. Huston states:

> To the question of whether there can be a strategic decision distinct from a logistical decision the answer must be no, for virtually all considerations entering into the major decisions of war are logistical. Logic would suggest—and military planners would prefer to believe—that logistic plans stem from strategic plans; that first there must be strategic decisions and plans, with logistic plans drawn as a consequence of them to provide support at the right place and the right time. World War II turned out to be somewhat the reverse of this logical sequence of events . . . high-level strategic decisions generally were based on logistical limitations more than on any other consideration.[12]

However, that situation has changed over time. By maintaining large forces in a combat-ready status, our nation has enabled the military to maintain an effective and ready logistic base. Now, at the highest decision-making levels, operational and logistical objectives can be accomplished concurrently, for the most part, through military strategy. This part of the model illustrates what was earlier described as strategic logistics.

Of course, logistic objectives affect logistic requirements and the logistic substrategies which are derived from military grand strategy. Asset requirements are transmitted to the logistic base which is external to the Air Force system. The base is primarily the national economy, represented for the most part by defense industry, but it also includes other sources such as the Defense Supply Agency, the Army, and the Navy. As in the marketing model, this model reacts to inputs from the base, like new technology, and to limitations from the base, like production capacity. The base is an environmental force which provides inputs to the logistic system.

The five logistic substrategies shown in the model can be thought of separately or in combination. For example, the several strategies are interrelated in the weapon system management concept. Logistic requirements are the essence of what was earlier described as support logistics. It follows that the logistic strategies bridge the gap to operational logistics, which can generally be regarded as organic to the using commands. Let us turn now to a brief analysis of those strategies.

First, the supply strategy determines what is provided to the customer and the form it takes. Alternative choices of strategy range from individual item control, as with mechanic's tools, to furnishing a unit with thirty days' supply of rations, fuel, and munitions. Another choice might be the design of an item so that it can be repaired and returned to use, versus making it expendable or "throw away" at time of first failure. Another is the use of automatic or "push" resupply versus "pull" supply in response to requisitions. A number of these choices might be combined to form a supply strategy.

Second, in development of the services strategy to accomplish logistic system objectives, a basic decision concerns where equipment is repaired—in the using organization, the depot, or a contractor's facility. One alternative would be partial use of all three. Another is to send contractor or depot teams to the using organization to render assistance on site. Finally, we could contract all services to a civilian agency. This has been done several times on a temporary basis when the Air Force lacked the needed skills. Again, the size and complexity of the logistic system would necessitate a mix of these alternatives to form a services strategy which will meet system requirements.

Third, the distribution strategy involves

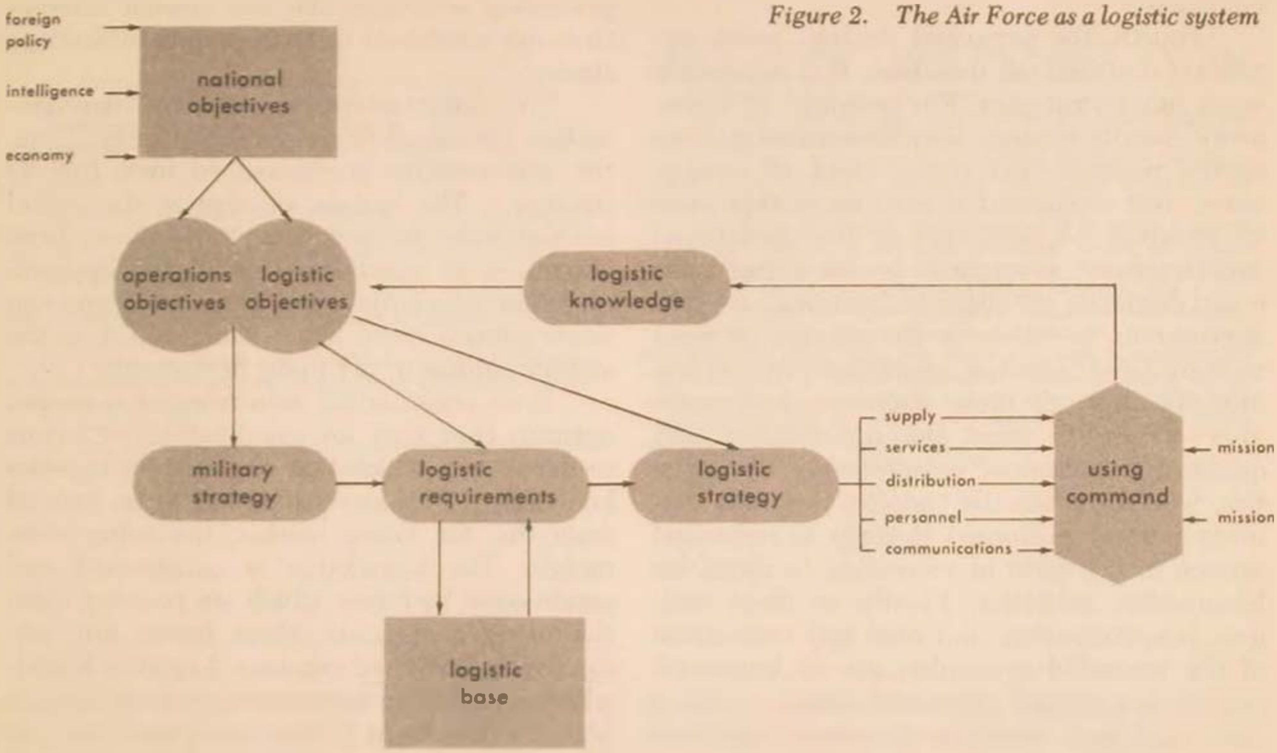


Figure 2. The Air Force as a logistic system

the delivery of logistic assets to the using commands. However, this strategy involves more, much more, than the apparent choice between air and surface transportation. The distribution network involves the depot, the wholesaler, and base supply, the retailer. Decisions about the number of depots and their locations are interlocked with decisions regarding transportation systems. Finally, the entire depot-base supply network can be bypassed through direct shipment of supplies from the contractor to the using organization. Here, again, a mix of these alternatives would be developed so that the system could meet the varied demands of its market, the using commands.

Fourth, the personnel strategy poses significant and difficult decisions. It is dependent upon other strategies. For example, a "throw away" supply strategy simplifies training down to the removal and replacement of components. But sophisticated equipment that must be repaired by personnel of the operational logistics function organic to the using command demands sophisticated training. Another decision to be made is the choice between military and civilian personnel in certain jobs. In sum, all these decisions, and probably others, to meet the quantitative and qualitative personnel requirements for logistics, would dictate the training program. Another part of personnel strategy is personnel service in the form of recreation facilities for leisure-time activities. Finally, medical services, hospitalization, and care and evacuation of the wounded in combat are an important part of the overall personnel strategy. All of these, and many more, are personnel functions that would be mixed into a logistic strategy to meet system needs.

Fifth, the communications strategy is an essential part of the logistic system. Definite similarities exist between the other logistic substrategies and those seen in the marketing model. In communications, the similarity is quite limited because the logistics market, the using commands, hardly needs to be convinced to use the product. However, much remains to be communicated to the customer regarding the product. Technical orders, manuals, and other forms of communication are used to tell the customer how to use and service his equipment in order to derive the best benefit from it. Another part of this strategy is the communication of supply status to the using commands as is now being done by computer. Occasionally, more informal methods, such as newsletters, are used to "advertise" available logistic services and to discuss mutual problems. Finally, in addition to computer networks, other sophisticated communications systems may be built to ensure the continuous flow of logistic information between support and operational logistics, especially in periods of military crisis. As with the preceding strategies, all the chosen alternatives are combined to form a communications strategy.

The alternatives chosen by decision-makers are mixed to form a substrategy. Then, the substrategies are mixed to form logistic strategy.[13] The system concept in the model enables one to proceed in analysis from objectives to substrategy or in the opposite direction with equal ease. These strategies can never remain static. They must adjust as the system adjusts to act upon new inputs.

If we consider the substrategies as system outputs, then they are conditioned by inputs to the system which take the form of logistics knowledge. This knowledge has to be derived from the Air Force market, the using commands. The knowledge is constrained and conditioned by forces which are pressing upon the using commands; these forces are, primarily, the assigned missions. Logistics knowledge, gathered by information systems like the Maintenance Data Collection system and the Unsatisfactory Report system, or gathered from statements of operational requirements and similar sources, completes the system. Logistics knowledge acts as a feedback to confirm or modify existing logistics objectives or to create new ones.

system management for logistics

Undoubtedly there is room for improvement in the logistics model. Nevertheless, it is the concept which supports both models that is of immense value. Management should view the Air Force as a logistic system, an open, living system which interacts with its environment. This managerial concept provides the framework for organizational analysis and design.

Organization creates the array of components, the people, facilities, and functions necessary to accomplish objectives according to plan. It would enable the Air Force, when viewed as a logistic system, to improve its focus on the logistic requirements of the using commands. According to Staudt and Taylor, this concept "involves the structuring of planning-, decision-, and control points to insure that those responsible for market [logistic] results have the requisite tools and resources to fulfill that responsibility."[14]

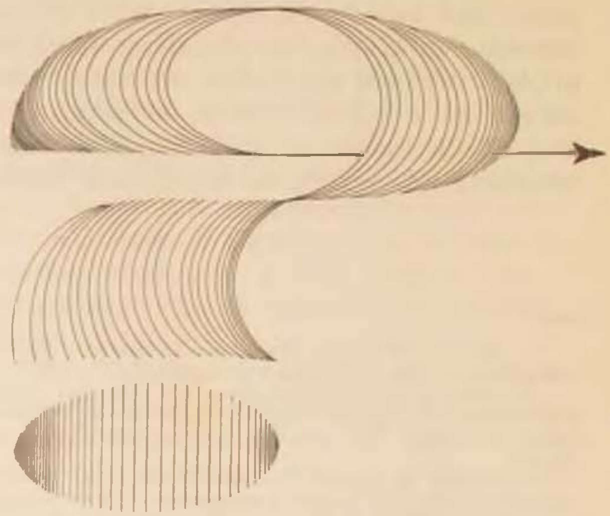
The potential involved in this managerial approach to logistics seems extremely valuable. This logistic system concept, borrowed from marketing, could prove to be the most successful management innovation that the Air Force has ever adopted.

Arizona State University

Notes

1. Graham W. Rider, "Logistics—The Bridge," *Air University Review*, XIX, 1 (November-December 1967), 93–97.
2. Rocco Carzo, Jr., and John N. Yanouzas, *Formal Organization, A Systems Approach* (Homewood, Illinois: Richard D. Irwin, Inc., and The Dorsey Press, 1967), pp. 527–35.
3. Richard A. Johnson, Fremont E. Kast, and James E. Rosenzweig, *The Theory and Management of Systems* (New York: McGraw-Hill Book Company, Inc., 1963), p. 308.
4. *Ibid.*, p. 56.
5. A. K. Rice, *The Enterprise and Its Environment: A System Theory of Management Organization* (London: Tavistock Publications Limited, 1963), p. 183.
6. Thomas A. Staudt and Donald A. Taylor, *A Managerial Introduction to Marketing* (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1965), p. 10.
7. *Ibid.*, p. 542.
8. The entire discussion of the marketing model is based on a lecture by Professor George Downing given to a Doctoral Seminar on Marketing at Arizona State University on 2 October 1967 and subsequent conversations with him.
9. Johnson, *et al.*, pp. 61–62.
10. U.S. Government, Public Law 253, 80th Congress, National Security Act of 1947, as amended.
11. Figure 2 has been derived from Professor Downing's model of the firm as a marketing system, but I assume full responsibility for the design of this adaptation.
12. James A. Huston, *The Sinews of War: Army Logistics 1775–1953*, Vol. II of the *Army Historical Series*, ed. Stetson Conn, Office of the Chief of Military History, U.S. Army (Washington, D.C.: Government Printing Office, 1966), p. 424.
13. Martin L. Bell, *Marketing Concepts and Strategy* (Boston: Houghton Mifflin Company, 1966), pp. 345–54. It is this reference which gave the writer the idea of applying the mix, composed of chosen alternative courses of action and of strategy composed of mixes, to logistics management. This book is recommended to any reader who wishes to probe more deeply into the concept proposed in this article.
14. Staudt and Taylor, p. 505.

In My Opinion



WHY THE VTOL FIGHTER?

Lieutenant Colonel Kennith F. Hite

HISTORY credits the Chinese with development of the first vertical takeoff and landing (VTOL) vehicle some 2000 years ago. Called the Chinese top, the device was really a toy consisting of a short stick with two or more feathers inserted at the top to serve as rotor blades. When the stick was spun between the hands and released, the toy would rise vertically like a helicopter, then descend slowly in the autorotation mode. Although this simple Chinese device was not referred to as a VTOL, the term today includes, technically, a wide range of such vehicles, from the now commonplace helicopter to exotic space systems such as the Gemini and Manned Orbiting Laboratory. In more general terms, however, the VTOL is thought of as a conventional type of aircraft with special features added to enable it to rise vertically during takeoff and to land from a vertical descent. The successful and imaginative employment by the military of the first VTOL type, the helicopter, is now part of aviation history. Currently, the military focus of attention is on a new VTOL type, the VTOL tactical fighter aircraft.

Progress in the development of a practical and capable VTOL fighter has been exceedingly slow over the years, largely due to propulsion limitations and related problems. Among the first and most interesting of the VTOL fighter forerunners was the Chance Vought V-173 conceived in 1933 and first flown in 1942. Called the "Flying Pancake," the V-173 was a tail-sitter intended to rise vertically, then transition to normal flight attitude. Unfortunately, however, the airplane weighed 3000 pounds and had only 2000 pounds of propeller thrust. As a result, the Flying Pancake never made a vertical takeoff or landing, although it made some 210 successful flights in the conventional aircraft takeoff and landing mode.

The project was canceled by the Navy in 1948 when its partial successes were overshadowed by conventional fighter aircraft powered by the newly developed turbojet engine. Interest waned, and efforts toward further development of this type of aircraft over the succeeding decade were sporadic.

Today, however, resurgent interest in the VTOL fighter is in evidence. The aircraft industries of some six or more major countries are currently active in the testing, development, or production of VTOL aircraft. For example, West Germany and Italy are presently engaged in a joint venture in the development of a VTOL fighter. This project is now in its early stages and the prime contractors, Vereinigte Flugtechnische Werke (VFW) of Bremen, Germany, and Fiat Aircraft Company of Turin, Italy, have established a development program that will result in the initial construction and testing of six prototype V-191B tactical fighters by mid-1969.

In Great Britain, the Hawker Siddeley Company has designed, developed, and placed into service the world's first production VTOL strike fighter, the P.1127 Kestrel.

In France, a version of the well-known mach-2 strike fighter, the Mirage III, has been converted for VTOL operations.

In the Soviet Union one model of the MIG-21 jet fighter, which is now making a dubious history over North Vietnam, has been converted for VTOL operational tests. The VTOL performance of this and two other converted Soviet fighters was demonstrated in the July 1967 U.S.S.R. Domodedovo Air Show. At this same air show a Soviet fighter designed by Yakovlev specifically for VTOL operations also performed.

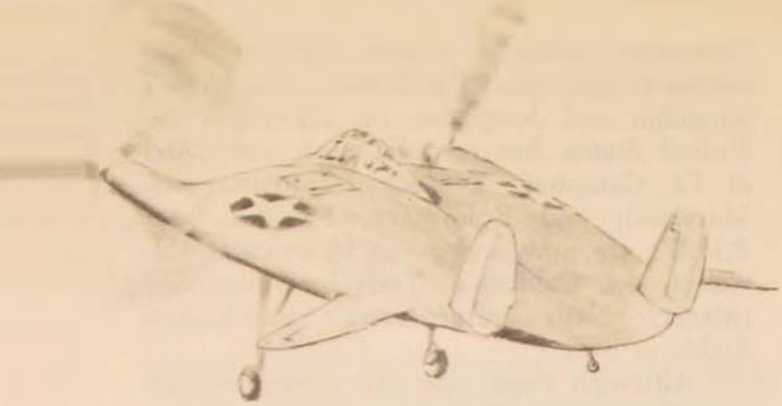
In the United States interest in VTOL has been demonstrated by all three military services. Most recently Ryan Aircraft, a pioneer in the VTOL field, has been engaged in tests of its XV-5A Vertifan VTOL, developed for the Army. The U.S. Air Force recently signed a contract with North American Aviation to gather data utilizing the Lockheed-developed XV-4B Hummingbird VTOL fighter. North American has subsequently scheduled more than 300 flights in fulfillment of this project. Triservice testing of a later version of the British P.1127, called the Kestrel in the United Kingdom and designated the XV-6A in the United States, has recently been completed at Ft. Campbell, Kentucky; Patuxent NAS, Maryland; and Eglin AFB, Florida. Four P.1127's are now under test by USAF at Edwards AFB, California. Tests have included extensive Navy aircraft carrier qualification flights as well.

Although these examples represent only a partial survey of world aviation industries presently engaged in the design, development, testing, or production of VTOL fighter aircraft, the widespread interest some 34 years after the conception of the Flying Pancake is significant. But how did industry arrive at this point in VTOL development? Why this sudden intense international interest? Of what practical application is the VTOL fighter today?

Historically, three basic types of propulsion have been used to power VTOL fighter aircraft: propeller, ducted fan, and turbojet. A fourth type of propulsion, the rotor, although used as the prime lifting means for the helicopter, has never been seriously considered for VTOL fighter application because of its relatively low efficiency in forward flight and resultant low forward speed capability.

There are two factors basic to VTOL fighter operations. First, in order to attain hovering flight, sufficient thrust must be directed downward to exceed the weight of the aircraft. Second, there must be a means of transition to normal flight attitude and aerodynamic flight speed. Of course this transition to normal flight requires a means of control during hovering and low-speed flight. The old V-173 Flying Pancake possessed all these capabilities except sufficient power to rise vertically.

As with the V-173, a majority of the subsequent VTOL efforts in the United States have been subsidized by military contracts. A few years after the Navy's cancellation of the V-173, two more Navy contracts were let for tail-sitter VTOL fighters—the Convair XFY-1 and Lockheed XFV-1. Both these aircraft were powered by the Allison 5000-horsepower turboprop engine, both made their first flight in 1954, and both were terminated in 1956 fol-



Chance Vought V-173 "Flying Pancake" (1942)

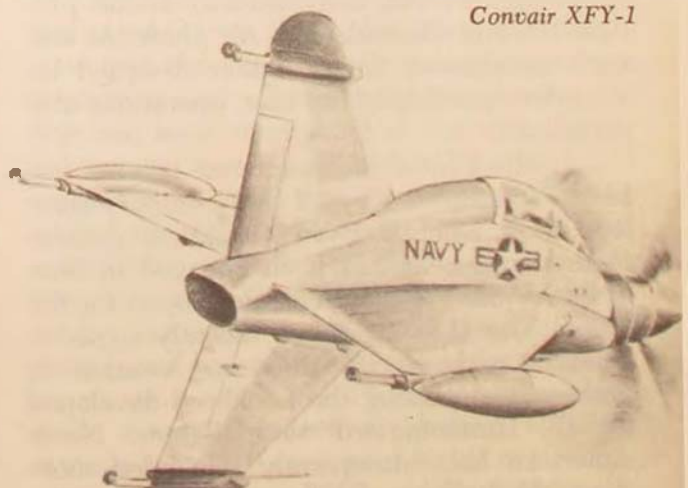
lowing two years of testing plagued by engine and propeller problems. Flight control of both was exercised during hovering and transition flight through the use of conventional aerodynamic controls, inasmuch as the wings and tail surfaces were bathed by a high-velocity flow of air provided by the large propeller during takeoff, transition, and landing. The Convair XFY-1 was successful to the degree that it was the world's first propeller-driven aircraft to make a successful vertical takeoff, transition to conventional flight, and land vertically. As later described by witnesses:

> It was truly a magnificent performance, the first time in history that any VTOL aircraft except the helicopter had accomplished the complete VTOL operation.[1]

The XFY-1 had a cruciform "sitter" platform with a very wide tread, whereas the less successful XFV-1 had such a narrow tread there was concern that it might tip from its tail-sitter position during takeoff or landing. As a result the XFV-1 never made a vertical takeoff or landing, but it was used to gather data during airborne transitions to vertical flight utilizing conventional takeoff and landing technique. State-of-the-art engine power-to-weight limitations required both aircraft to be equipped with propeller blades longer than optimum for efficient cruising, in order to provide adequate thrust for vertical takeoff. This of course compromised in-flight speed and maneuverability, two factors so vital to a military tactical fighter. Additionally, the tail-sitting takeoff and landing attitude of these two aircraft required the pilot to perform these most critical flight maneuvers from a position flat on his back with his feet up in the air and looking over his shoulder—a somewhat less than optimum position for aircrew safety and comfort.

Experiments with ducted-fan propulsion for VTOL fighter aircraft have been somewhat more rewarding. The ducted-fan propulsion principle incorporates a propeller imbedded within a shroud or duct. The propeller or fan may be powered by either a reciprocating piston engine or a gas turbine. One of the more successful aircraft of this type, which is still undergoing service testing, is the Ryan XV-5A Vertifan. This aircraft rises vertically while retaining a level-flight position. The Vertifan is powered by two J-85 turbojets of about 4300 pounds' thrust each, which operate three ducted fans through a diverter valve for vertical operations. Two fans are imbedded in the wing roots and one in the nose of the low-wing aircraft. Control during VTOL is achieved through variable louvers. Once airborne, the louvers covering the ducted fans are deflected to produce sufficient forward thrust to attain sufficient speed for aerodynamic flight. When flying speed is reached, the fans are covered over, and the full thrust

Convair XFY-1



of the two turbojets is diverted and ejected out the aft tailpipe in a conventional manner. This propulsion principle, with its mechanical advantage, shows considerable promise for certain applications.

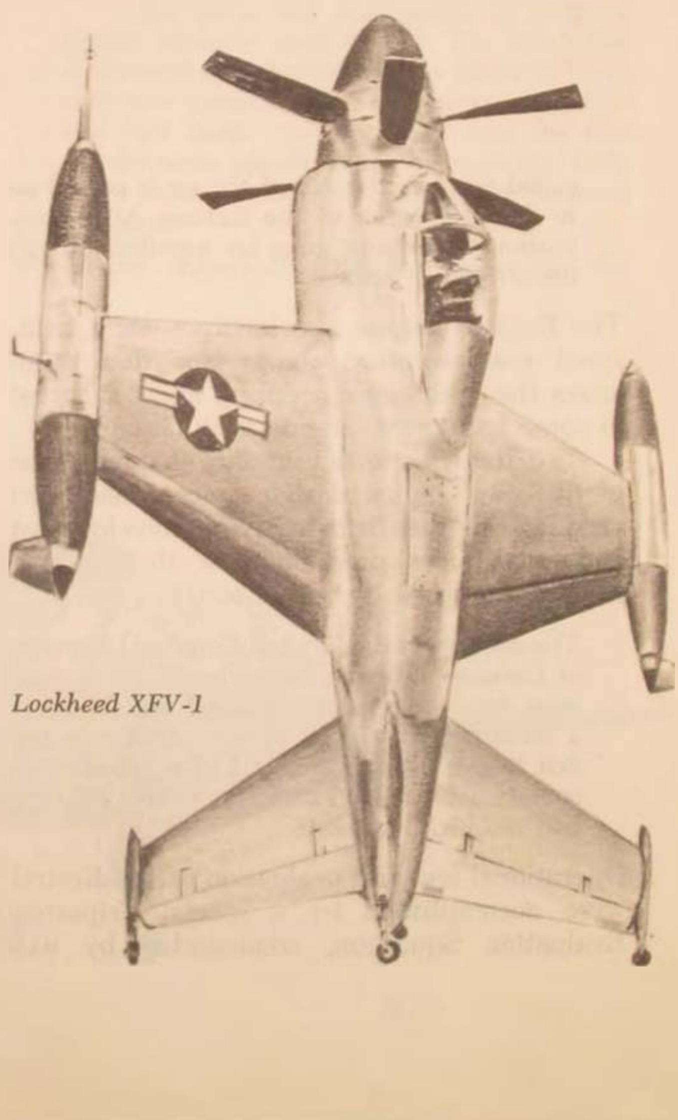
> Since the fans deal with a much larger airmass than the engines, the [Vertifan] system produces about three times more thrust than the basic engines, reducing the usual requirement for very powerful engines for VTOL operation.[2]

A major problem that detracts from the potential of the Vertifan for VTOL fighter application, however, centers around the structural weakness inherent in the louvered wing design, which tends to restrict the G-forces that can be applied. Of course wing loading and G-forces are directly proportional to maneuverability, a key factor in tactical fighter performance.

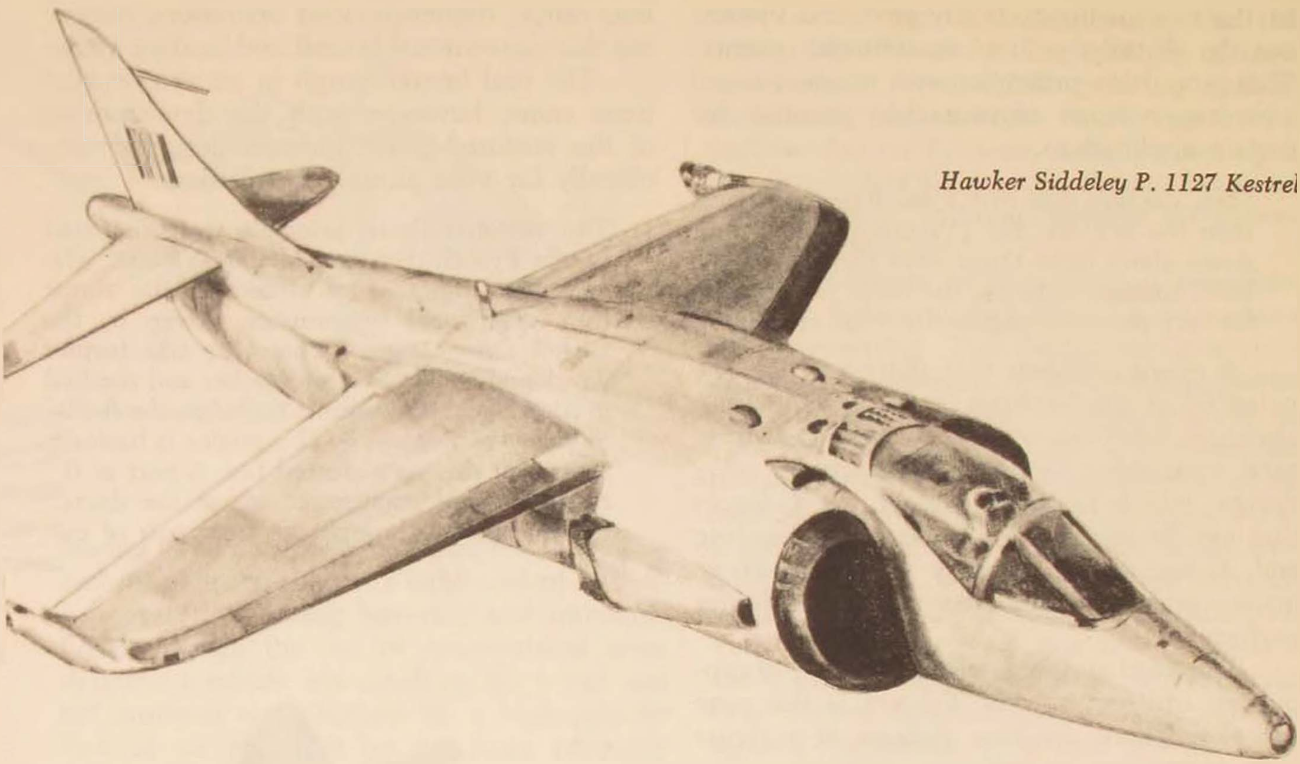
The third and most promising type of propulsion utilized in VTOL fighters is the pure turbojet. There are two systems of turbojet VTOL propulsion in common usage today. The first involves the use of small, vertically mounted turbojets of the J-85 type, installed either in the fuselage behind the pilot or on booms attached to the fuselage aft of the cockpit. These vertically mounted engines provide the thrust for vertical takeoff, hovering flight, and vertical landing. The aircraft is maintained in a level flight attitude throughout vertical operations and transition maneuvering. Aircraft control during vertical operations is provided by small jet outlets, powered by compressor bleed air, installed in each wingtip and in the aft section of the airframe. Forward speed for aerodynamic flight is provided by a separate conventional turbojet, exhausting from the rear of the aircraft. When aerodynamic flight speeds are reached, the vertical jets are shut down, retracted if necessary, and covered over in a streamlined manner for normal flight operations. The French Mirage III-V used this propulsion system to enable it to become the world's first mach-2 VTOL in 1966. Although the vertical-thrust engines are dead weight when VTOL operations are not required, the engines can be removed and replaced with fuel cells for long-range, higher-payload operations requiring the conventional takeoff and landing mode.

The real breakthrough in jet VTOL operations came, however, with the development of the vectored-thrust turbojet designed specifically for VTOL aircraft installation.

> The vectored thrust principle was originated by the French designer, Michel Wibault, who conceived the idea of deflecting the thrust from centrifugal compressors, driven by the Bristol Orion engine. This idea was further developed by Dr. Stanley Hooker and resulted in the first vectored-thrust turbofan, the Bristol Siddeley 53 Pegasus 5. This engine is basically a turbojet driving a ducted fan. A part of the relatively cool compressed air of the ducted fan is expelled through the front pair of cas-



Lockheed XFV-1



Hawker Siddeley P. 1127 Kestrel

caded nozzles; the rest of the air is passed on to the compressor of the turbine. After combustion the exhaust gases are expelled through the aft pair of nozzles.[3]

The Pegasus engine also incorporates a twin-spool contrarotating compressor that minimizes the gyroscopic coupling effect inherent in some early VTOL engine installations.

To date the most significant application of this new engine design concept has been attained by the British in the development and subsequent production of their P.1127 Kestrel. As noted by one observer:

> The decision of the [United Kingdom] Ministry of Defense, taken in November 1966, to start mass production of the Kestrel was however a milestone in V/STOL history, as it was the first time a V/STOL project had resulted in an operational aircraft. Finally the V/STOL concept had reached maturity.[4]

Operational test and evaluation of the Kestrel were accomplished by a special Tripartite Evaluation Squadron, commanded by RAF Wing Commander David Scrimgeour and composed of United States, United Kingdom, and West German air force pilots. The production P.1127 is a swept-wing VTOL fighter equipped with the latest version of the Bristol Siddeley Pegasus 6 turbofan, producing a thrust of about 19,000 pounds. Takeoff weight is in the neighborhood of 14,000 pounds, which gives the aircraft a payload of about 5000 pounds or, in military terminology, six 750-pound bombs. This payload is comparable to that of several first-line jet-powered military fighters in use today, including the well-known F-100 and F-104 aircraft. The maximum speed of the Kestrel is reported to be just under mach 1. In recent trials this aircraft demonstrated the capability to land day or night in a 150′ x 300′ clearing surrounded by 60-foot-high trees. The only special equipment required was an aluminum mat 50′ x 40′ in size, upon which to touch down. The purpose of the pad was to prevent the jet exhaust from blowing up debris or high-speed pellets and rocks that could damage the aircraft skin or be ingested into the jet engine, with resultant compressor damage.

The British have indeed made a breakthrough in turbojet engine design with their vectored-thrust Pegasus. At the same time, United States jet engine technology and state-of-the-art advances are producing some outstanding results. For example, Pratt & Whitney is now marketing a high-bypass-ratio conventional turbojet engine designated the JT9D, which has a takeoff rating of 42,000 pounds' thrust and has a growth potential to 47,000 pounds' thrust. The application of United States technology to the vectored-thrust principle could undoubtedly provide some truly amazing VTOL power plants.

What are United States intentions? The Commander, United States Air Force Aerospace Systems Command, General James Ferguson, has stated:

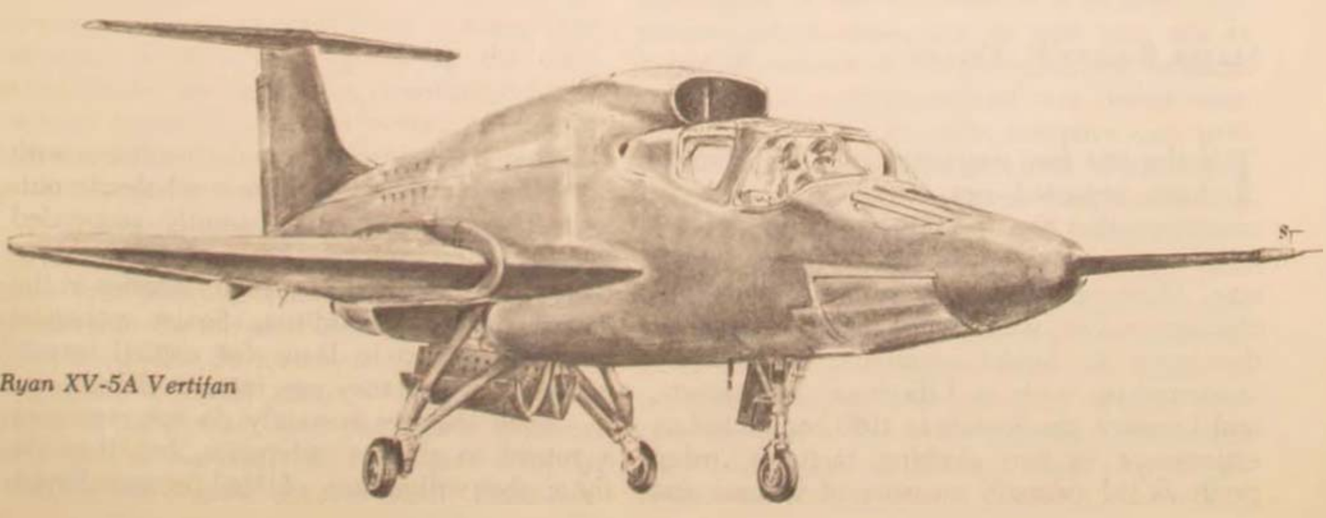
> We plan to press for solutions to the current problems and generally stay ahead of the expressed needs of operational commanders by demonstrating V/STOL systems that will be practical for their purpose.[5]

THE VTOL has finally come of age and appears to be here to stay. There remain many problems to solve in the development of concepts for employment and logistic support; but the military applications of this type of aircraft are many, and the potential for further development and improved performance is great. Let us consider one example of VTOL application:

The problem of developing an economical and flexible manned tactical weapon system that can survive a surprise air attack and continue to operate effectively against the enemy has long been of paramount military importance. During the June 1967 Israeli-Egyptian air campaign, the use of air power by the Israeli Air Force (IAF) was classic. The first wave of IAF attack aircraft flew in low, underneath the radars, and used a newly developed lightweight "dibber" bomb to interdict Egyptian runways. According to one on-the-spot report:

> . . . this bomb has retrorockets to brake it almost instantly upon release. The bomb tilts downward and another rocket blasts it vertically into runway surfaces to blow a hole several feet deep. . . . in every case the first attacks were passes along the runways. Only a few craters, judiciously placed, put them out of action.[6]

Following interdiction of the runways, the



Ryan XV-5A Vertifan

Israelis then strafed the grounded Egyptian aircraft with withering accuracy at will, thus reducing the Egyptian Air Force to relative impotence within a breathtaking and decisive three-hour time period. Six days later organized Arab military opposition to the advance of Israel's armed forces ceased.

How would a VTOL tactical fighter have helped Egypt? With sufficient military foresight, supporting aerospace technology, and a well-dispersed and adequate force of VTOL tactical fighters, independent of the requirement for long concrete runways, the outcome of the Arab-Israeli campaign could well have been reversed.

And so it could be with other farsighted nations on another day.

Ramstein, Germany

Notes

1. John P. Campbell, *Vertical Takeoff and Landing Aircraft* (New York: Macmillan Company, 1962).
2. "VTOL Ups and Downs," *NATO's Fifteen Nations*, No. 12, June-July 1967, p. 57.
3. *Ibid.*, p. 59.
4. *Ibid.*, pp. 59–60.
5. General James B. Ferguson, "Providing the Means to Meet Aggression—at Any Level," *Air Force and Space Digest*, November 1967, p. 92.
6. Robert R. Rodwell, "Three Hours—and Six Days," *Air Force and Space Digest*, October 1967, p. 58.

Additional references

The following useful sources supplement those cited in the notes.

Riccius, Rolf, and Guira, Franco. "VFW/FIAT VAK-191B," *Interavia*, September 1967.
"The P.1127 Goes into Production," *Interavia*, November 1966.
"VTOL Aircraft 1966," *Flight International*, 26 May 1966.

ON LEARNING FROM THE SOVIETS

MAJOR ROBERT H. KELLEY

IN the last few years American economists have reported—not without a touch of smugness—that the U.S.S.R. is adopting capitalist methods to improve its sagging growth rate. Moreover, the facts support their conclusions rather well. After several years of discussion in Soviet economic journals by academicians such as Liberman, Nemchinov, and Leontev, the Soviets in 1965 conducted an experiment in two clothing factories, using profit as the primary measure of success and allowing the factories to make contracts with both their suppliers and their wholesale outlets. The experiment apparently succeeded because these reforms have since been extended to about half of all the factories in the Soviet Union. In addition, Soviet managers can now negotiate loans for capital investment, for which they pay interest charges.

Such changes certainly do not represent a return to private enterprise, but they do show the willingness of the present Soviet regime to use capitalist techniques to improve their system. The Communist hierarchy has sound historical precedents for these moves: Khrushchev in 1962 proposed the use of interest charges on invested capital, quoting Lenin himself as having said, "We should be able, if necessary, to learn from the capitalists, to adopt whatever they have that is sensible and advantageous."

Now suppose we put the shoe on the other foot. If we in the United States should find Soviet methods that we could profitably use, would we be willing to "eat a little crow" and adopt their methods? American devotion to economic efficiency and our reputation as pragmatists both argue that we would change most readily. For this reason, I believe it would profit the U.S. to examine current Soviet economic reforms for possible application in the Department of Defense. Although our national economic systems are very unalike, there is a striking resemblance in the structure, operation, and problems of the U.S. Department of Defense and the Soviet economy. This may seem rather startling at first glance, but closer examination reveals many parallels between the two.

parallels

Planning and budgeting. Both the DOD and the Soviet economy operate from generalized five-year plans or goals. Each goes through an annual budget cycle, beginning with general guidelines from above and increasing in detail at each lower echelon. The proposed budgets then return up the command ladder for validation, coordination, and reclama action. Finally, the overall program is approved by the political decision-making authority and put into effect.

Command structure. While the great disparity in size lessens the value of organizational comparisons somewhat, there are close parallels in the forms of organization that have been tried. The Soviet economy is directed by a politico-technical center (Gosplan), which receives basic policy from the highest political source, the Council of Ministers. Gosplan administers vertically organized functional ministries, which operate autonomously once resources are assigned to them. This pattern coincides roughly with our Department of Defense, which operates under the executive branch and administers vertically organized functional commands.

During the Khrushchev era the Soviets tried a system of horizontally organized economic units which directed geographic areas (sovnarkhozy). While these units proved easier to administer, there was excessive redundancy in services and research. In addition, each unit attempted to become self-sufficient, and this resulted in uneconomical production. In the DOD, we had already learned these lessons during the development of strategic strike forces and in space operations. We shifted to a functional (mission) organization several years before the Soviets reached the same conclusion.

Incentives for managers. The DOD and the Soviet Union face a similar problem in motivating managers to use resources economically. The absence of personal monetary profit and precise measurement of returns on invested resources greatly complicates efforts to identify and reward effective management. One of the main weaknesses for both systems has been the lack of some means to place a real value on the amount of capital invested or the length of time before investment becomes productive. Without these measures of performance, the only reference available is comparison with previous performance. Thus we see reports of Soviet production as being 105 percent of previous year or cost per unit as being 96 percent of the norm. In DOD we have cost reduction programs and zero defect campaigns, but we can only compare our performance with our own previous efforts. Since there are no profits, rigorous cost accounting yields no real measure of performance.

Resource allocation. In the absence of a market system to allocate goods, both DOD and the Soviets use a plan. The primary difficulty is in achieving optimum input of goods to maximize output and maintain desired production. Just as the Soviets found in 1965 that they had failed to develop their plastics industry sufficiently, the U.S. found that it had overautomated defense supply systems for combat units. The lack of direct competition often allows uneconomical methods to persist long after a better way has been discovered.

Common service functions. Such services as transport, communications, supply, and housekeeping are common to all military organizations and governmental ministries. Both of the systems we are considering have grappled with the problem of providing these services efficiently without a large amount of slack and redundance in facilities or procurement. Neither has found a really effective solution.

Product evaluation. Because they have traditionally rewarded industry on a basis of quantity of goods produced, the Soviets have constantly encountered difficulty in establishing quality controls. Inspection systems seldom worked because inspectors usually had a vested interest in high production results. Our Defense Department faces a similar problem because inspectors are usually members of the organizations they inspect. In addition, our inspection system is primarily method-oriented rather than output-oriented.

So what?

Assuming that the parallels I have suggested are valid, what is to be gained by studying the Soviets? They certainly have not achieved any fame in the last ten years as management experts or as innovators in allocation or evaluation. However, they are operating a much larger system than our DOD and have far more people working on these problems than we have. Further, in the past three years the Soviets have shown a growing willingness to innovate and increasing attention to management as a key to improved performance. Thus, the similarity between the Soviet and DOD systems, coupled with the increasing pragmatism of Soviet leaders, strongly suggests that we should carefully evaluate their programs. Perhaps we could benefit from their experience.

The first Soviet experiment involved only two apparel factories, the Mayak ladies garment factory in Gorki and the Bolshevichka suit factory in Moscow. Their managers were given local authority to determine the product mix and to contract for their supplies and output. They worked on the basis of orders from wholesalers and stores. Their primary measure of success was the net profit on sales. In September 1965 Premier Kosygin announced that the experiment had succeeded and that some 400 to 600 additional plants would rapidly shift to the new system. The changes really amounted to (1) an increase in economic autonomy for managers, (2) development of automatic or market-type measures of performance, and (3) the adoption of motivating devices more closely tied to end results.

Many Western observers predicted that the reforms would quickly degenerate into just one more bureaucratic reshuffle of the centrally directed command economy. However, it now appears that considerable decentralization has actually occurred in the planning system. Practical necessity apparently outweighed ideological resistance to the changes. Current reports indicate that all Soviet industry will be operating under the new system by 1969.

some lessons for DOD

In the Defense Department we hear many of the same complaints and problems as those voiced by Soviet economists and managers. For many years there have been recurring complaints of wasted and unused resources in the military. Air Force units do not manage their own budgets for fuel, so they often use airplanes to save airline fares, which are dollar-budgeted. Navy ships have frequently been used in commercial movie making. Quartermaster supplies are often stockpiled to protect against uncertain delivery. Units of all services try to spend all appropriated funds by the end of the accounting year in June, possibly to avoid the appearance of having excessive budgets.

Another area in which the military has been notoriously lacking in economic efficiency is in the negotiation and administration of contracts. A report by Joseph C. Goulden in the *Philadelphia Inquirer* of 14 January 1968 pointed to a number of contracts in which military buyers were grossly overcharged compared with commercial customers. The author blamed inept management and noncompetitive bidding. In response, a Defense Department official, Thomas D. Morris, pointed out that Defense makes 15 million transactions per year and cannot be expected to do well on all of them. Both men were correct. Centralized control of such immense numbers of contracts cannot be effectively maintained. The Soviets learned this in the early 1960s, and it is one of the main reasons for Soviet decentralization. If both control and accountability could be decentralized throughout the Department of Defense, the product *user* would then become the contract administrator.

Still another major DOD inefficiency stems from the manager's lack of accountability for invested capital. Funds appropriated for construction or new equipment are treated as sunk costs and do not necessarily require a compensating increase in performance or productivity. Thus, each commander continually seeks more funds to improve the appearance, convenience, or importance of his operation. Again, the Soviets faced an identical problem in their command economy, and they have introduced a charge for invested capital in their profit measurement. DOD could certainly benefit from such a system.

Consider one simple example. In 1963 a family housing project was completed at an Air Force base in the South for about 550 families at a cost of approximately $17,000 per unit or $9,350,000 total construction cost. Assuming an average annual savings of $1000 per unit in military housing allowance, the investment would be recouped in 17 years if the invested capital was free. If the going cost of Treasury borrowing in 1963 (about 4 percent) is added, the payout period of the project extends to nearly 30 years. But the needs of the military are transitory, so that by 1967 the base population had dwindled to the point that the quarters could not be filled. In addition, many military homeowners in the adjacent community were in economic distress, with no rental income and no housing market. Had the project been evaluated originally on its economic merits, it seems obvious that the commander would have found an investment with better expected returns.

possible applications

For obvious reasons the Defense Department could not apply all the practices which the Russians have adopted, nor could it apply these practices to all facets of DOD operations. Some operations might be unnecessarily inhibited by fiscal accountability. In other units there is no quantifiable product to measure. But these units probably constitute the exception rather than the rule.

Some of the Air Force functions that might most readily be economically decentralized are the service and support units, such as communications, transport, training, base housekeeping, weather service, supply, food service, and housing. As a starter, a controlled experiment might be conducted by several relatively stable units in the training or transport commands. Under the experiment the unit would pay for all its inputs and operate against target costs per unit of output. A charge for invested capital would also be included. After a period of time, the unit would begin to "sell" its product as the new system was extended to more units.

Eventually, a base commander would have complete independence in applying his budget. He would determine his personnel needs, contract with training units for new people, pay (and receive) bonuses for increased productivity, and sell his support services to the combat units on the base. In short, his operation would be almost identical to that of an independent division in a large corporation.

Limited attempts in this direction have already been made in DOD. The industrial funding system for purchasing airlift from Military Airlift Command is one example. A second step is the Resource Management System currently being implemented. But these applications are too timid and incomplete to achieve really significant results, since the charges are not realistic and the manager has no monetary stake in lowering expenses or increasing "sales." Too many of the costs of military operations are simply accepted as "given" rather than as factors in the overall task of the manager. Until a means is found to give the manager a personal stake in cost-effective operations, there is little hope of making major improvements in the management of military units. If such a system seems impractical or unrealistic, consider the uproar that must have accompanied such suggestions in a Communist economy. Nevertheless, economic pressure finally forced their acceptance. The rising cost of military operations and continued balance-of-payments squeeze have placed Defense in a similar position today.

With current military expenditures running at $200 million per *day*, it would be worth a lot of extra effort to reverse the upward trend of operating costs. Who knows, maybe we could learn something from the Soviets.

Air Command and Staff College

Books and Ideas

CIVIC ACTION–
A WEAPON FOR PEACE

MAJOR LAUN C. SMITH, JR.

THE term "military civic action" is relatively new in the history of military strategy and tactics, but the military has been used as a tool of government during peacetime and wartime since biblical times at least. The term has been given an official definition with broad application by the U.S. Joint Chiefs of Staff in JCS Publication 1, *Dictionary of United States Military Terms for Joint Usage*, but civic action still faces staunch opposition by many hard-line hardware-type military commanders today.

Since the Korean conflict or even earlier, U.S. military leadership has been aware of the value of a good military civic action program as applied during wartime. More recently military civic action has been recognized as an excellent way to counter insurgency in underdeveloped or developing nations. One of our key civic action directives is the Foreign Assistance Act of 1961, mainly because President John F. Kennedy cited civic action as one method of countering subversion.

But military civic action has a multitude of peacetime applications also. In fact, there are those who say that the most important phase of military civic action must occur during peacetime so that insurgency or all-out war can be averted.

Two books have been published on this

subject recently. Dr. Edward Bernard Glick has written *Peaceful Conflict, the Non-Military Use of the Military,*† and Mr. Hugh Hanning has authored *The Peaceful Use of Military Forces.*†† Dr. Glick is a professor of political science at Temple University, and Mr. Hanning is an Englishman with a background in both military and foreign affairs. Both books are recommended reading for young career officers in the Department of Defense as well as the Department of State.

Both books are well written. To the professional they provide interesting reading and a valuable insight to the history, the uses, and the promises of military civic action in a world of either rudimentary or highly sophisticated military establishments involved in regional, national, or international socioeconomic development. And they stress the political and diplomatic overtones as well as causes and effects.

Most U.S. military men are aware of the tremendous impact the services have on nearly all aspects of civilian life today—from space technology, to civil engineering, to transportation, to medicine, to marine research, to name a few. One is impressed with the significance of such an impact after reading either Hanning or Glick. They both point to the military as having the most natural and widely applicable systems of training, education, and career development to provide for the needs of developing as well as developed nations. But they caution that nations should try to assure that training provided while a man is in the military be used by him when he returns to civilian life.

Glick treats the United States experience more directly, comprehensively, and critically than does Hanning. His objective in writing his book was to "present a concept [civic action], to philosophize about it, to describe its historical and present workings, to evaluate and criticize it." He accomplished his objective, using mainly the military civic action experiences of the United States, Latin America, Israel, Vietnam, and the Philippines. His strongest chapters are the first, in which he defines terms and discusses conflict, counterinsurgency, and civic action, and his last chapter, in which he classifies civic action and discusses its problems and promise.

Hanning, on the other hand, treats more extensively the civic action programs and resettlement programs of a greater number of countries, most of them in more detail than Glick, who devoted more space to a much-needed historical account on the subject. Hanning coined an acronym, PUMF (peaceful use of military forces), which is somewhat distracting to the reader.

The strength of Hanning's book lies in the thoroughness of his research, the impressive appendixes containing documents from seven countries to supplement his text, and his central theme of using the military as a training ground for future productive citizens through proper prerelease and resettlement programs after military obligations are met. To prove his points he relied heavily on the experiences of Israel, Peru, Colombia, Iran, and the United Kingdom.

The two authors are in agreement on most points. They make a strong point in favor of military civic action, or peaceful use of the military, properly applied. And both dwell on the dangers of military civic action. Glick, in particular, warns that it could become a tool for power in the wrong hands. But to both men there are more favorable aspects *for* civic action than there are unfavorable ones *against* it. At least it is worth a try.

Glick says the civic action doctrine of the United States "assumes that we should merely advise or support in what are essentially host country programs." The activity flow is from the U.S. military to its foreign counterpart, then from the latter to its people. Armies, he says, should work *with* the civilians on

---

†Edward Bernard Glick, *Peaceful Conflict, the Non-Military Use of the Military* (Harrisburg: Stackpole Books, 1967), 223 pp.

††Hugh Hanning, *The Peaceful Uses of Military Forces* (New York: Frederick A. Praeger, 1967), xxvi and 325 pp.

Natives of Chimán, Republic of Panama, welcome the first aircraft to land on the airstrip they hacked out of the jungle with hand tools. The USAF Southern Command U-10 had assisted them from the air by loudspeaker instructions. Soon commercial flights from Panama City were landing there.

projects the civilians want and need. Armies should never work for civilians. He points out that nearly all experts agree that civic action endeavors of the armed forces should never be permitted to degrade their military usefulness.

Hanning expresses much the same philosophy. Both writers agree that military support of a civic action project should end when a civilian agency becomes capable of carrying it through. In other words, peaceful uses of the military should help establish an economy but should never take from civilian industry, business, or labor the livelihood that is justly theirs.

To both men, training is the key. Hanning points out that training incorporates the vital principle of self-help which is really the core of the military civic action or PUMF philosophy. Training while *in* the military *by* the military "is the greatest economic boon which any defense establishment can confer on the community; and it is one which embodies few of the overtones of the more controversial functions of PUMF."

The intangible results of military civic action can be even more important than the concrete ones. Both authors stress this in one way or another. The attitudes and manners of those performing the civic action can do more harm or good than completion of the actual project—a road, bridge, schoolhouse, etc. As Hanning puts it, ". . . one of the villager's fundamental needs is to be treated with respect."

This point has too often been overlooked by commanders in the field during wartime. It has also been overlooked until recently by commanders in peacetime. To stress this point, both Glick and Hanning use the recent experiences of the United States and Israel. What they say is that the best person to perform civic action is the man trained or educated for the job. The United States now does this, they assert, by sending specially trained men out as Mobile Training Teams to perform civic action functions. Israel is doing the same thing, probably with greater effectiveness, through her two most important civic action institutions, Gadna and Nahal. Other nations are following suit.

A strong feature of Glick's book is the nine pages of text he devoted to the civic action memorandum of Lieutenant Colonel John T. Little, former chief of the White Star Mobile Training Team in Laos. Little's memorandum contains a basic formula for the conduct of a civic action program, and it is recommended for study by those who are planning such a program for the first time.

Another point that the authors agree upon and stress is the need to select the in-service training that will most benefit the man and his society when he leaves the service. Too many developing nations stress industrial skills and omit agricultural training entirely, with the result that too often the trainee wanders back to his farm highly skilled as a mechanic but with little if any added skill as a farmer.

Finally, both Glick and Hanning point out that military civic action, or the peaceful use of military forces, is not the answer to all the ills of a nation, especially in a counter-insurgent situation. Glick says that "counterinsurgency cannot succeed through civic action alone, neither can it be lastingly successful without it." Hanning writes that the "correct counter-insurgent posture is two-handed—the closed fist of military force and the open hand of friendship."

Many mistakes have to be avoided to assure successful use of military forces in peaceful pursuits. Both Hanning and Glick have made a good case for civic action, but they have also been quite objective in stating the problems to be encountered. In a few instances they have posed solutions to some problems that many in the armed forces will find difficult to agree with. But they deserve consideration, study, and alternate solutions at least, because they are problems that are more demanding of solution today than they have been in the past.

Quarry Heights, C.Z.

The Contributors

Major General Charles H. Roadman (M.D., Northwestern University) is Commander, Aerospace Medical Division, Air Force Systems Command. After interning at Baylor University Hospital, he entered the Medical Corps in 1940. He completed the School of Aviation Medicine in 1941 and pilot training in 1942. During World War II he was assigned to the Central Pilot Instructors School. Other assignments have been as staff member and Executive Officer, School of Aviation Medicine, 1946–49; student, Air Command and Staff School; Command Surgeon, Air University, to 1951; Air Attaché, U.S. Embassy, Argentina, to 1954; student, Air War College; Chief, Human Factors Division, Directorate of R&D, Hq USAF, to 1960; Special Assistant, Office of Life Sciences Programs for Aerospace Medicine, NASA, to 1961; Director of Aerospace Medicine, Manned Spaceflight, NASA, to 1963; and Command Surgeon, Air Defense Command, until his present assignment in 1966.

Colonel Timothy N. Caris (M.D., Ohio State University) is Commander, Aerospace Medical Sciences Division, USAF School of Aerospace Medicine, Brooks AFB, Texas. He entered the Air Force in 1951 and was a resident in medicine, Brooke Army Hospital, Fort Sam Houston, Texas, 1952–55. He received the master of science in internal medicine from Baylor University, 1955. Other assignments have been at Johnson Air Base, Japan; at Scott AFB, Illinois, as Chief of Cardiology, 1959–62, and Chairman, Department of Medicine, and Chief, Cardiology Service, 1962–64; at Wright-Patterson AFB, Ohio, as Deputy Commander and Chief of Hospital Services, 1964–66, and as Commander from June to August 1966. Colonel Caris is a Fellow of the American College of Cardiology and the American College of Chest Physicians and is certified by the American Board of Internal Medicine.

Dr. Anthony A. Thomas (M.D., University of Budapest) is Director, Toxic Hazards Division, Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio. Since 1956 he has developed a toxicological research program to support occupational and aerospace medicine requirements of the Air Force research and development program and has designed unique facilities for this research. He has been a USAF liaison member of the Committee on Toxicology, National Research Council; has served on the Tri-Service Steering Committee on Toxicological Research of the Advanced Research Projects Agency; and is a visiting lecturer (associate professor) in toxicology, Ohio State University. Dr. Thomas has published numerous papers on propellant and aerospace toxicology and is a charter member of the Society of Toxicology. He was awarded the Exceptional Civilian Service Medal in 1967 for his pioneering work in aerospace toxicology.

Dr. Hubertus Strughold (Ph.D., University of Munster; M.D., University of Wurzburg) is Chief Scientist and Professor of Space Medicine, Aerospace Medical Center, Brooks AFB, Texas. A pioneer in aviation medicine, he became director of the Aeromedical Research Institute in Berlin, Germany, in 1935 and by 1945 was a colonel in the German Medical Corps. After the war he was appointed Director of the Physiological Institute, University of Heidelberg. In 1947 he joined the USAF School of Aviation Medicine, where he served for nine years as Chief, Department of Space Medicine, and five years as Adviser for Research before assuming his present position in 1962. Dr. Strughold is the author of *Space Medicine* and *The Green and Red Planet;* is coauthor of *Principles of Aviation Medicine* and an atlas on aviation medicine; and has published numerous articles on physiology, aviation medicine, and space medicine.

James W. Brinkley (B.S., Ohio State University) is a research scientist, Aerospace Medical Research Laboratories, Air Force Systems Command, Wright-Patterson AFB, Ohio. Since his graduation in 1958 he has been involved in the development of escape systems for the B-58, B-70, and F-111 and in research in support of Projects Mercury, Gemini, Apollo, and the Manned Orbiting Laboratory. Mr. Brinkley has written numerous technical papers and reports dealing with acceleration tolerance, restraint systems, and impact attenuation. He was named AMRL Scientist of the Year in 1966.

General Maxwell D. Taylor (USMA), USA (Ret), is President, Institute for Defense Analysis, Arlington, Virginia. During World War II he served as Chief of Staff and Commander, 82d Airborne Division, 1942; in the Sicilian and Italian campaigns, 1943–44; and Commander, 101st Airborne Division, Western Front, 1944–45. Subsequent assignments were as Superintendent, USMA, 1945–49; Chief of Staff, American Forces in Europe, 1949; Commander, American Military Government and Army forces in Berlin, to 1951; Deputy Chief of Staff, Operations and Administration, U.S. Army, to 1953; Commander, Eighth Army, Korea, 1953; Commander, U.S. Army Forces, Far East, 1954; U.S. and U.N. Commander, Far East, 1955; and Chief of Staff, U.S. Army, until his retirement in 1959. He was recalled to active duty as military representative of the President, 1961–62, and Chairman, Joint Chiefs of Staff, 1962–64. He was U.S. Ambassador to Vietnam, 1964–65. General Taylor is the author of *The Uncertain Trumpet* (1960) and *Responsibility and Response* (1967).

Major John F. McMahon, Jr. (M.A., University of North Carolina) is assigned to the Applications Branch, Special Warfare Division, Deputy Directorate of Plans for Policy, Hq USAF. After completion of flying training in 1956, he served as a jet instructor pilot at Greenville AFB, Mississippi, and Craig AFB, Alabama. He was on the faculty, Department of Political Science, U.S. Air Force Academy, from 1961 to 1963, when he joined the 366th Tactical Fighter Wing. He served in Vietnam as an F-4C aircraft commander. Major McMahon is a 1967 graduate of the Army Command and General Staff College.

Mrs. Amoretta M. Hoeber (B.A., Stanford University) is an analyst, Strategic Branch, Analytic Services Inc. (ANSER), Falls Church, Virginia. She was previously employed as a research assistant in the Strategic Studies Center, Stanford Research Institute, Menlo Park, California, 1963–66.

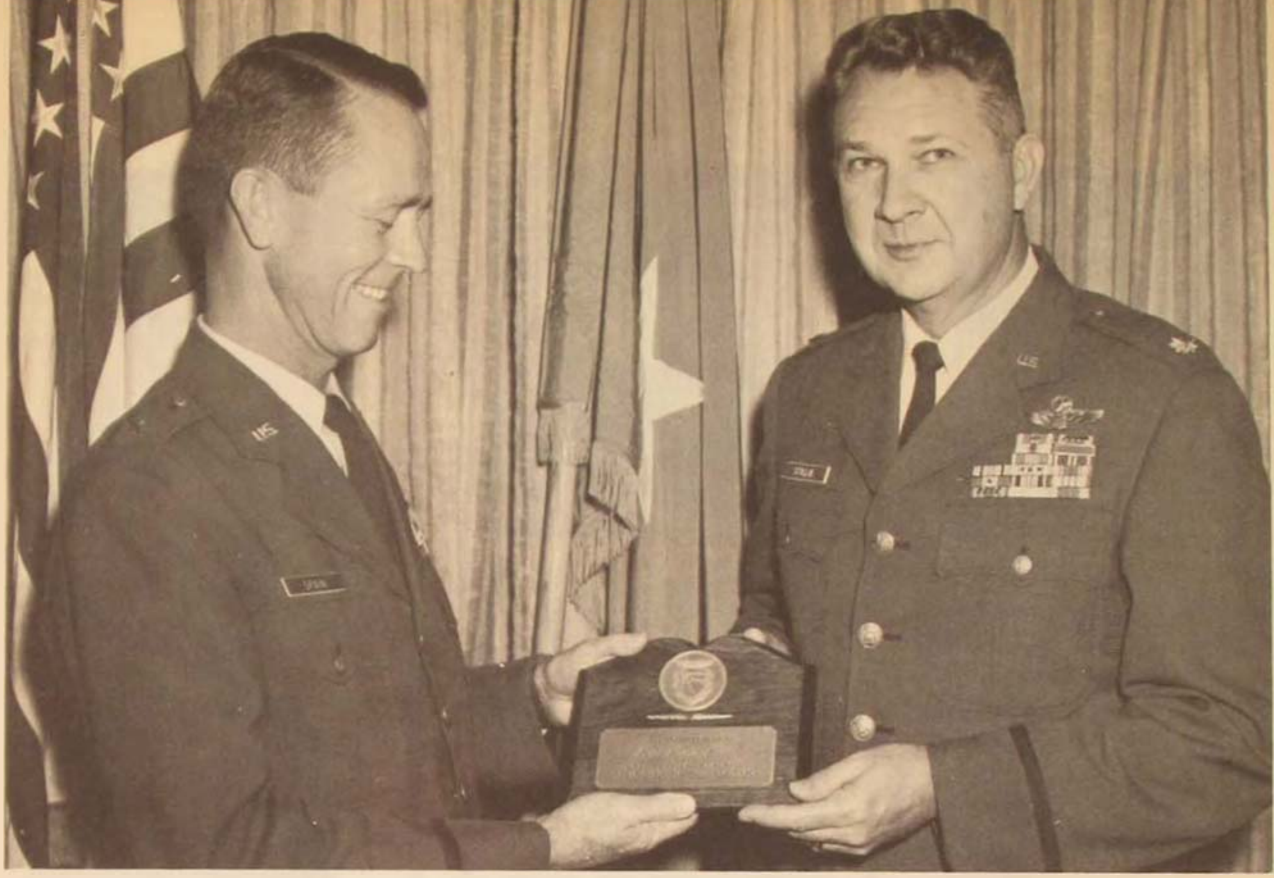
Dr. Robert D. Miewald (Ph.D., University of Colorado) is a member of the Political Science Department, California State College, Long Beach. He served with the First Infantry Division from 1961 through 1963. Dr. Miewald's primary interest is with problems of military management, and his doctoral dissertation (1966) was on the development of managerial doctrine in the United States Army.

Major Graham W. Rider (USMA; M.S., Air Force Institute of Technology) is a doctoral student, College of Business Administration, Arizona State University. After graduation from West Point in 1952, he attended the Airborne Communications Officer Course, Keesler AFB, Mississippi. He has served as Armament and Electronics Maintenance Officer, 64th Fighter Interceptor Squadron, Elmendorf AFB, Alaska; staff officer, Armament and Electronics, Hq 25th Air Division, McChord AFB, Washington; Adviser to the Imperial Iranian Air Force, Teheran; Weapon Systems Officer, Hq Air Defense Command; student, School of Systems and Logistics, AFIT; and faculty member, Graduate Logistics Management Studies Department, AFIT, where he will resume duty upon completion of his present studies.

LIEUTENANT COLONEL KENNITH F. HITE (USMA) is Chief, Attack Branch, Offensive Operations Division, Fourth Allied Tactical Air Force, Germany. After flying training in 1952, he flew 90 F-86 combat missions over North Korea. Other assignments have been as fighter weapons instructor, Nellis AFB, Nevada; instructor in military studies, U.S. Air Force Academy, 1957–60; student, Air Command and Staff College; Plans Officer, Kadena AB, Okinawa; in Operations Plans Division, Hq PACAF, Hawaii, 1963–65; as Chief, 4520th Combat Crew Training Wing Command Post, and F-105 instructor, Nellis AFB; and as squadron commander, 388th Tactical Fighter Wing, Thailand, flying 100 combat missions over North Vietnam.

MAJOR ROBERT H. KELLEY (M.S., George Washington University) is a member of the faculty, Air Command and Staff College, Air University, Maxwell AFB, Alabama. After completing OCS in 1952 and navigator training in 1953, he served as OIC, Navigator Section, 22d Troop Carrier Squadron, Tachikawa AB, Japan, until 1956. After pilot training in 1957, his assignments have been with the 59th Weather Reconnaissance Squadron, Kindley AFB, Bermuda, to 1961; as Flight Examiner, Chief of Standardization, 1371st Photomapping Squadron, Turner AFB, Georgia, to 1965; and as student, ACSC, 1966.

MAJOR LAUN C. SMITH, JR. (M.A., University of Pennsylvania) is Regional Desk Officer for Central America, Public Affairs Office, U.S. Southern Command. He served during World War II as an enlisted man and returned to active duty as an officer in 1952. His principal assignments have been as Information Officer in Morocco, 1954–56, and at Richards-Gebaur AFB, 1956–58; Assistant Professor of History, U.S. Air Force Academy, 1958–62; Deputy Assistant for Policy and Programs, SAF-OII, from 1962 until his present assignment in 1966. He has written extensively on military subjects and has served in several editorial positions, most recently as editor of the *Supplement to the Air Force Policy Letter for Commanders.*



Brigadier General DeWitt S. Spain, DCS/Plans, Hq Tactical Air Command, presents the Best Article Award plaque to Lieutenant Colonel Edward O. Stillie, Chief, Concepts Division, DCS/Plans, Hq TAC, for his article "Tactical Air Employment—Current Status and Future Objectives," in the November-December 1967 issue of Air University Review.

AIR UNIVERSITY REVIEW AWARDS PROGRAM

Lieutenant Colonel Edward O. Stillie, USAF, currently Chief of the Concepts Division, DCS/Plans, Hq Tactical Air Command, has been selected by the Air University Review Awards Committee to receive the award for writing the outstanding article to appear in the *Review* during fiscal year 1968. Colonel Stillie's article, "Tactical Air Employment—Current Status and Future Objectives," was previously chosen the outstanding article in the November-December issue.

The Awards Committee has also announced the selection of "Our Space Venture and Our Role in the World" by Brigadier General Henry C. Huglin, USAF (Retired), as the outstanding article in the May-June 1968 issue of *Air University Review.*

The awards program provides for individual awards to authors writing in each issue, a $50 award for the outstanding article in each issue, and a $200 savings bond for the yearly outstanding article written during off-duty time. Bimonthly and yearly award winners who are military or civil service employees writing on duty time receive a plaque.

The bimonthly winners for the past year are Air Marshal F. R. Sharp, RCAF, "Reorganization of the Canadian Armed Forces," July-August 1967; Colonel John R. Stoner, USAF, "The Closer the Better," September-October 1967; Lieutenant Colonel Edward O. Stillie, USAF, "Tactical Air Employment—Current Status and Future Objectives," November-December 1967; Major Frank H. McArdle, USAF, "The KC-135 in Southeast Asia," January-February 1968; Dr. Paul S. Holbo, "Isolationist Critics of American Foreign Policy—A Historical Perspective," March-April 1968; and Brigadier General Henry C. Huglin, USAF (Retired), "Our Space Venture and Our Role in the World," May-June 1968.

ATTENTION

Air University Review is published to stimulate professional thought concerning aerospace doctrines, strategy, tactics, and related techniques. Its contents reflect the opinions of its authors or the investigations and conclusions of its editors and are not to be construed as carrying any official sanction of the Department of the Air Force or of Air University. Informed contributions are welcomed.

UNITED STATES AIR FORCE

AIR UNIVERSITY

REVIEW