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Organization of the Air Force

A Revolution in Management

JOHN J. MCLAUGHLIN

REVOLUTION usually implies political and social upheaval. In the physical sense of the word, a wheel makes a revolution and returns to a beginning point. It appears that management of the United States Air Force has returned to a strongly centralized control, which existed before it became autonomous nearly fifteen years ago.

During World War II the Army Air Forces had been largely directed by its professional military leadership. In the following decade civilian influences came to dominate the entire military establishment, reaching their apogee during the first Eisenhower Administration.

H. Struve Hensel, who was counsel for the Nelson Rockefeller Committee which authored many of these changes and who became General Counsel for the Defense Department to implement them, described "Changes Inside the Pentagon" in 1954 for the *Harvard Business Review* in these words:

> Operations have been decentralized and delegated downward to the three military departments. Lines of command are being made clearer and simpler. The three military departments and their Secretaries have been raised in prestige, and at last the Secretaries have adequate power to operate and direct their departments. Modern business practices, as distinguished from governmental formalism and bureaucracy, are in the ascendancy.

This civilian-oriented decentralized control was in turn overtaken during the late 1950's by a technological surge forward, principally marked by the ICBM and the sputnik-instigated race into space. To come to terms with these advances, it appears that we have recently entered a new and unusual phase of military management. The burden of power is moving away from middle management in two opposite directions—up and down: on one hand, to the highest civilian levels centered around the Secretary of Defense; on the other hand, to the soldier-scientists in the field. Just one year ago, for example, the Air Force Systems Command was given complete managerial control of new weapons, from initial development to their delivery to operational commands. The new Air Force Logistics Command was given sweeping authority to procure all common-usage items and to provide logistical support for each weapon system throughout its operational life.

Thus in the relationship existing between the Office of the Secretary of Defense (OSD) and the Air Force, we now have a centralized-civilian, decentralized-military management. This organization is not necessarily self-defeating or contradictory. While splitting responsibility may offend some purists, we propose to let those philosophers who worship at the altar of consistency worry about larger meanings or the lack of them. If the history of managing the Air Force embraces any consistent philosophy, it is that Air Force management meets the test of pragmatism. What is practical now guides our conceptual planning, yet we are among the first to recognize that currently accepted ideas may not attain for us the millennium of military management.

WITHIN the Army Air Forces in 1946 everyone wanted a separate Air Force, but there was decidedly less agreement as to just what place should be found for the Air Staff in relation to the top civilian authority. The job of finding the answer Secretary Symington assigned to Eugene M. Zuckert, his Special Assistant. They hoped to avert the jungle of jurisdiction entwining the civilian authority of the Secretary of War and the prerogatives of the uniformed War Department General Staff, while the quasi-autonomous Ordnance, Quartermaster, and Signal Corps and other technical services floated somewhere in between. We were quite aware that many of the problems had arisen in the War Department—just as they would be likely to in any organization—during a century and a half of dedicated national service. In this connection I note that these old-line organizations have been excised in the far-reaching reorganization of the Department of the Army announced last January.

During the coming months *Air University Quarterly Review* proposes to publish a series of articles about Air Force management. The first of the series bears the by-line of John J. McLaughlin, Administrative Assistant to all seven Secretaries of the Air Force who have held office since unification in September 1947.

Mr. McLaughlin's article is intended to provide a general view of top management policy, past and present.

Future articles will deal with specific management objectives and problems. The second of the series, which is in preparation for our next issue, will examine the practice of combat-force management as exercised in the Strategic Air Command.

In the months after the tide of combat had receded and before the War Department management could be refitted for long-haul peacetime duty, the Air Force wanted to structure its own organization to profit from the experience of its parent service. We hired the C. D. Cline Management Associates from Chicago to relate the Air Staff organizationally to an independent Air Force. We also conducted other surveys and studies, more notable among them being the work of Professor Edmund P. Learned of the Harvard Business School.

The Air Force that evolved when the National Security Act of 1947 became effective was built around the four basic concepts of functionality, flexibility, decentralization, and simplicity. Early relations between the Office of the Secretary of the Air Force (OSAF) and the Air Staff were informal. A small, closely knit organization managed the Department of the Air Force with a minimum of paper work. There was a special "in the family" camaraderie between Secretary Symington and General Spaatz, the first Chief of Staff of the United States Air Force, and it was also shared by General Vandenberg, who was chosen to succeed General Spaatz in 1948. Having come through the roles and missions debates pre- and post-unification together, the OSAF and Air Staff were not disposed to fuss over administration. It is a matter of record that Spaatz and Vandenberg were never "directed" to do anything other than what they and the Secretary had already agreed to do.

Intraservice harmony was not always carried over into interservice relations. In mid-1948 the first joint Army–Navy–Air Force budget was being wrung out. It was an era of "balanced forces." Funds were carefully divided on a mathematical basis with little regard to service mission requirements. In retrospect a decade later, Senator Symington was reminded of hungry tigers snarling over a piece of meat tossed into an arena.

In 1948 the Air Force established the program "Management Control Through Cost Control." This heavy emphasis upon dollars versus effectiveness had previously persuaded us to set up a military comptroller in the Air Staff. The Air Force was the first service to do so, an innovation which the first Hoover Commission endorsed in 1949.

In August 1949 the National Security Act of 1947 was amended to provide for a single executive Department of Defense under the direction, authority, and control of the Secretary of Defense. The three military departments lost the status of executive departments, which they had enjoyed under the National Military Establishment created by the Act of 1947. Secretary of Defense Louis A. Johnson named Air Force General Joseph T. McNarney to serve as Chairman of the Defense Management Committee to implement the additional defense savings that were supposed to be inherent in the new law. Eugene Zuckert was named to that committee, together with Gordon Gray for the Army and Dan Kimball for the Navy.

For nearly a year the Defense Management Committee labored to take out the fat and leave the sinew of our national defense. The committee's efforts were overtaken by events: (1) in that same August of

1949 the Soviet Union exploded an atomic device; (2) in June 1950 the United States became involved in a large-scale limited war in Korea.

The Air Force months before had decided against proportionate across-the-board reductions in its strength within the narrow 48-wing structure. We augmented procurement of the B-36 to ensure the delivery capability of the Strategic Air Command, for—as Winston Churchill had said in March 1949—only the atomic bomb in U.S. hands stood off Soviet aggression and the communization of western Europe. In consequence of this essential concentration to strengthen the strategic force, our air defense and tactical air forces remained at skeletal proportions.

When Soviet T-34 tanks driven by North Koreans rumbled south across the 38th parallel, we discovered that our streamlined management had left the Air Force with an "efficient" versus an "effective" organization. Consider the parallel of the factory manager who tried reducing his operating expenses to improve efficiency. Employer of 1000 machinists, he closed down the 500 least efficient machines, thereby achieving maximum possible production with the smallest possible force. Unhappily, total production was insufficient to fulfill his contractual obligations. And so he had attained an "efficient" operation, but not an "effective" one.

Air Force management was shaken when President Truman on 27 June 1950 ordered U.S. air and naval forces to help South Korea repel the invasion. Our carefully nurtured Management-Control-Through-Cost-Control made a 180° turn as the Air Force underwent successive accelerations with little regard to cost. From a starting position of 48 paper wings (actually about 42 wings) and 416,000 men in July 1950, the Air Force expanded to 70, then to 87 wings. It was ordered to beef up to 95 wings and 1,061,000 men by July 1952. In October 1951 the Joint Chiefs of Staff set a goal for further expansion to 143 wings. That was later trimmed to 137 wings.

At this time administration of the USAF on an informal first-name basis began to disappear. To cope with the problems accompanying the explosion in manpower, materiel procurement, and installations, it became necessary to construct new, official channels of command and coordination between the OSAF and the Air Staff to effect orderly consideration of policy. Formalizing the relationship between the Secretary and the Air Staff was dictated by another compelling reason. Congress was strongly moved to give clearer statutory basis to civil-military relationships not only in the Air Force but throughout the Pentagon. The lines had become blurred during a succession of sensational investigations. In the protracted B-36 hearings of 1949 and the MacArthur hearings of 1951, the sight and sound of high-ranking military leaders publicly taking sides on controversial national and military policies had become disquieting.

Shortly thereafter, so that the civil-military relationship could not possibly be misunderstood, Public Law 150 (82nd Congress) provided a new legal basis for the internal organization of the Air Force. The Organization Act of 1951 reaffirmed the authority of the Secretary of the Air Force and fixed beyond doubt the principle of civilian control. The original unification law of 1947 was amended to limit the command power of the Chief of Staff, USAF, by striking out the words "command over the United States Air Force" and substituting the words "command over the air defense command, the strategic air command, the tactical air command, and such other major commands as may be established by the Secretary. . . ."

The new act also fixed the role of the Air Staff as a professional aid to the Secretary, his principal assistants, and the Chief of Staff.

In 1953 the incoming Administration gave further impetus to subordination of the military influence in the Pentagon. President Eisenhower tended to advocate greater civilian control of the Department of Defense. In a letter to Congress in April 1953 he stated: "Basic decisions relating to the military forces must be made by politically accountable civilian officials. Conversely, professional military leaders must not be thrust into the political arena to become the prey of partisan politics."

In June 1953, Reorganization Plan No. 6 created six additional Assistant Secretaries of Defense, making nine in all, and a General Counsel. The intent of this provision, based on the Rockefeller report endorsed by the President, was to clarify the lines of authority within the Department of Defense by strengthening the civilian control. Moreover in October 1953 the Secretary of Defense issued a revision of the 1948 Key West Functions Paper, which designated the Secretaries of the military departments—rather than their individual Chiefs of Staff—as "executive agents" for specified or unified commands. As implemented, Reorganization Plan No. 6 made the service Secretaries "truly responsible administrators."

The professional military influence was further de-emphasized by legislation passed in 1954. Public Law 562 (83rd Congress) added two more assistant secretaries to each military department, making four for all. The Air Force Organization Act of 1951 was amended to require that one of the new assistant secretaries "shall be designated Assistant Secretary of the Air Force for Financial Management and may also act as Comptroller of the Air Force, if so designated by the Secretary of the Air Force." Similar legal provisions were inserted into statutory regulations of the Army and Navy.

Secretary of Defense Charles E. Wilson interpreted the new law to require each service Assistant Secretary for Financial Management to assume the duties of Comptroller or to "delegate that function to an official directly responsible to him." Secretary of the Air Force Order No. 100.1 of 8 February 1955 established an unprecedented command line in the Air Force organization charts to make his Assistant Secretary for Financial Management "responsible for directing and supervising the Comptroller of the Air Force."

Such a departure from chain-of-command procedure was dictated by the importance placed upon civilian-dominated management, which the Administration believed could be effectively attained through control of the budget. In a broader sense than had been attempted six years earlier, management control through dollar apportionment achieved some success in the years 1953–1957.

In his Semiannual Report for FY 1954, the Secretary of the Air Force reported:

> The Air Force continued to stress more effective management of its money, manpower and materiel. Economy and efficiency remained the watchwords in all activities, to the end that the United States would receive the maximum return from its investment. Wherever feasible, tried and proven practices of private industry have been adapted to meet the needs of USAF managers.

In that year also, Mr. Hensel wrote that "the tendency toward centralization in the Department of Defense has been ended. Decentralization is today's reality."

In 1955 national defense expenditures dipped to $35.8 billion, the lowest figure since before the Korean conflict. Principal credit for the economies should properly go to the "vice presidents" of OSD. Uninfluenced by service associations, they swept away many cobwebs of vested interest.

General Edwin W. Rawlings, who served four years as Air Force Comptroller and headed the Air Materiel Command for the next eight years, has referred to the management experts as the "cross pollinators" of ideas. General Rawlings frankly credits the management consultant as the originator of the weapon system concept, which grew out of recommendations that the approach to weapon support be realigned in accordance with the industrial concept of the "product manager." In 1953 the Air Force started to recast its horizontal breakdown by supply classes in favor of a vertical breakdown by weapon systems. By treating a complex weapon system from the beginning as a complete and integrated unit we were frequently spared the need for costly modifications.

MANAGEMENT-control-through-budget-control in the Eisenhower Administration had no sooner built up a full head of steam than, like its predecessor of 1948–49, it began to be overtaken by events. Early in 1954 the Von Neumann "Teapot Committee" had completed a prophetic report. Development of an ICBM that could carry a compact nuclear weapon was now feasible. On 15 August 1954 the Air Force established the Western Development Division and a month later contracted with the Ramo-Wooldridge Corporation to exercise broad technical management authority in expediting Air Force ballistic missile research and development.

Reports of Soviet progress in this field gave sporadic impetus to the national ballistic missile program, culminating in award of the highest Presidential priority in the fall of 1955. Two years later the first sputnik was sent into orbit, and for the next several years U.S. policy-making was flagellated by alarmist reports concerning real or fancied Soviet breakthroughs in missile and space research.

Suddenly the topside civilian-oriented management found itself ill-equipped to cope with technology. As Mr. Hensel had observed: "In order to delegate there must be an effective recipient of such delegation. . . . Vacuums are filled—in nature and in the Pentagon."

In some instances the vacuums were filled with indecision. The enlargement of the immediate staffs of the Secretaries of Defense, Army, Navy, and Air Force to 25, each with additional deputies and special assistants, was not speeding up all essential business of the Department of Defense. In important areas of technical decision, the whole of authority rested with one group of men, but the bulk of knowledge and experience resided in another. In the Air Force this knowledge and experience resided mainly in the Air Staff or in the field.

To meet the ballistic missile crisis in 1954, it was not possible to recast immediately the Air Force management structure. On an ad hoc basis the Western Development Division under command of Brigadier General Bernard A. Schriever was given important authority over many functions performed by the Air Materiel Command and the Air Research and Development Command. The procedures of "concurrency" began to overtake those of economy, although for a while they continued alongside one another in not-so-peaceful coexistence. To be sure, AMC people continued to perform the functions of contracting and contract administration, but they did so under the management direction of Air Research and Development Command. As time went on, the functional relationships between AMC and ARDC became clouded.

By 1958, in the post-sputnik era, management difficulties began to center on the missile and space development program. At the top governmental levels, Dr. James R. Killian and Roy Johnson were brought in to give unity to the accelerated effort in basic and applied research. At the service level, project direction began to be decentralized. "Systems analysis" became the order of the day in the management of many technical military programs.

This new management technique by systems occasioned no shock in the Air Force, which by establishing RAND in 1946 had expressed an interest in it. In May 1949 the Air Force and industry began to develop a fighter-interceptor, the F-102, built around a desired fire-control system. Weapon complexity, we realized, would not much longer permit the separate development of components that required microscopic tolerances to be assembled and enclosed in the structural shell of a missile or supersonic aircraft.

But while the Air Force made substantial progress in "systems acquisition," the U.S. Navy in January 1957 focused its management talents to an extraordinary degree on one special problem. Complete authority was given to Vice Admiral William F. Raborn as Director, Special Projects Office, and he brought the Polaris missile to operational status in record time.

Systems acquisition in the Air Force achieved good to excellent success, especially in the ballistic missile programs. If it was less spectacular than the Navy's, there were obvious reasons. First, we were spreading not-overabundant technical talent rather thinly. Second, we never gave our program directors carte blanche but tried to reconcile their authority with the divided control existing between ARDC and AMC. And third, there was reluctance at the highest national policy levels to admit publicly that we were in a race into space—hence the understandable indecision in the Pentagon as to how much emphasis should be placed upon the military development program.

Had the policy direction been clear, there was still the problem of authority resting with one group of men and the bulk of knowledge and experience residing in another.

In June 1958 an Ad Hoc Committee on Research and Development headed by Dr. H. Guyford Stever, former Chief Scientist, USAF, was reporting to General Thomas D. White, Chief of Staff, on R&D weaknesses in these words:

> The typical Air Force R&D project officer, who has the responsibility for bringing a technical development or weapon system into being, has above him too many officials who have or assume authority for controlling critical portions of his resources and for approving in detail his project decisions. . . .
>
> The trend of the past few years must be reversed. Authority and responsibility must be delegated together. The authority must include control of all resources required to get a job done, and the opportunity to stand or fall on the basis of competence to make sound decisions. Higher headquarters must limit the direction which they give the operating echelons to general policy and fiscal guidance. The operating levels must be freed from the present unending demands for information on all minutiae of all phases of their activity.

The Stever Committee was "convinced" that a principal reason for our long weapon development cycle as compared to the Soviet Union's was "the failure of each echelon and organization to trust lower echelons . . . and to discipline itself to do its own job well and not to meddle with others." It called the maze of communication channels, the excess of paper work, the continual reviews and justifications, and the diffusion of decision-making responsibility and authority "the most formidable single barrier to the success of the Air Force R&D program." As a case in point, the ARDC had reported in 1958 that weapon system cycles from concept to operation took ten years, that the cycle for large capital facilities ran from four to fourteen years.

The Stever Committee in effect was attacking a basic DOD management concept reflected in Mr. Hensel's argument that there was a "need for generalists" in the Department of Defense who could blend into a single decision the knowledge and experience accumulated by "specialists." By 1958, however, technological breakthroughs had enforced a different approach. The Reorganization Act of 1958 took account of the diffusion of R&D authority and responsibility. In establishing the high post of Director of Defense Research & Engineering, the legislation recognized the greater need for a scientific expert with a knowledge of management than for a management expert with a knowledge of science. To reinforce this trend, in 1961 Secretary of Defense McNamara gave Research &

Engineering a second statutory position by designating the Deputy Director of Defense Research & Engineering as an Assistant Secretary of Defense. To comply with a Presidential directive, another Assistant Secretary's post was reassigned to handle civil defense, which had previously been a responsibility of the Office of Civil and Defense Mobilization in the Executive Office of the President.

Over all, by February 1959, when the Reorganization Act became effective, the civilian "vice presidents" had been cut down in number, OSD losing two, each service one. Furthermore an Assistant Secretary of Defense was enjoined from issuing orders to a military department unless the Defense Secretary specifically delegated such authority to him. Also the service Secretaries were removed from the chain of operational command previously exercised through them in their capacities as "executive agents."

Under the new law, considerable power and prestige were restored to the Joint Chiefs of Staff. The Chairman was given increased status, and the Joint Staff was enlarged from 210 to 400 officers. By administrative delegation of the Secretary of Defense the JCS was assigned operational direction over the unified and specified commands. Over all, it meant that the pendulum of power had swung back to a more central point after a decade of diminution of the professional military man in Government councils.

To THOSE concerned that increased authority granted to the Joint Chiefs of Staff would give rise to a "Prussian general staff," it should be pointed out that the new law gave the *civilian* Secretary of Defense greater authority over service roles, missions, and budgets and also spelled out his authority to engage directly in military research and development.

To implement the Reorganization Act of 1958, the Air Force Chief of Staff established in May 1959 the Anderson Board, which included the Deputy Chiefs of Staff, the Commanders of ARDC and AMC, and the Vice Commanders of the Strategic Air Command and the Tactical Air Command. Out of their deliberations emerged refined and detailed regulations for conducting systems management, which were embodied in the Air Force Regulation 375 series.

By early 1961 it was clear that in-house regulations could not alone cope with problems of changed functional relationships. In April the Air Force Systems Command and the Air Force Logistics Command were established, and a Deputy Commander of AFSC for Research was designated, who would be located near Washington and have responsibility for the entire exploratory research program of the Air Force. Concurrently the Office of Aerospace Research was activated in Washington, with direct access to the Chief of Staff, USAF.

At the Defense Department level other significant changes are taking place. The history of functional force groupings goes back to the first

Hoover Commission in 1949, but for our purposes the words of Dr. James R. Killian in 1956—he was then President of Massachusetts Institute of Technology—capsulize a radically new military concept inadequately reflected in the DOD organization at that time. Dr. Killian testified during the Symington "Airpower" hearings:

> The military task no longer divides up neatly into three mission areas, defined by the vehicle the fighting man rides in. . . .There are no longer any natural boundaries which cannot be penetrated by comprehensive offense, and our defense against this . . . threat does not separate naturally into three parts but requires new, functional-type military organizations to do the job.

Subsequently Colonel Albert P. Sights, Jr., USAF, and Henry A. Kissinger, among others, wrote in some detail about functional forces, and the idea found acceptance in recommendations to President-elect Kennedy in December 1960 by a committee headed by Senator Symington.

Shortly after the new Administration took office, Secretary McNamara initiated 130 penetrating studies of defense activities. He also introduced the new concept of "program packaging" in defense planning. Out of these studies have emerged further changes in the management of national defense. In addition to the Defense Communications Agency established by Secretary of Defense Gates in 1960, a Defense Supply Agency and a Defense Intelligence Agency have been established. The U.S. Strike Command has been created, combining much of the Army and Air Force tactical capabilities.

Beginning in FY 1963 the Department of Defense appropriation (over $50 billion has been requested of Congress) will be divided among nine program packages: Central War Offensive Forces, Central War Defensive Forces, Reserve and National Guard Forces, General Purpose Forces, Sealift and Airlift, Research and Development, Service-wide Support, Classified Projects, and Office of the Secretary of Defense. Significantly, each fiscal package will contain all military programs contributing to the same function, regardless of which service "owns" the function.

The Air Force has already begun to translate the inherent philosophy of President Kennedy's plan into OSAF–Air Staff organization. The Chief of Staff is directly responsible to the Secretary of the Air Force for the effectiveness of the Air Force and its preparedness for military operations. The Secretary's role is being shaped around the establishment of policy and the review of performance. As Leonard D. White suggested in his *Introduction to the Study of Public Administration,* the service Secretary intangibly personifies the ultimate supremacy of civil leadership over the military establishment. In the Air Force as in the other services, he is the "outpost of the Chief Executive and a representative of the political party whose policies he is to pursue."

It is significant that the Reorganization Act of 1958 charged the Secretary with responsibility for conducting the affairs of the Air Force. The role of the Air Staff in support of the Secretary is reflected in this quotation from Section 8032 (b) (1) of Title 10, U.S. Code, which was amended to read: "[The Air Staff will] (1) prepare for such employment of the Air Force, and for such recruiting, organizing, supplying, equipping, training, serving, mobilizing, and demobilizing of the Air Force, as will assist in the execution of any power, duty, or function of the Secretary or the Chief of Staff."

This section provides the basis for the Air Staff to serve both the Secretary and the Chief of Staff. The Secretary's role includes management of all Air Force missions plus the responsibility of acquiring weapon systems. It has thus become necessary for him to evaluate Air Force systems acquisition proposals consistent with program packaging evolved at the Secretary of Defense level.

To this end, last July the Air Force established the Designated Systems Management Group and the Systems Review Board. The DSMG has a membership of 15, including the highest statutory civilian and military officials. It replaces the Air Force Ballistic Missiles and Space Committee. DSMG provides a formal method of applying the collective judgment of senior Air Force officials to assist the Secretary in discharging his R&D and production responsibilities.

At the present time 12 systems are under the DSMG concept—"red-line procedures" in the Air Staff. To each is assigned a Systems Staff Officer (SYSTO). He serves as the "Washington representative" for the System Program Director in the field, who actually manages the program. Timely and reliable cost and package program data are being produced by this new system.

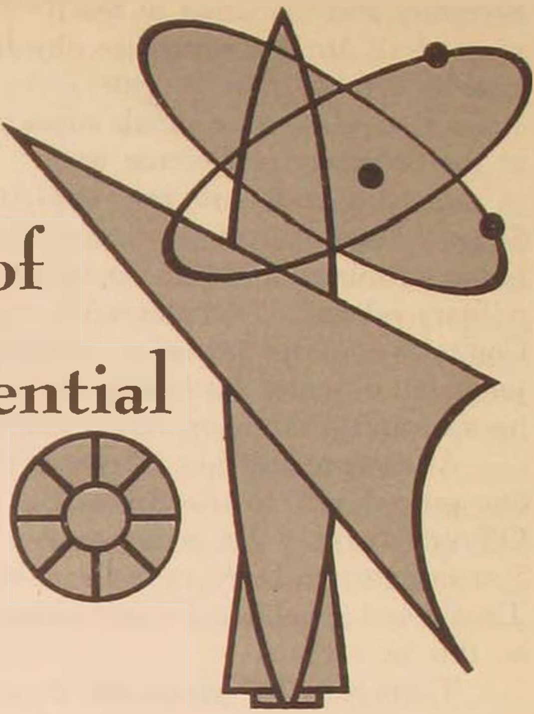
There may be complaints about DSMG, but they are not substantive in terms of any failure, because it is working. As we look back, military history demonstrates that "normal staff action" generally got sidetracked for the really big projects. This happened during the war when the Manhattan Engineering District was given a job and $2 billion to bring in the atomic bomb. It happened in 1954 when the Western Development Division was set apart from ARDC–AMC channels to produce an ICBM, and in December 1956 when the Navy Special Projects Office assigned top priority to a ballistic missile that could be fired from a nuclear submarine. The Air Force, in fact, is itself an historic example of "abnormal" organization that was created to capitalize on a decisive new idea.

We are not among those who regard consistency or procedure as virtues apart from results. One may recall the classic example of the Army Commissary General who in 1898 bitterly complained when the Spanish-American War came along and disrupted his splendid organization. He had simply lost sight of the purpose of his organization, which was to prepare to meet the ultimate test of war.

As MANAGERS in the Air Force, we must keep continuously in focus that we work with imprecise safeguards against foolhardiness or carelessness. In contrast to private industry, we have not the finite measuring stick of profit nor the last resort of bankruptcy as a way out. We have no alternative to success.

Office of the Secretary of the Air Force

The Safety of the Combat Potential



Major General Perry B. Griffith

IT IS not oversimplification to say that our aerospace power—indeed all military power—consists primarily of two elements: trained human beings and adequate equipment. Neither of these elements represents power without the other. But until the recent past, if this nation or its allies had one of the elements of power, we also had the time and the resources to muster the other element.

The professional military man today is well aware that the situation no longer prevails wherein one element of power can mark time until the other is acquired. The human beings and equipment we have today—the first highly trained and the other exceedingly costly and complex—represent our total aerospace power. Although we have resources of civilian manpower, as did the British after Dunkirk, a man cannot be trained quickly to fight a modern technological war, and we will not have time to train him anyway, should such a war come. Neither will we have the time or the economic resources to increase the store of aircraft and missiles now comprising our equipment. For this reason a program of conservation of men and equipment has become increasingly important.

The program of the Deputy Inspector General for Safety represents the Air Force effort to conserve the force now in being and its combat capability through the prevention of peacetime accidents that would kill or injure our trained men, destroy our complex equipment, and raise the defense budget.

If a safety program is necessary for the preservation of our capability to wage a modern nuclear technological war, it is equally necessary for the preservation of our capabilities for conventional war—the kind we have fought in the past. Although much of our hardware for conventional warfare is aging, our efforts to prevent its destruction through accidents must be just as vigorous as our efforts in the missile and nuclear fields.

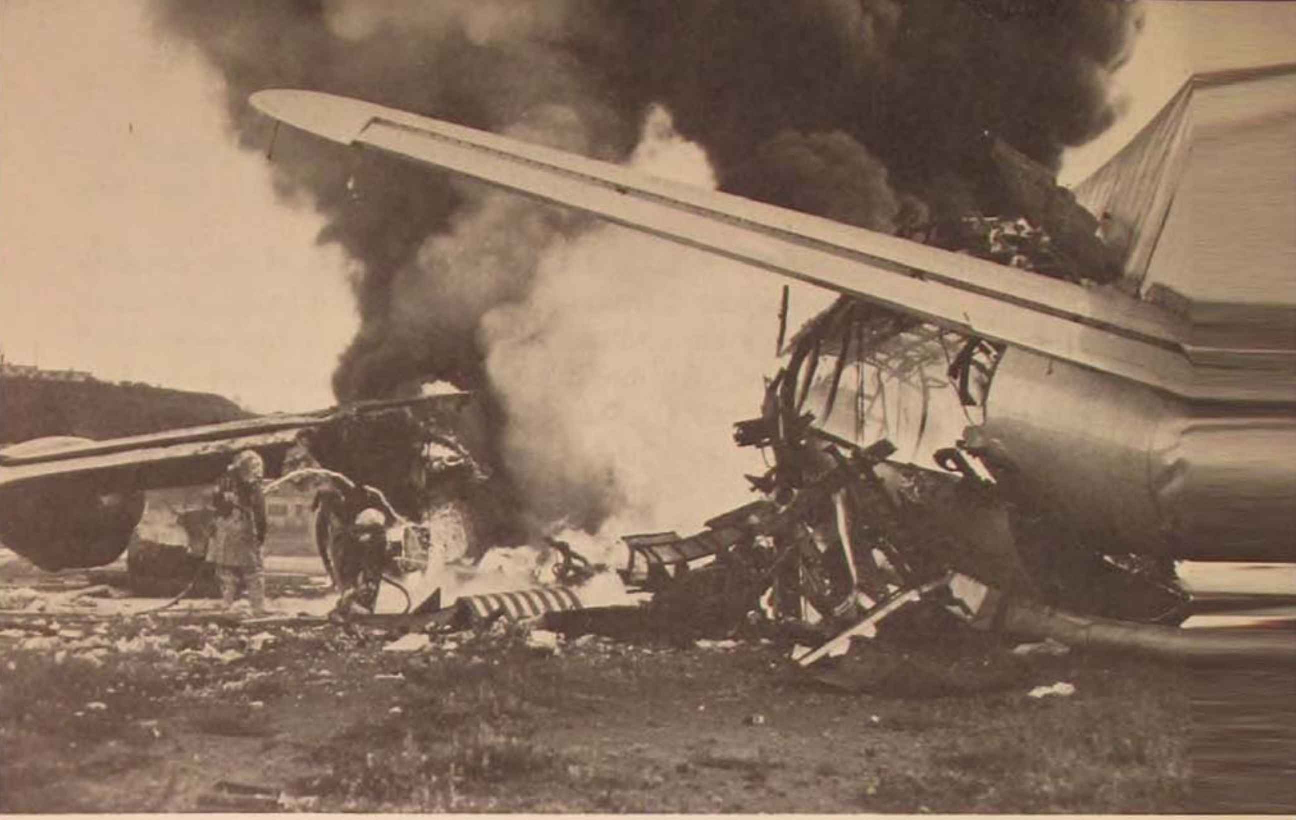
The United States Air Force safety program we know today began in 1940 with flying safety, and the ground safety effort came along two years later. For 20 years, from 1940 through 1960, we enjoyed a steadily declining aircraft accident rate, but in 1961 our rate crept upward slightly. So far in 1962 we are holding our own with 1960. The incidence of ground accidents has also been steadily lower over the same two decades, yet, being ground-environment animals, we continue to lose more men in automobile accidents than in aircraft accidents. Our relatively brief experience in the missile and nuclear fields has been excellent in regard to accidents, but the accident *potential* is nevertheless enormous, and fallible man is again the big factor.

The arbitrary division of the safety program into the four separate areas of flying, missile, ground, and nuclear safety is a management expedient, an organization of approach for convenience of operation. In truth it is impossible to delineate a precise division of accident-prevention responsibilities. The common root of almost all accidents is human error—by the operator, the maintenance technician, the manufacturer, the designer. Somewhere along the line someone did not do his job right, and the flaw was not caught.

I would like to explore each of the four safety areas with a view to seeing where we stand right now and what we hope to accomplish—indeed what we *must* accomplish—in the next decade.

flying safety

The evolution of flight safety by functional area stems from the changing nature of warfare, weapons, hardware, and force structure and the huge expansion of the civilian air fleet. The Air Force early recognized the need for safety measures to cope with the development of the flying machine. Beginning with "hangar flying," the information gained by experience began to be woven into a pattern of knowledge useful in the design, development, and building of safety features and procedures into aircraft. As the number of experiences grew, a philosophy of flying safety gradually evolved, directed at the prevention of accidents by drawing upon experience factors and aircraft accident investigation statistics. One axiom became apparent. Behind each potential accident is a cause or series of events that can be identified and eliminated. The



During 20 years after 1940 the USAF aircraft accident rate declined steadily. In 1961 the curve turned up again.

purpose of the flight safety program is to identify and predict these cause factors so that positive action can be taken to eliminate them.

In total concept flight safety is a factor from aircraft design to obsolescence. Its presence is seen in fabrication, operation, maintenance, logistics, and all the other defined functional fields within the Air Force. It extends from preliminary design, where errors on the drawing board can later cause costly modifications and down time on operational aircraft. These errors are inexcusable, but they occur.

As air power evolves into aerospace power, with accompanying increase in complexity of weapon systems, the potential severity of an accident reaches rather large proportions. Though rates of accidents have been reduced throughout the years, there is still room for substantial improvement. In the past decade the loss in aircraft hardware has exceeded $3.5 billion. This figure is more than the total cost of the entire B-58 program and equals the cost of several thousand missiles. But what did a C-47 cost? And what does a B-58 cost? This, of course, is 1962, not 1942 or 1952.

Since flying involves men and machines, it is only natural to expect that the prime reasons accidents occur are personnel error and materiel failure. The yearly statistics are fairly constant. Personnel error accounts for about half the accidents, and some type of materiel deficiency causes the remainder. The important fact is that the total number of accidents simply should be reduced.

Now this is really important, and industry can learn from it too.

Personnel errors can be categorized into crew-member error, maintenance error, and supervisory error. Statistical history reveals that crew-member error is responsible in about 39 per cent of all accidents, while maintenance and supervision are charged with a much smaller percentage. Although stupid and foolish errors on the part of crew members do cause accidents, the percentages reflect also the fact that crew-member error is more readily recognized and more easily assigned than is supervisory or maintenance error.

Personnel error is one area of accident prevention where the tactical commander can and must assert himself. Supervision is the tool he can employ best to combat personnel error. It is a proven principle that aggressive leadership and command interest and action produce lower accident rates. Each year the number of supervision-factor accidents is increasing. This does not mean that the quality of supervision is any less effective today than it was a few years ago. Actually the reverse is true. Instead it means that we have learned to recognize poor supervision as an accident-cause factor more readily than we used to. One aid has been our insistence on the reporting of all unusual factors in our four fields.

It is frequently difficult to adjudge supervision as the true cause factor in a particular accident; yet the actions that could have prevented the accident most often are in the area of policy and current procedure, where smart supervision should have deterred it. Attempting to complete a peacetime mission after an in-flight emergency occurs is hollow heroics if an accident results and all is lost. Supervisory inculcation of proper policy and procedure in such a situation is the answer.

Materiel failure is a fruitful area for future work in accident prevention. As equipment becomes more sophisticated and speeds increase, accidents produce more smashing and serious results. In 1957, 55 per cent of all major aircraft accidents resulted in destroyed aircraft, and 54 per cent caused fatalities. By contrast in 1961, 74 per cent resulted in destroyed aircraft, and 69 per cent involved fatalities. This trend can be expected to continue as man's quest for higher speeds and altitudes dictates ever more exacting pressures on material and design.

Basically, materiel failures are traceable to human failures. Most causes of materiel failure can be traced to human oversight or, in retrospect, lack of foresight. Some materiel deficiencies may not be the result of direct human error. In these cases warnings of an impending accident are generally evident if only the human recognizes the signs. To identify these warnings is the purpose of operational hazard reports and incident reports. If properly evaluated, these reports signal an impending accident. But safety reports are not the only source of warning signs. Materiel-failure data, if viewed from a safety standpoint, will serve the same purpose; and here the agencies charged with support and design functions can be most effective. Much effort needs to be applied to engineering known trouble areas out of new design. It is surprising and distressing how often old, known problems reappear year after year.

A Gallery of Aircraft Accidents

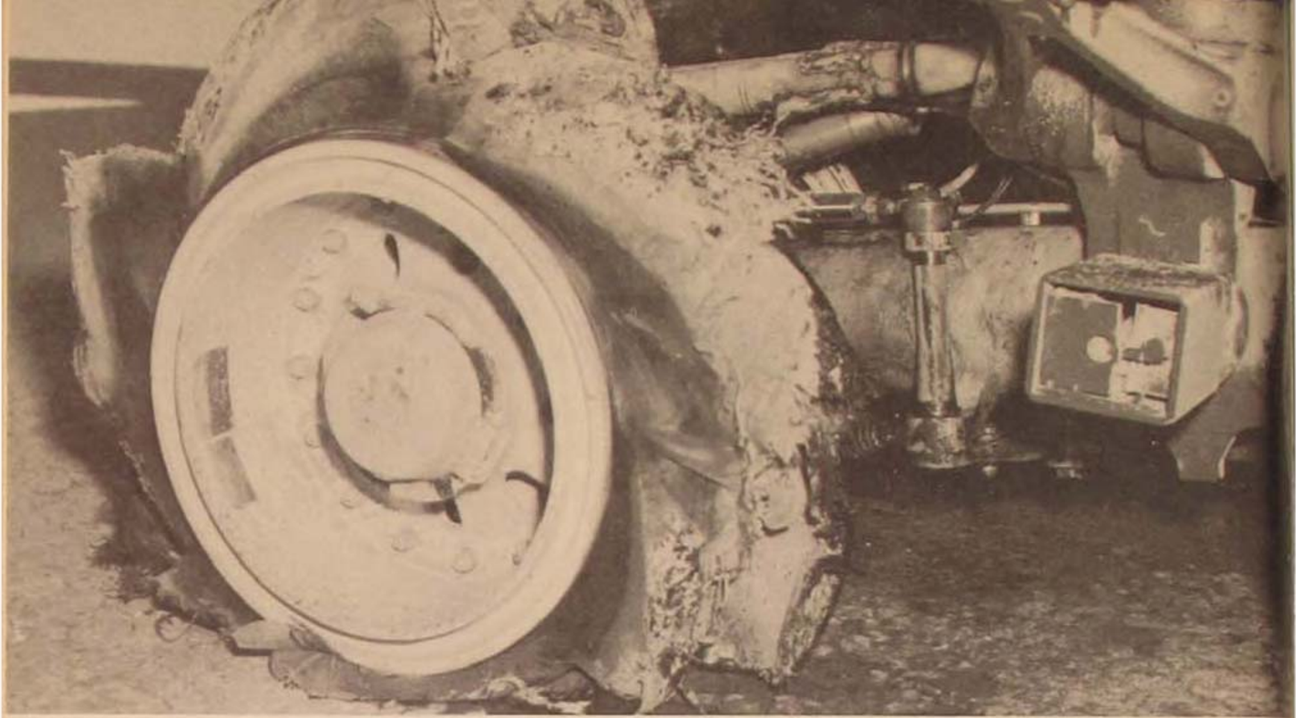
Although this pilot and crew ran out of what little runway was left after a long touchdown, they did not run out of luck. They survived the crash. Note the deep drainage ditch and eight-foot fence—two obstructions to a safe landing roll at this civilian airport. As a result of flight safety surveys, hundreds of similar hazardous conditions have been corrected at Air Force bases. But each year accidents due to landing long or to the opposite in undershooting take their toll in aircraft and lives.

Of the 32 major F-100 accidents in 1961, forty-five per cent were caused by materiel failure. The landing-gear system was charged with six major accidents. These six accidents included one main wheel axle failure and five main gear trunnion failures.

Although the F-102 accident rate in 1961 was a respectably low 19.2 major accidents per 100,000 flying hours, the money lost would buy 28 more F-102's. High sink rates, metal fatigue, and design criteria all contributed to the nearly 100 accidents that involved landing gear, the big problem. Modification to beef up the trunnion lug area and side-brace boss area was prescribed.

Primary cause for this damaged F-104B was failure of the crew chief to connect the hydraulic quick-disconnect properly in the No. 1 system pressure line and the No. 2 system return line. After severe flight control difficulties, the pilot elected to try to land rather than to eject. Loss of control just over the runway prevented him from rounding out, and the plane hit nose wheel first and porpoised. In succeeding leaps all three landing gear collapsed. Such accidents led to the destruction of 16 F-104's in 1961.

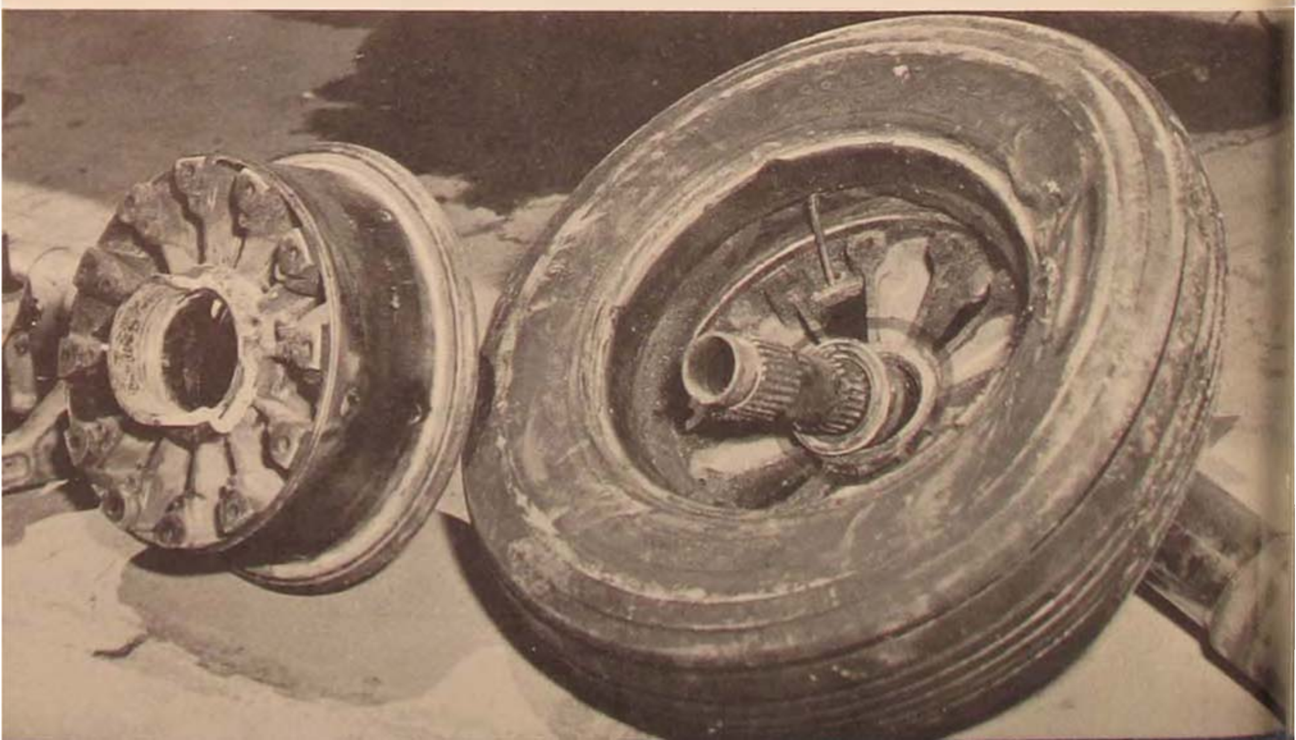
In 1961, eight F-106's flamed out after loss of alternating current power. Three of these incidents resulted in major accidents with two fatalities. When loss of AC power and boost pumps occurs with less than full number three tanks, the dual "T" check valve bellmouths can become uncovered. Air is then ingested into the tank-to-engine fuel lines and engine flameout results.



Tires and Wheels

Demands upon wheel and tire have increased with heavier aircraft and faster take-off and landing speeds, but no marked improvement in tire design has appeared. A point system provides one of the "crutches" used in coping with the problem. Each tire is charged a certain number of points for each take-off, in accord with the gross weight of the aircraft. The tire is removed upon accumulation of a predetermined total.

Wheel-bearing failure, F-100 aircraft. Heat is a major foe of tires and wheels. If a 100,000-pound aircraft lands at 100 knots for a maximum deceleration stop, the brakes convert enough energy into heat in 17 seconds to raise the temperature of 47 gallons of water from 60° to the boiling point. Although brakes are designed to dissipate much of the friction-generated heat, wheels and tires must withstand great temperatures from braking and tire revolution. While larger wheels support larger friction brakes and carry larger tires, the penalty in aircraft weight would be unacceptable in performance.



Materiel-failure data are collected by the bucketful to arrive at logistic support levels, and yet buried in these data somewhere may be a warning of an accident, unnoticed because of a mound of paper work which we have to shovel and which we cannot shovel fast enough.

After all this information is correlated, aggressive and extensive actions are necessary to translate information into accident prevention. All—and I repeat all—accidents except acts of God can be prevented by the application of proper controls. We exercise stringent controls on nuclear devices, where safety is the prime consideration. The cost alone of future aircraft accidents may require that similar restrictive controls be placed on flying operations. To go back again to 1957, the cost to the Air Force averaged $395,000 per major accident; but in 1961 this figure increased to $1 million per accident. This rapid rise in accident cost can only increase with future aircraft. The work we do today in evaluating operational and training procedures for obsolescence or real necessity will reap dividends in future accident-prevention programs.

Over the years accident data have indicated that certain aircraft design features provide greater safety than others. But we have not yet reached the point in aviation where safety is the overriding consideration in building aircraft. Many times the "most safe" features are traded off in some degree to meet "performance or mission" criteria. Experience has shown that single-engine aircraft suffer more than half of all Air Force accidents; yet when we consider accident exposure, we note that these aircraft fly less than one fourth the total USAF flying time. Obviously one design consideration to reduce drastically the frequency of accidents would give all aircraft more than one engine. Similarly, one design feature to effect a reduction in crew-caused mishaps would be provision for two pilots, placed side by side. Such features of design would exemplify two basic concepts in applied accident prevention, i.e., reliability through redundancy and a system of personnel checks and balances.

In the pure mechanics of aircraft systems we learn slowly. Over the years aircraft have continually experienced inadvertent release of armaments or externally carried fuel tanks. In the cockpit we design circuit interruptions to force the pilot to take several independent actions before his stores can be fired. However, we route the armament circuits through one terminal board, where one small drill shaving or other foreign object can cause a short circuit and unexpectedly fire the ordnance. The practice of routing sensitive circuits through cable bundles and terminal boards common to normally energized circuits negates the armament safety devices engineered into the cockpit.

The use of dissimilar metals in connecting electrical circuits has caused overheated wires and resulted in in-flight fires. It is not uncommon still to find copper terminals connected to aluminum cables, ridiculous as it sounds and to the disgrace of some manufacturers and inspectors.

Power loss is a major cause of take-off accidents, and the requirement to reduce gross weight rapidly if power loss is experienced has been recognized for a long time. Some aircraft equipped with external tanks have the ability to jettison those tanks; but a capability for rapid fuel dumping is needed in all aircraft.

Some design safety problems are less obvious, even though long accident histories have been recorded. Failures of tires, wheels, brakes, and landing-gear systems make up a large portion of the accident and incident files. Many of these failures are a direct result of the growth of the aircraft after original design. In our efforts to increase the mission effectiveness of on-hand equipment, it is inevitable that additional fuel and armaments will increase gross weights beyond the original specifications. This has been so because of airframe space limitations. Recognition of aircraft growth should be a design consideration, and definitely space allowance for tire and wheel growth should be provided for on the drawing board.

Increased weights and take-off speeds of future aircraft will bring wheel and tire problems to a critical stage. We are already approaching limitations in the state of the art of tire reliability. Nonfrangible wheel materials and fuzible wheel plugs to relieve heat-generated tire pressure are coming into use, but these devices are only a crutch for the basic problem. Considerable research must be expended toward new concepts of landing-gear systems to avoid tomorrow's aircraft shooting themselves down by shrapnel effects of explosive wheel disintegration.

These are only a few of the design considerations apparent through accident-prevention activities. There are more, of course. Some are old, some new, but each one will become increasingly important when any small failure could cause catastrophic results in tomorrow's space machines.

Let us try to foresee problem areas in the near-term future—the next 10 to 15 years. In these years the prime flight safety problems will be reliability of aircraft and crowding of the airspace. The Air Force will be operating substantially the same equipment we are using today, with only a few new models. This means the problems of safety will be centered around aging equipment and how to keep it from failing or falling apart with its also aging pilots. (My wife says, "How true.")

Materiel-failure data will play an even more important role in this time period. We can anticipate a slight change in the cause factor ratio in the direction of (1) fewer personnel-error accidents and (2) a higher percentage of materiel-failure accidents. Experience has shown that as soon as an aircraft approaches the state of obsolescence, its problems are de-emphasized in preference to those of new models. However these poor old birds still cause the majority of the accidents that kill our people.

Let us move to the other big problem for safety planners to consider in the near future: the saturation of the airspace, especially around terminal centers. It is estimated that by 1975 military flying will be reduced by approximately 36 per cent from present levels but that civilian aviation, particularly air-carrier flying, will be increased by 80 per cent. By this time almost all our fast flying will be competing for the same airspace at jet altitudes. Studies of traffic control conclude that positive flight-following, through positioning from the ground, is necessary to effect positive aircraft separation. But the development and provision of equipment to do this job satisfactorily will take time. In the meantime restrictive flying controls or arbitrary divisions of airspace may be necessary to prevent mid-air collisions.

The manned space systems of the future will grow out of Dyna-Soar and similar programs just as naturally as our present aircraft grew from the Wright brothers' bicycle shop. Even in that age the basic problems of flight safety will not change, but it is likely that the application may change. Manned space vehicle accidents can be expected to be more critical than aircraft accidents, just as we have seen the destroyed-aircraft rate increase with speeds and performance of our present-day aircraft. Therefore safety will brook no compromise with performance or mission requirements on the design boards. In design considerations the emphasis in this time period will shift to safety first and performance second.

As we come into the truly aerospace age, with a vehicle capable of operating in space as well as in the atmosphere, the aircrew member will become a monitor, actually, of the progress of his craft, much in the manner of a ship's captain supervising the safe progress of a vessel from one port to another. Electronic machines will do the physical work while the crew member provides the decisions and, I assume, throws down banana pellets or gets shocked. Material and design reliability will play the predominant role in flight safety; and, yet, my 16-year-old prep-school son wants to go into the Air Force providing he can do as well in calculus as at baseball.

missile and space vehicle safety

Our future flight safety programs must be oriented to meet this challenge to a much higher degree than they are today. Experience demonstrates that safety must be a fundamental consideration in the design, development, production, maintenance, and operation of missile and space vehicle systems as well as aircraft. The concurrency concept which had its inception with the advent of ballistic missiles has in this respect been a mixed blessing. It did give us operational missiles at an earlier date, but it brought problems which contributed directly and indirectly to accident potential. In this sense concurrency reacted on itself in that the very process designed to attain early initial operational capability actually delayed finished combat-readiness because of requirements for redesign, retrofit, and extensive modification.

Unfortunately during the earlier stages of missile development the importance of sound safety engineering was overlooked. Some attention was given to systems safety requirements but not by a systematic and concerted effort on the part of safety specialists who could identify hazard potential in hardware and procedures. It is now recognized that safety considerations must be incorporated into the original design and development of the weapon system.

The best means of accomplishing the integration of safety is to utilize fully the services of the weapon system developer on a contractual basis, supported by definitive work statements. These work statements should require the weapon system developer to identify risk factors and probabilities of hazardous occurrences and to establish quantity–distance criteria and safety standards on the basis of tests designed to determine the hazards generated by fire, blast, fragmentation, toxicity, and radiation of propellants, both solid and liquid. Other safety considerations are the limitations of the human element and hardware in the operating environment, the establishment of comprehensive emergency procedures, and the development of detailed safety check lists for use in the development, test, and operational phases.

This realistic approach to safety was taken in the case of the Minuteman weapon system. A weapon system safety group was formed by our system project office. This group acts as a focal point for all safety matters during the development and testing program and provides the technical assistance for eliminating accident potential on a continuing basis. A detailed, system-wide safety plan is progressing in parallel with the development of the system itself. Specific safety milestones have been established which will provide detailed check lists and plans for the installation and checkout phase and category II test phase at each site. Considerable progress has been made, and we must profit from our mistakes and recognize that accidents can be attributed to the interaction of hardware and the human element.

Missile propellants, liquid or solid, are capable of releasing great quantities of energy. The energy release of liquid biopropellant explosion depends upon the manner and amount of oxidizer and fuel mixing. Hypergolic propellant systems present little chance of explosion, but the propellants burn violently and result in high-order deflagration. Liquid monopropellants when mixed can detonate much like TNT. Solid propellants of high specific impulse are extremely dangerous. In a sense, these superthrust propellant compositions can be considered as new primary explosives.

All these propellant combinations are potentially explosive, with resulting overpressures great enough for severe structural damage to launch facilities. A counterpart of explosion is the fragmentation pattern, which will vary according to whether the burst occurs above or below ground. Prior to the Titan in-silo explosion at Vandenberg, it was erroneously assumed that an explosion in a silo would result in a smaller fragmentation pattern than would result from one occurring above ground. Actually the opposite was true, and distance criteria had to be completely revised.

The importance of achieving a proper balance between safety and reliability so as not to compromise operational capability cannot be overemphasized. Reliability, like safety, must be designed into a weapon system at the outset. Reliability statements should be written into contractor and associate contractor agreements and a specific value assigned. In terms of mean time to failure this means that a component must perform without a failure a specified function under given conditions for a specified period of time.

A reliability program initiated at the outset of design pays fantastic dividends. It minimizes expensive redesign and rework. It results in product improvement, especially in operational ground equipment reliability. A good program results in tighter controls and serves to educate personnel in prevention of failures rather than in correcting them. It can be said that reliability is the end product of strict quality control, validated and timely technical data, sound engineering practices, timely availability of trained personnel, and adequate funding throughout the lifetime of the system. Design errors and oversight will thus be minimized, and through an organized plan for finding, fixing, and feeding back deficiencies a safe and reliable weapon system will evolve.

A further word should be said about lack of or inadequate technical data, since this has been one of our most troublesome problem areas and has been a major cause factor in missile mishaps. A concerted effort has been made to improve the accuracy and adequacy of technical data content. The validation and verification of tech data are now the subject of a team effort on the part of the Air Force Logistics Command, the contractor, the using command, and the Air Force Systems Command. This work is now being accomplished during installation and checkout, before a missile site is turned over to and accepted by the using command. This is a major step forward in correcting a deficiency that was compounding procedural errors.

When one speaks of weapon system reliability, it is all too easy to consider the hardware aspects while neglecting the human component. Yet we find that it is this human component which in most instances causes the accidents. It would be desirable to reduce human reliability to a mathematical equation so that the total weapon system reliability could be considered as the product of the machine's reliability and human reliability. This unfortunately is not possible. It is possible, however, to define the areas in which the human is most prone to err and to reduce the probability of failure in these areas.

The first step in reducing human-caused accidents is a clear analysis of the role which the human plays. When it is determined that a specific task is close to the human's limiting capabilities, careful criteria for selecting people will result in a smaller gap between demand and capability. The probability of human failure, and hence accidents, can be further reduced by clearly defined operational procedures which will not jeopardize the gains made through selection and training. The key to this entire process of decreasing the demands upon the human capability is a clear understanding of the problem and controlled supervision at all levels of selection, training, and use. Although this process will not result in a positive numerical designation of the human reliability component, it will result in a positive increase in our system reliability and over-all safety.

The advent of large space boosters in the 12- to 22-million-pound-thrust category, which will be required for the U.S. lunar programs, will impose safety problems far exceeding those of present-day systems. The hazards associated with blast, fire, fragmentation, acoustics, toxicity, and radiation will have a critical impact on launch facility siting, the design and location of launch pads, structures, and support equipment. All these hazardous areas require timely studies, analyses, and tests to obtain definitive data on which to base design and siting considerations to prevent undue hazards to property and personnel both military and civilian.

Historically, valid operational hazards data have invariably only been available after the fact, resulting in the costly acquisition of additional land easements, extensive redesign and modification, and hence delay in operational capability. To obtain the essential safety data in time for use of planners and designers in the research and development phase of space vehicles and weapon systems, adequate and separate funding for the purpose is mandatory. Accordingly both the Air Force and the National Aeronautics and Space Administration, as primary participants in the space vehicle program, must accord hazard studies a high priority. We only have to look at the quantity–distance problems we have recently experienced involving Titan and Minuteman to recognize the validity of that statement.

A "Preliminary Hazard Report" was prepared and published in June 1961 by a joint Hazards Analysis Task Group made up of NASA and USAF personnel, assisted by nationally recognized experts in each technical area. This report is an excellent first look at the potential hazards associated with large space boosters, both solid and liquid. Significantly the main conclusion of the report was that in no area (blast, acoustics, toxicity, etc.) are there adequate data on space booster systems of the magnitude programed to be in the U.S. inventory.

In its preliminary report the Hazards Analysis Task Group identified the areas that required further study. Since these hazard studies touch on critical areas in missile and space vehicle safety, a brief summary of the most important findings may be appropriate:

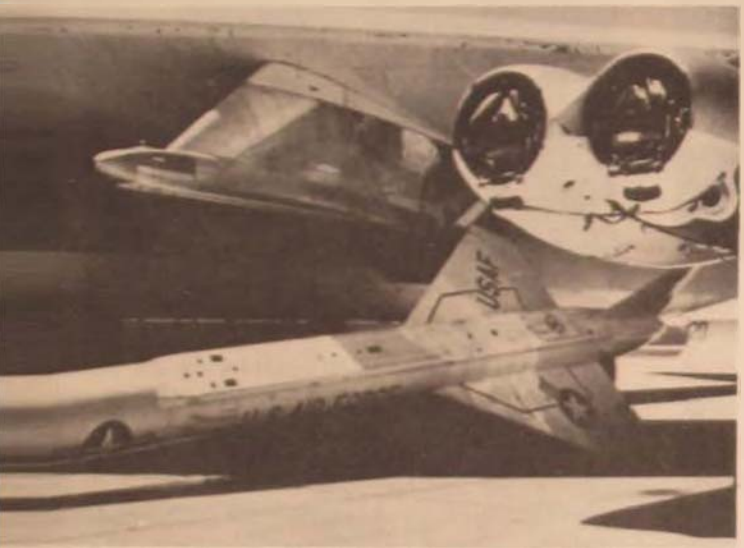
(1) Considerable data are desired on the blast potential of large solid rocket motors, the data to include biological hazards.

(2) Large gaps exist in knowledge of the physical, engineering, and biomedical aspects of the acoustic problem. Specifically, data are required on noise generation by boosters of more than 150,000-pound thrust, on the propagation and attenuation of low-frequency sound, the structural damage that can be caused by low-frequency noise, and the human response to high-intensity, low-frequency noise.

(3) Toxic hazards involving fluorides and boranes have generated similar requirements. Safety equipment and procedures must be developed to provide personnel protection. Quantity–distance requirements

Missile Safety

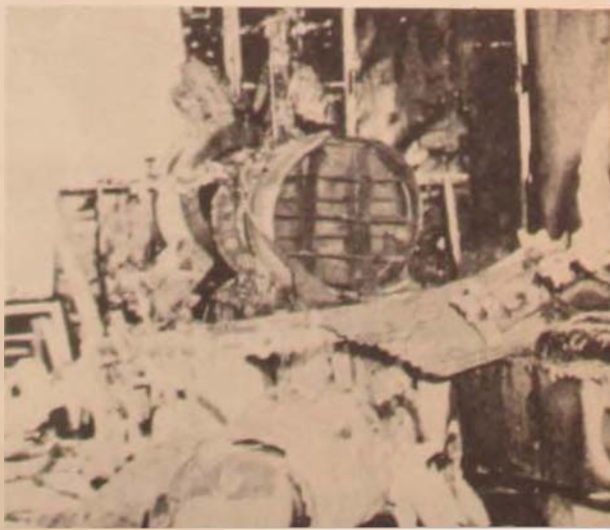
Before a violent in-silo explosion that hurled large fragments over one-half mile, this hole in the ground had been the site of a Titan missile. As the fully loaded missile was being returned to the silo, an elevator control valve failed. A safety device was by-passed, and the elevator bottomed at over twice the velocity for which it was designed. This particular accident resulted in a re-evaluation of the safety criteria.

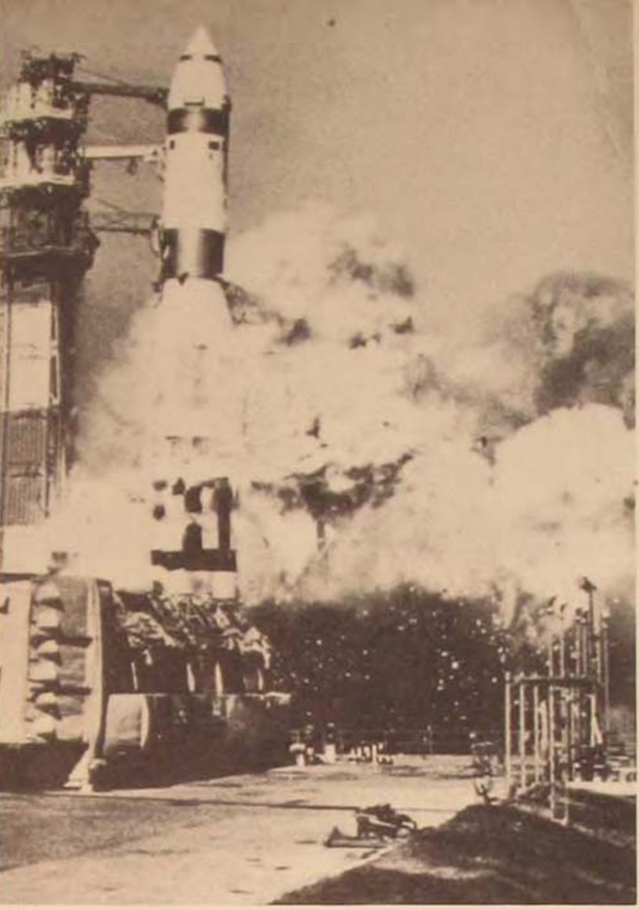


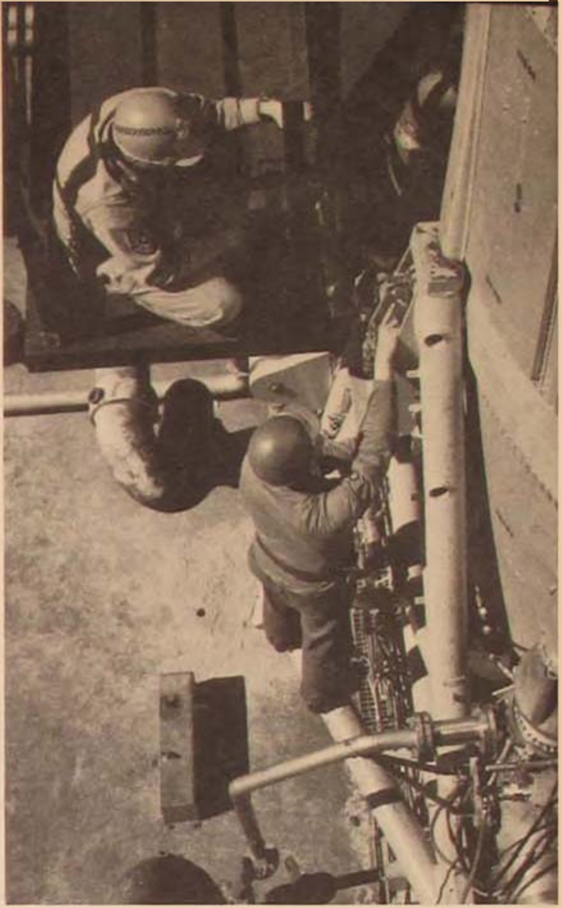
Preliminary to uploading a Hound Dog air-to-ground missile a critical circuits check of the right-wing circuitry was begun without removing the electrical squibs on the already loaded left-wing missile. The explosive squibs actuate the release system. As a result the system visibly worked all too well when the manual external missile release handle was pulled as a part of the check.

During an Atlas fueling an intermediate bulkhead crumpled between the liquid oxygen and fuel tanks. An explosion followed. This particular bulkhead reversal was the result of a faulty sensing circuit and slow reaction by personnel involved when the fault was detected.

The destruction of a Bomarc and its warhead created headlines in 1960. Investigation revealed that over a period of time the helium tank would rupture if pressurized to design specifications. A high-pressure ground container now tops off the helium tank preceding launch.



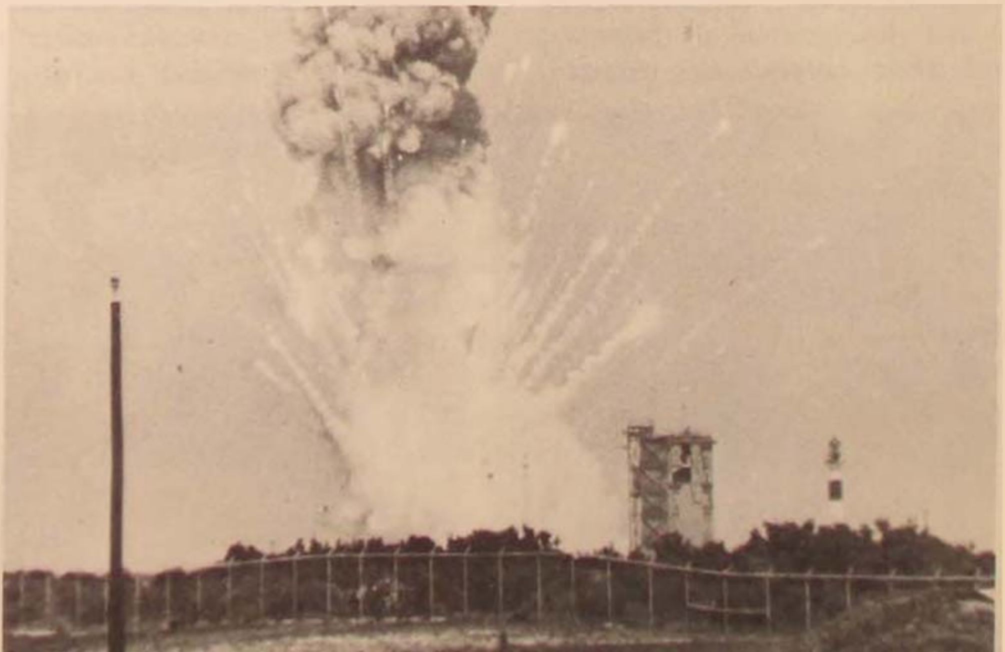




A Titan in its death throes because of premature activation of the hold-down bolts. Activation pulled the umbilical prematurely and caused the engine automatically to shut down. Design deficiency in the hold-down bolt circuitry was the primary cause of the accident.

The pad chief and his assistant carry through the daily inspection on an Atlas missile at Vandenberg AFB. With the Atlas in alert configuration little actual maintenance can be performed. These walk-around inspections are similar to a pilot's visual preflight aircraft check.

Not only the liquid-fueled missiles get into trouble. This solid-propellant Minuteman exploded after emerging from its silo, when failure of a $1.50 diode caused the second stage to ignite immediately after first-stage ignition. Circuitry redesign was undertaken against a recurrence.



have yet to be determined for protection against sudden and unexpected toxic atmospheres and against toxic environments that may linger for long per[illegible] Atmospheric conditions will play a major role in the proper ha[illegible] and use of toxic propellants. More study is required in this area.

The nuclear rocket engine will certainly be a part of our future large booster systems. The attendant hazards of radiation from reactor operation and from fission by-products will require careful and extensive evaluation and tests.

The problems associated with large space vehicle boosters which will place manned and unmanned space vehicles in orbit have already been discussed. Hazards to which man will be exposed during countdown and boost phases can readily be defined. It is another thing to create an environment in which man can operate successfully. The creation of a compatible environment will in no way reduce the human error common to atmospheric operations. Design engineers must provide for man an adequate terrestrial-like environment in space. This is no minor problem. Physical difficulties will arise from absence of gravity effect, and physiological compromise can result from minor errors in the development of an adequate biological support system. Psychological stresses associated with isolation, darkness, claustrophobia, and unknown sensations will be intensely important considerations. These problems must be anticipated and resolved on a timely basis.

ground safety

Plans for providing an adequate terrestrial environment for man in space in the future presuppose, of course, that he will live safely on the ground in the meantime. People who regard ground safety as a "soft-core area" do so because they lack understanding of its objectives. Flying safety, missile safety, and nuclear safety (and they are glamorous) are activity patterns to ensure safe weapons and delivery systems; but the ultimate employment of our weapons must be accomplished by highly skilled man, and our capability is decidedly reduced if that man is lying in the graveyard as a result of a ground accident. Ground safety seeks to conserve the essential elements of combat capability: people, time, money, equipment, materiel, and facilities. As I mentioned before, more people are killed in ground accidents than in any other category.

It is really hard to get a handle on ground safety because of two factors: variety and complexity. The element of variety requires little discussion. All we have to do is reflect on the myriad of activities in which airmen and officers involve themselves in the 24-hour period and the numerous opportunities to injure themselves, kill themselves, or damage Air Force property. From the engine repair shop to the mess hall, from the hobby shop to the flight line, at the Officers Club swimming pool or out on U.S. 66, there is no place where the safety of our men can be left to chance. Ground safety cannot be just industrial safety, or explosives safety, or driving safety, or home safety—it must be

Chemicals Safety

Protective clothing was once almost exclusively in the wardrobe of the flying crew. Today ground personnel require many items of protective equipment to accomplish their work safely.

Red fuming nitric acid is but one of many chemicals unknown in the USAF a decade ago. Now support crews must handle it routinely. RFNA is extremely corrosive with most metals. It reacts violently with paper, wood, cloth, leathers, and other organic materials and forms a highly explosive mix with petroleum products. It is sensitive to a spark or light shock. All in all, it is a bit more difficult to handle than aviation gasoline.

Clothed in protective suits and masks, missilemen fuel the Bomarc with aniline and furfuryl alcohol, inhibited red fuming nitric acid, and JP-X fuel.

all of these. The civilian employee is also covered by the program during his on-duty hours.

The element of complexity is a natural product of modern weapon systems. In an attempt to classify our accident experience and problems, we group our ground accidents and preventive efforts into three areas: off-duty safety, conventional explosives safety, and industrial-type safety. Let's look briefly at each of these areas.

In the off-duty ground safety area our greatest single source of manpower loss is in the operation of private vehicles. During 1961 alone 377 airmen died and about 3400 sustained disabling injuries in private motor-vehicle accidents. Even though this represents almost 13 per cent improvement over 1960, it is still very evident that much remains to be done in this area. Our second-greatest killer in off-duty ground accidents is found in sports and recreation—swimming, hunting, football, boating, skiing, and the like. In this area during 1961 the USAF incurred 52 fatalities and about 2000 disabling injuries. Both these areas are being given maximum consideration in our planning for the future.

In the Office of the Deputy Inspector General for Safety we plan

Missile propellants are capable of producing great power. They also burn violently.

to assign a traffic safety coordinator devoting his full time and attention to analyzing these accident causes and recommending corrective measures. A study is under way to refine our driver training and improvement courses. Included in this study are provisions for greatly expanded use of the driver simulators resembling in many ways the aircraft simulators used to train pilots on the ground.

Explosives safety has a long history. After World War I a series of explosions of military ammunition caused such violent property damage and loss of life that Congress and the President suffered terrific criticism. Continued public outcries resulted in passage of Public Law 1028. That law requires the military establishment to maintain an acceptable degree of safety from explosives, to protect both the military and the public. Even though adequate corrective actions were taken when the law was passed, some military installations relaxed their safety vigilance and single explosions have occurred within the past 20 years wherein as many as 320 people were killed, 390 injured, and property damaged to the extent of $13 million.

Explosives, of course, are used for various purposes throughout all weapon systems, conventional as well as nuclear and missile, and a detonation of an explosive in any weapon could cause public criticism which might result in the "grounding" of the weapon system. The result could be disastrous if such action degraded our combat posture. Compliance with explosives safety requirements thus not only saves lives and property and conserves our combat capability but also prevents the USAF from becoming a target for legitimate public and Congressional criticism.

Operational concepts of the Air Force are constantly changing as technological advances swiftly dictate new methods, procedures, and work processes. This progressive modernization is characterized by the necessity to incorporate in USAF ground operations modern industrial safety features geared to present requirements and future developments. Ground safety must be responsive to the environmental, industrial-type hazards which threaten to reduce our combat potential. And of course we have much to cross-check with the airlines and industry—which we do. Future application of engineering knowledge to the control of work environment will allow the safety engineer to meet the challenge of technological advance. Future work environments must be adapted to the physiological and psychological limitations of man, but the objective is to reach the maximum safe as well as efficiently productive man–machine–environment system.

We have barely scratched the surface in application of engineering techniques to industrial-type safety problems in the Air Force. Ground safety engineering must become more explicit in its approach to the future. New areas such as human-factor engineering, industrial loss control, and operations research will be explored to determine how they may best contribute to the furtherance of Air Force ground safety accomplishment. There must be positive and continual attention by the ground safety engineer to development of improved measurement techniques so that ground accident prediction and control can be maximized. Finally, extensive research to uncover new approaches will reveal the truths of industrial-type accident phenomena. As weapon systems become more complex, our research will provide the guidance needed for optimum safety success. It is not easy.

This guidance will be vitally needed not only because of more complex systems but also because we will have to cope with the increased hazards inherent in these systems. The hazards generated by transportation of explosives, increased firepower, high-frequency electrical scanning equipment, propellants, noise, temperature extremes, toxic fuels (such as hydrazine, fluorine, and red fuming nitric acid) introduce ground safety problems that stagger the imagination. These hazards, complicated by a decentralized force scattered over many areas, greatly increase the challenge to our ground safety program. Moreover the temperaments of people in localities never before exposed to this type of operation pose a problem indeed.

The job of ground safety in tomorrow's Air Force will demand more engineering knowledge, more technical ability, and more managerial skill. The day of the novice in ground safety is long over.

nuclear safety

To move from ground safety to nuclear safety, let me say that in

Nuclear Weapons Safety

Members of a nuclear safety team examine a B-52 clip-in system. "Survey" and "Check List" are the chosen watchwords of the Directorate of Nuclear Safety.

The Directorate of Nuclear Safety is also responsible for investigating accidents which involve nuclear weapons. It must evaluate the nuclear system to determine if the equipment functioned as envisioned by the Nuclear Weapon System Safety Group. The evaluation will pinpoint weaknesses, if any, and make recommendations. Here the chief of the DNS Engineering Branch inspects the U-2 rack and the suspension system of a B-52 that crashed near Beale AFB, Calif. He found that the nuclear weapons and suspension equipment functioned properly.

the nuclear area our basic idea of conservation takes on a slightly different connotation. We have come a long way since 1945 in terms of numbers and variety of nuclear weapons and their uses. Furthermore today's Air Force is a quick-reaction force. Here, too, we have come a long way since 1945. Today SAC nuclear-armed bombers stand five-minute airstrip alerts. Fighter-bombers stand ready to scramble with appropriate nuclear payloads. Missiles similarly stand poised—none of them need take longer than 15 minutes from standby to launch.

The readiness and dispersal of Air Force offensive and defensive forces are two important elements in the present-day deterrent capability of the United States. That capability represents the hard core of the Free World defense posture. We must let no preventable accident interfere with the maintenance of this posture. We must convince our allies abroad and our people at home that this posture is tenable—and safe. One of the best convincers is the maintenance of our record of no accidental nuclear explosion.

Our nuclear safety program has two basic parts. The first is a thorough and comprehensive analysis of each nuclear weapon system. Analysis and evaluation commence with the initiation of the system as a developmental concept and continue until the retirement of the system from the physical inventory. The examination covers the entire stockpile-to-target sequence. All aspects of the weapon system are investigated: design, electrical circuitry, handling and loading procedures, operational procedures, security and personnel, training and requirements.

This analysis is performed under the monitorship of the Directorate of Nuclear Safety (DNS) under the Deputy Inspector General for Safety (DIG/S). The Air Force Systems Command assembles and provides the technical data for these analyses, and the safety studies and rules are reviewed by the Air Force Nuclear Weapon System Safety Group (NWSSG) under the chairmanship of my Director of Nuclear Safety.

The six important steps in this continual appraisal are known as the Air Force milestones of nuclear safety:

- Initial Safety Study. The NWSSG examines all available information about the new nuclear weapon system against the requisites of safety. Its members represent each major Air Force command having nuclear weapon responsibility, the Defense Atomic Support Agency (DASA), and the Atomic Energy Commission. The Air Force Special Weapons Center provides the technical input (called the Safety Analysis and Evaluation Report) for the group's consideration. The purpose of this study is to provide appropriate safety guidance to the developing agencies.

- Preoperational Safety Study. The NWSSG conducts a second study of the new weapon system shortly before the system becomes operational. At this point the weapon design is definitive and the Air

Force's plan of operations is clearly defined. This investigation is extremely detailed. It considers every imaginable facet of the weapon system's life. It examines handling procedures, testing equipment, security measures, and emergency doctrines, among others. It produces refinements for safety and the proposed safety rules governing the peacetime operation of the weapon system.

- Safety Rules. These proposed rules are reviewed extensively and carefully. After agreement by the NWSSG, the DNS, and the rest of the Air Staff, concurrence must be obtained from DASA and the Joint Chiefs of Staff. This concurrence must then be approved by both the Secretary of Defense and the AEC.

- Preoperational Survey. Shortly before the operational date of the weapon system, DNS conducts a field survey of a selected unit, examining the entire system in its operational environment. This is to ascertain if the safety rules for that particular weapon system are adequate, understandable, and usable.

- Operational Review. It is evident that operational experience with a particular weapon system may produce ideas or information which may enhance operational safety. Hence DNS reviews the weapon system's safety again after it has been operational for a prescribed period of time (not over a year). This is just one more step designed to ensure the efficacy of the safety rules and operating procedures.

- Special Safety Reviews and Studies. DNS or NWSSG conducts special reviews whenever circumstances require them.

If we assume that we have done a good job at the above milestones and have provided the field with an operationally effective weapon system that can be handled safely, there remains one more thing to be done. That is to ensure that units in the field do indeed operate the weapon system safely. This requirement is the goal of the second part of our Air Force nuclear safety program, the establishment of aggressive and effective nuclear safety programs at all levels of command.

Here the role of the operators, the units in the field, is paramount. We in Deputy Inspector General/Safety provide general guidance on the establishment of the programs. Command programmatic surveys are made by DIG/Safety on a recurring basis. The prime responsibility, however, rests with commanders—safety is a function of command.

A nuclear weapon is, of course, dangerous. The main objective of the designer is to produce a reliable weapon that will detonate as intended at the proper point in time and space. At the same time the designer incorporates in his design sufficient safety devices to prevent accidental or unauthorized detonation prior to that time. However, safety in design is not enough. It must be supported by effective supporting procedures, access control, technical orders, check lists, and the "buddy system." These procedures must be understood and rigidly enforced by commanders at all levels. A nuclear safety program at the operating level is designed to ensure awareness on everybody's part of the necessity for constant and unfailing adherence to these procedures.

Another aspect of nuclear safety concerns the utilization of nuclear energy in applications other than weapons. The increased application in military and civilian areas is no longer a fantasy; accelerated development of the use of atomic energy is the stated policy of many nations. In our country, in addition to the many power systems using atomic energy, emphasis is being placed on a number of nuclear aerospace systems.

These systems include Snap (systems for nuclear auxiliary power), using both reactor and isotope packages; Spur (space power unit reactor); Pluto, a nuclear ramjet; Rover, a nuclear-powered rocket; and the Orion project for lifting large payloads by detonating nuclear devices below the base of the payload.

Everybody concerned with nuclear reactor applications must keep safety measures in step with the development and operation of nuclear systems. Every possible action must be taken to minimize the possibility of a reactor accident with its dire consequences. We follow the same basic approach and use the same safety milestones in this program as in the weapons program.

The major emphasis at present is being placed on those Snap systems which have been tested or are approaching the test and operational phases. A Snap-3 safety study was recently conducted for the Navy Transit, a navigational aid satellite launched from Cape Canaveral. All the recommendations made in this study were incorporated by the Canaveral safety personnel. Preparations are being made at the Pacific Missile Range for other launchings of nuclear aerospace systems.

The remainder of the Transit series, which will carry a Snap of much higher power, will be launched from the Pacific Missile Range, as well as the series of Snapshots that will test the orbiting of reactors. To ensure that all aspects of the Air Force's nuclear safety responsibilities are considered, safety studies for both the range and Snapshot are currently being accomplished by the Nuclear Reactor System Safety Group, the counterpart of the NWSSG.

An impressive testimonial to our entire Air Force nuclear safety program proceeds from the fact that the nuclear-yield accident rate is still zero. The diverse and manifold factors that have produced this rate will serve as a foundation for any of our future nuclear missions, regardless of their scope and challenge. This foundation has one basic ingredient: awareness. Part of this awareness is recognition of the increased importance of our operating personnel in the field and the necessity for unceasing vigilance.

Common to all accident-prevention consideration—and to each of the four areas I have discussed—is the categorical fact that accidents are attributable to either materiel failure or human error. By logical manipulation, all materiel failure can be traced to human failure or all human error can be called materiel failure. From this latter viewpoint, for instance, if a car hits a concrete wall and is destroyed, the fundamental problem is lack of structural strength—otherwise no accidental damage would have occurred.

These extremes contribute little to positive accident-prevention thinking. Without attempting a critical definition of the point at which materiel failure ceases and human error becomes involved, one can state that in the early phases of any program, when the equipment is new, the greatest cause of error is functional or structural breakdown of the equipment. With time, as the bugs are shaken out of the system so that materiel reliability becomes greater, human error becomes a relatively more prominent cause factor in accident rate.

As time goes on, equipment has become more and more complex, with consequent greater demands upon the human designer, builder, and operator. The human, however, has not changed much. The result has been that, while materiel failures occur and are corrected, the basic human errors have remained essentially consistent. It can be anticipated that this state of affairs will continue. Errors of omission and commission, inadvertent acts, lapses of attention, and other failures so prevalent today will persist in the future. In the forthcoming space age, therefore, it can be anticipated with a high degree of certainty that the initial failures will to a great extent be hardware failures. Past experience would suggest that these failures will be overcome with not too much difficulty.

The basic problem in accident prevention will again become control of variations in the human element. It must be accepted as axiomatic that human limitations cannot be exceeded. Experience indicates, however, that acceptance of the existence of these limitations and careful measuring of their parameters can provide limitations data which if properly used will help to prevent accidents attributable to human failures. This type of information can be integrated into basic design of equipment; it can be used to develop definitive personnel selection criteria; it can serve as the basis for carefully controlled training, and can dictate the operational conditions under which most efficient human operation may be anticipated.

In the final evaluation it is considered that greatest gains in accident prevention both now and in the future will depend upon an accentuated emphasis on determining the definite causes of common human failures. This approach has prevented accidents. It is stated on faith that it will lead to the prevention of future accidents.

The fundamental thesis of the entire accident-prevention program is that no accident is inevitable. Any one accident can be prevented; and if any one can be prevented, theoretically all can be prevented. Although this is an ambitious goal, it is not as unrealistic as a casual evaluation would suggest.

Headquarters United States Air Force (DIG/S)

Limited War for Unlimited Goals

Colonel Albert P. Sights, Jr.

As THE atomic arms race continues and we progress from kilotons to megatons to "gigatons," the question must be faced as to what are appropriate objectives for military power in the present era. The time has come to seek new directions in strategy that lead to realistic goals.

In this reappraisal of strategy, perhaps we should begin with a review of its historical origins. Fortunately we need not go back very far. Useful military history began in 1945. What happened in the many centuries before that date has little relevance to the current problems of grand strategy. Except for the philosophical insights they provide into the general nature of conflict, Alexander, Napoleon, Clausewitz, Mahan, and Douhet may be put aside. To those who are shocked by the summary dismissal of such eminent strategists, we hasten to acknowledge the brilliance of their insight into the two- or three-dimensional wars of the pre-1945 era. But now the new dimension of atomic power calls into question all previous theories of war. And surely, if these great strategists were living today, they would be among the first to acknowledge the vastly altered circumstances of military conflict.

A fundamental characteristic of military power is its capability for discriminate destruction. Originally military force destroyed people; later it destroyed horses, fortifications, ships, and artillery; and much later it destroyed tanks and airplanes. Weapons are the instruments of destruction, and they have progressed through the ages from clubs to bows and arrows, to catapults, to cannons, to aerial bombs. This progress, if we may call it such, might be plotted on a graph in which time is measured along the horizontal scale and the total destructive power of all the world's military forces on the vertical scale. If such a plotting began back in the Stone Age and was continued until 1945, progress in destructive capability would be represented by a very slowly rising curve. Even so revolutionary an advance as the invention of gunpowder would have caused hardly more than a tremor in the tracing needle inscribing this curve. Beginning in 1945, however, the needle would have recorded a spectacular jump to several million times the previous level of destructive power.

The word "million" has come into such common usage that we need to remind ourselves of its magnitude. When we speak of some value increasing a millionfold, we are referring to something altogether different from a mere doubling or tripling, although even that order of increase is often spectacular. Let us say that in tracing out the rise in destructive capability since the beginning of history on the particular scale we have chosen, our needle has reached by 1945 a height of one inch above its base line. If we then suddenly doubled or tripled this destructive capability, the needle would instantly rise to a height of two or three inches, and the curve it was tracing would at once reflect an event unique and unprecedented in the history of war.

But what of a millionfold increase? We would have to send for considerably larger graphing paper, because the plotting needle would rise more than 15 miles! We cannot say exactly how far the needle has climbed since 1945, because actual destructive capacity is a closely guarded secret of the major powers that are stockpiling nuclear weapons. Available evidence suggests, however, that the increase is something now or soon to be measured by the millionfold and that it is still climbing steeply. This increase delineates the new dimension of military power. It is the reason that our analysis of military strategy must begin with LeMay and the atomic bomb and not with Alexander and the phalanx.*

In the aftermath of World War II the atomic bomb was looked upon as a device for destroying big concentrations of potential military power. Of course military planners were mindful of its utility also in attacking warships, airfields, troop concentrations, and other purely military targets, but it was nevertheless the big concentrations that got the most attention. A basic tenet of strategic bombing theory was that the shortest road to victory lay in the destruction of the enemy's military power at its source. Since potential military power is a combination of people and the products of industry, destruction of big concentrations of industrial power would serve the dual purpose of curtailing the flow of

*Dr. Bernard Brodie has pointed to the inadequacy of traditional concepts and called for a fresh approach to the subject of strategy: "In a world still unprepared to relinquish the use of military power, we must learn to effect that use through methods that are something other than self-destroying. The task will be bafflingly difficult at best, but it can only begin with the clear recognition that most of the military ideas and axioms of the past are now or soon will be inapplicable. The old concepts of strategy, including those of Douhet and of World War II, have come to a dead end. What we now must initiate is the comprehensive pursuit of the new ideas and procedures necessary to carry us through the next two or three dangerous decades." Bernard Brodie, "Strategy Hits a Dead End," *Harper's*, 211 (October 1955), 37.

war materiel to the fighting forces and of substantially reducing manpower. To many analysts the effects of strategic bombing in World War II were not decisive, but the atomic bomb cast a whole new light on the question and greatly strengthened the arguments for its decisive capability. In any event strategic bombing became the big stick of U. S. military power, and American superiority in air–atomic strike forces is generally credited with having deterred the Soviets from exploiting their postwar superiority in ground forces by an overt assault on western Europe.

The Korean War served to raise some second thoughts on the utility of strategic bombing. At that time the West no longer enjoyed an absolute monopoly of atomic weapons, but still the United States did have an overwhelming superiority in atomic strike power. Not only was there an available option to attack the ultimate sources of Communist strength but also there were many remunerative targets in North Korea itself. Whether atomic bombs should have been dropped either inside or outside the Korean peninsula still remains a subject for lively debate among military authorities, but it is sufficient for our present purpose simply to note the fact that they were not used.

In the post-Korean period we have seen a rapid growth of Soviet nuclear capabilities and a clear ending of the West's atomic monopoly—despite the continuing tendency of some military students seemingly to think of nuclear war only in terms of our ability to deliver nuclear warheads on the enemy. The term "parity" has come into common usage as signifying not an exact numerical equivalence but rather the capability of both East and West to inflict disastrous damage on each other. Critics of strategic bombing now assert that this great capacity for mutual destruction invalidates any idea of "winning"; therefore a nuclear exchange will not likely be initiated by either side and, so long as this condition of parity continues, all wars will be limited by the exclusion of strategic bombing. If strategic bombing is thus to remain inactive on the sidelines, the argument naturally follows that we should spend no more on it than what is necessary to maintain the condition of parity and should spend correspondingly more on those forces that will do the actual fighting. This concept of parity is endorsed by a number of military authorities, and it warrants careful examination.

A nation uses military forces to impose its will on another nation. This does not necessarily mean war. More often than not a nation will achieve its ends by the threat of war, expressed or implied. The interplay between two unfriendly nations is influenced by a continuing assessment on both sides of the comparative balance of military power between them. The mere existence of preponderant military forces in one nation will tend to support its national purposes even though these forces are never alluded to in diplomatic discourse.* But under the concept of

*The influence of latent military power in international relations has long been recognized and is well illustrated by the following familiar extract from a speech by President Theodore Roosevelt at the Minnesota State Fair on 2 September 1901: "There is a homely adage which runs, 'Speak softly and carry a big stick; you will go far.' If the American nation will speak softly and yet build and keep at a pitch of the highest training a thoroughly efficient navy, the Monroe Doctrine will go far."

parity, a small strategic counterforce is in effect neutralized by the tacit admission that there is no intention to use it. A facade of bold talk will not conceal weakness in the supporting military structure. Without predominant strength there can be little credibility in a threat or counterthreat, expressed or implied, to employ strategic air power, and accordingly it becomes ineffective as an instrument for pursuance of national interest.

Another drawback to the concept of parity is its inherent quality of instability. Nations will live in the fear or hope, as the case may be, that some means will be found suddenly to escape from this condition of checkmate. An escape might be seen in a new scientific discovery or even in a tragically incorrect assessment of enemy will or capability because of faulty intelligence. As a hedge against the possible voidance of parity there will be constant pressure to spend vast sums on active and passive defense measures as well as to modernize and perfect the small but expensive nuclear deterrent forces which are never intended to fight. At the same time other types of costly military forces will be required to fight those kinds of lesser wars that are regarded as endurable. In short, the idea of nuclear parity offers the grim prospect of an indefinitely continuing conflict against the backdrop of an uneasy nuclear truce—an earth-sized powder keg with a short fuze that might be lighted at any time.

What are the possibilities of escape from this dilemma? One alternative is in the idea that we can win a nuclear war. This is a rejection of the concept of parity. In essence the proposal is to develop a combination of offensive forces and defensive measures that are clearly sufficient to prevail in a nuclear exchange with the enemy. Advocates of winning acknowledge that the cost will be high, in development of the required military posture, in casualties, and in reconstruction and rehabilitation after victory is achieved. In particular let us note that under this concept of winning there is no suggestion the U.S. could be sheltered from enemy attack even with the most extensive and elaborate preparations. Although estimates vary widely, the deaths expected in such a war are customarily reckoned in millions or tens of millions.

Let there be no mistake about the object of military strategy being victory, not stalemate or defeat. It is the task of our military leaders to determine how to win—certainly with minimum loss in lives and property, but always to win. It is the task of political leaders in this country, not the military, to prescribe the alternative if something less than military victory is the desired national objective.

Contemporary military authorities, writing on the subject of strategy, have advanced a wide variety of proposals, but all seem to cluster around one or the other of the two basic concepts just discussed. These concepts might be broadly restated in the form of alternative courses of action: (a) to accept the nuclear "stalemate" or parity as a permanent condition of life or (b) to prepare to win the nuclear war.

The strategy of winning the nuclear war hopefully would impose a rapid attrition on the enemy forces, but nevertheless a considerable number of his bombs and missiles would be expected to reach targets in this country. Since this is undesirable, we must consider how the enemy might be deterred from launching a nuclear attack while at the same time we are methodically reducing his capability and incentive to do so.*

ARMED forces required for a general nuclear war would comprise three basic elements: atomic weapons, missiles, and manned aircraft or spacecraft. A decisive military victory will not be possible until these elements of enemy power are neutralized or destroyed. Let us then consider the prospects of doing so.

In the case of atomic weapons, extensive industrial facilities are required for their production. We could probably locate most of these complexes and destroy them by air and missile attack. However, large stocks of nuclear weapons would have already been produced and no doubt would be well dispersed and carefully concealed. The difficulty of finding and destroying *all* of a large nation's nuclear weapons is readily apparent. Even granting improbable success in our campaign, the undiscovered residual stocks of weapons would continue to pose a very serious threat. We are thus drawn to conclude that stocks of bombs and warheads do not present a suitable target system for a decisive campaign of attrition.

But if a nuclear device is to serve any useful purpose in war, it has to be delivered and exploded reasonably close to its intended target. The present means of delivery are missiles and aircraft. Perhaps in the future orbiting satellites or spacecraft can be used for this purpose. To avoid the charge of oversimplification, let us also acknowledge that there are other means of delivery—artillery, mines, and torpedoes, as well as clandestine introduction aboard merchant ships, trucks, commercial aircraft, or, for that matter, even on the backs of men and mules. All these methods may be effective in special circumstances, but they are supplemental to the central body of decisive attack that must be delivered by missiles and aircraft. Since the supplemental delivery systems cannot in themselves be conclusive, we will here focus our attention on the two primary means of delivery.

The missile is regarded by a number of authorities as the principal instrument of strategic warfare and the heir apparent to the manned bomber. Undeniably the missile has some impressive military characteristics. It has almost unlimited range, and it can approach its target at very high speed. It has sufficient accuracy, in most cases, to include the target within the destructive radius of its nuclear blast. In any event its accuracy will doubtless improve, as will its reliability. The missile can be fired from impregnable underground silos or from submerged

*The growing natural distaste for a nuclear exchange is reflected in the following excerpt from a talk by President John F. Kennedy at the University of North Carolina on 12 October 1961: "We move for the first time in our history through an age in which two opposing powers have the capacity to destroy each other, and while we do not intend to see the free world give up, we shall make every effort to prevent the world from being blown up." Transcript in *New York Times*, 13 October 1961, p. 14.

submarines. It can be camouflaged and hidden. It can be moved about continually on mobile launching platforms such as railway trains, barges, and ships. By a combination of measures involving protective shelters, concealment, and mobility, the missile forces of a nation can be made a difficult target system for decisive attack.

With regard to targeting, these considerations leave only the manned aircraft or spacecraft. An airplane on the ground is a large, fragile machine that is quite vulnerable to bombs or gunfire. It is not easily concealed or buried underground. It requires long, flat surfaces for take-off and landing, as well as extensive supporting facilities that are both conspicuous and vulnerable to attack. In the case of aircraft carriers some measure of protection is afforded by mobility, but the number of carriers is necessarily limited by their cost and as floating air bases they are peculiarly vulnerable to total and permanent loss. We know from the experience of World War II and Korea that progressive attrition can be imposed on the military air capability of a nation to the point of virtually complete mastery of its airspace. And let us also note in passing, this same war experience demonstrated that a condition of air supremacy can be achieved with conventional, non-nuclear armaments. Thus it is evident that of the three major target systems, nuclear stockpiles, missiles, and aircraft, the latter is the one that best lends itself to planned systematic decimation.

But the objective of strategy is to reach a decision. At this point the reader might very well ask two questions. How could enemy aircraft be engaged and destroyed without precipitating general war? And even if this destruction were possible, how could it conceivably be decisive when the enemy still possesses largely intact a potent missile force and an ample stockpile of nuclear weapons?

Let us begin with the second question. The answer lies very simply in a critical weakness of the missile itself as an instrument of war. A missile is dumb and blind! A missile can go only where its thinking, seeing master sends it. If its master can also be made dumb and blind, the marvelously intricate 5000-mile missile with its megaton warhead remains an impressive pyrotechnic but becomes virtually useless as a military weapon.

The commander of a missile force would like to employ his missiles against important targets whose destruction will be of the greatest military benefit to his own nation. To do this, first of all he must know what these targets are, and second, he must know their locations. Also he would do well to learn the characteristics and configuration of each target, including the nature of its environment, in order to employ those yield and fuzing options best suited to the task. Inevitably there will be some critical targets, like nuclear-storage areas and missile-launching sites, on which required information is incomplete or totally lacking. These gaps of knowledge must be filled by aerial reconnaissance. And for all targets, even ports or airfields whose locations and characteristics are well known, reconnaissance will be required after the missiles are fired, to determine the results actually achieved.

We conclude therefore that a missile force alone is not a complete warfare system. It must be employed in conjunction with adequate aerial reconnaissance.* Aircraft and spacecraft are the eyes of the missile force commander. But, as we have seen earlier, the aerospace forces of a nation are themselves vulnerable to air attack. They can be overwhelmed and destroyed by a superior air force. And regardless of the size of its missile forces and nuclear stockpiles, any nation that allows an enemy to gain undisputed mastery of the air becomes thereby an unseeing giant, still capable of destroying cities in blind revenge but in no position to continue the war for rational objectives. Thus destruction of the enemy's air forces alone would be decisive.

We must now return to the first question of how this decisive result might be accomplished without triggering the nuclear war which we wish to avoid. The analysis of this question must proceed from the premise that man is still a rational animal capable of struggling on the brink of a precipice without yielding to urges for insensate acts likely to project both combatants into the abyss. If this premise is not valid, there seems indeed little prospect that the human race can escape destruction by its own technology.

UNDER what circumstances might an enemy decide to launch a massive nuclear attack? From a purely military standpoint there is only one rational justification, namely, a firmly held conviction that in the initial assault the nuclear capabilities of his opponent would be so drastically reduced as to make the immediate counterblows endurable *and that the ensuing pattern of war would lead to decisive victory.*

The problem of deterrence, then, is to develop and maintain a position of military strength from which no such conviction could be reasonably arrived at by a potential aggressor. While military authorities agree generally on the concept of deterrence, their opinions are widely divergent on the size and character of forces required to sustain it. Some believe the guaranteed ability to incinerate a few enemy cities is sufficient. Others would expand the counterblow to wipe out almost the whole nation, including its cities and towns as well as its military forces. This argument over how much deterrence is enough deterrence is futile insofar as it concerns the question of how much urban destruction enemy leaders might be willing to risk. The answer to this question is a subjective one that defies analysis. However, if we recall that victory is the real objective of military strategy, the way is open to a more concrete approach.

Whatever retaliatory damage an aggressor might feel he could accept, a nuclear attack will become a tempting course of action only if it seems to offer him a reasonable prospect of ultimate victory. And, as we have seen, the mere possession of a superior missile force offers him

*General Carl Spaatz, USAF (Ret), writing on the continuing need for manned aircraft, has pointed out the vital role of aerial reconnaissance in missile warfare: "The best missile will be next to useless without the up-to-the-minute reconnaissance only a manned plane can still supply today. Reconnaissance satellites can do only part of the job, at best, and will be vulnerable to attack by counter-satellites in any war of the future." — "The Case for the B-70 in an Age of Missiles," *Newsweek*, LVII (17 April 1961), 34.

no such assurance. Command of the air is still the *sine qua non* of victory in a nuclear war. Therefore deterrence will be operative so long as potential aggressors are persuaded they cannot win the air battle. In other words, air power remains the keystone of the deterrent arch. This being the case, we must now consider how air power might be employed to force a decision in war without precipitating general nuclear war.

For purposes of illustration, let us assume that a major hostile power, which we shall call Country X, has powerful missile and air forces that could inflict great damage upon us. Let us further assume we have developed, in pursuance of a new strategic concept, air forces patently superior to those of Country X, together with such accompanying protective measures that a surprise attack by X is unlikely to upset our air power advantage. Under these circumstances X does not launch his nuclear-armed bombers and missiles because he sees no prospect of ultimate victory. Nevertheless he does threaten their use and presently undertakes some lesser form of overt military aggression, perhaps the invasion of a small neighboring country directly or by proxy. What should be the nature of our response?

In the actual event, political factors would influence and perhaps dictate the course of military action to be followed, but we shall exclude these political considerations in order to view the situation purely in terms of a military problem.

Remembering that command of the air is the one essential ingredient of any military strategy designed to win, let us see how our superior air strength might be employed. In our illustrative example, Country X has started a war with a ground invasion which he believes we will not or cannot cope with successfully. Presumably X, or his agent, will provide air support for his invading troops; and in so doing X presents the means of his own undoing.

The pattern of our response is clear. Those air forces which X has committed must be promptly engaged, and once this local air battle is joined, *we must allow X no subsequent opportunity to disengage his air forces*. How can this be done? By a deliberate incremental expansion of the air war, by allowing the enemy air forces no quarter, by respecting no sanctuary for them.

Provocative? No. Country X is the aggressor, and a nation attacked, whose vital interests have been placed in jeopardy, is morally obligated and legally entitled to undertake measures necessary to defend itself and those interests.

Aggression? No. It is not aggression for a nation brought to war to pit its own strengths against enemy weaknesses.

Preventive war? By no means. We are already under attack.

Dangerous? Yes. But we live in an age of peril, a period in which the danger of doing something may well be less than the danger of doing nothing.*

*At a news conference in Washington on 11 October 1961 President Kennedy said, ". . . we happen to live in the most dangerous time in the history of the human race." *New York Times*, 12 October 1961.

In the particular case we have selected, what are the likely consequences? Sooner or later we will have to overfly the boundaries of Country X; and the reader may well ask if this would not precipitate a general nuclear war. Basically the question now posed is whether the concept of deterrence which was operative in peace will remain effective in war. There is no simple or certain answer.

In our hypothetical illustration we have made Country X manifestly inferior in air power, although his missile forces are possibly superior to ours. His evaluation of the opposing strengths has convinced him that he could not gain command of the air. Accordingly he was deterred from initiating a nuclear war. Now he is confronted, let us say, with a shallow penetration of his sovereign airspace by a lone reconnaissance aircraft which either escapes or is shot down. Later there is more reconnaissance with fighter escort, and X loses a couple of planes. Presently an airfield in Country X is bombed and strafed, and the next day another. The tempo of air operations begins to pick up as X concentrates his own air forces to meet this developing threat. If X stands and fights he faces defeat by superior air power. If he undertakes a withdrawal, his air forces will be relentlessly pursued. They will be attacked from a different direction and then another and another. Ultimately X will lose command of the air, and though surface hostilities may continue, his eventual defeat is ensured.

At what point in this process will X resort to the nuclear war he knows he cannot win? On first sighting the reconnaissance plane? Following the appearance of two blips on a radarscope that night? After a bombing and strafing run that did no really critical damage? To ask such questions is to answer them. X will temporize. And on each day that passes, the initial asymmetry of air power that deterred him in the first place will become more heavily weighted against him. His chances of winning in the desperate gamble of a nuclear war will correspondingly diminish.

There is more involved here than just the loss of airplanes and airfields. The progressive physical destruction of an enemy air force is something tangible and measurable in terms of aircraft shot down and bomb damage produced. But more important is the progressive attainment of that abstract condition known as command of the air—a condition in which we enjoy comparative freedom in using the airspace for our purposes while denying the enemy a like freedom in using it for his purposes. Command of the air exists only in a relative sense. It can seldom be absolute, but it is very real nonetheless.

To illustrate, let us say that the scales of air warfare are tipping in our favor. The main focus of air operations will shift toward the enemy's boundaries and gradually expand deeper and deeper into his territory. As this campaign progresses, the enemy will find that little by little he is being divested of the veil of secrecy he has drawn about himself. His airfields, missile sites, atomic stockpiles, control centers, and other precious military assets will start coming under the scrutiny of our aerial reconnaissance. Along with this unwanted disclosure of his own secrets, the enemy will face increasing difficulty in learning our secrets as we constrict his freedom to use air or space for reconnaissance purposes.

In the nuclear era, reconnaissance assumes an increased importance not always appreciated. As pointed out earlier, reconnaissance is the handmaiden of missile power. The combat value of a missile force is roughly equivalent to the value of the military targets it can destroy. Since information on military targets is largely derived from reconnaissance, and reconnaissance capabilities vary with the degree of command of the air, it follows that the strength or weakness of the missile force will have a direct relationship to the success or failure of the air campaign. Therefore the nation which finds itself on the losing end of the air battle will see paradoxically a withering of its useful missile power, even though the numbers and quality of its missiles are being constantly raised.

The reader may wonder what would be happening back on the surface while we are off fighting this air campaign. The answer will make it plain that this is no prescription for victory through air power alone. If the situation involves a land invasion, as we postulated earlier, our own ground forces must meet this threat and harass, delay, halt, or hurl back the enemy as the particular circumstances may require. If the situation involves a commitment of enemy submarines, our naval forces must engage and destroy them because neither land nor air operations can be sustained abroad without control of the seas. With respect to the air campaign itself, it should be understood that in this discussion the terms "air force," "air power," etc., are used in a generic sense to mean all elements of national air combat power, irrespective of service.

We have used the imaginary aggression of Country X in the realization that such a hypothetical illustration never exactly fits a real-life situation. There might be no ground invasion. Instead a ship might be sunk or an aircraft shot down in international waters. It might be that U.S. aircraft are molested in a lawful air corridor such as the one leading to Berlin. There might be an unprovoked air attack on some small outpost of the Free World such as the island of Quemoy.

The guiding principle in all such cases is that a military commander cannot reasonably be expected to submit to and endure hostile incursions from a privileged sanctuary. If enemy forces attack, it is an act of war. We must be flexible and quick-reacting, ready to seize on unprovoked aggression in any form or guise and to counter it in whatever manner may be to our own advantage. We can be sure of one thing: the enemy will select the weapons and arena of conflict best suited to his purposes. But we are neither legally nor morally bound to accept his choice. Our legitimate prerogative is to meet aggression, if we can, on terms more favorable to us than to the enemy. Whether he likes it or not, we must draw out his air forces and lock them in a fight to the finish.

If the air battle is fought to a decision in the manner suggested, it will be an action without parallel in the history of warfare. The strategic objective is to bring about the capitulation of a major nuclear power through a form of limited war and thus to avoid incurring millions of American casualties.

The concept involves stepping gingerly over a succession of small thresholds. It involves a calm, intelligent appraisal of the risk at every step, coupled with the courage and resolution to take the necessary risks in the face of insult, bellicose threat, bluster, and the brandishing of atomic rockets. It involves a piecemeal commitment of force, contrary to one of the time-hallowed principles of war; but in this case tactical considerations must be secondary to the requirements of over-all strategy. The pattern that emerges is a grim, perhaps prolonged, battle of attrition in which the capability of both sides to replace losses might play an important part in the final outcome.

We have not faced directly the question of whether nuclear weapons should be used in such a campaign. They could be, depending on the level of risk at which we decide to play the game. The difference between the largest high-explosive blockbuster and the smallest atomic bomb may be little in terms of yield, but it represents a very great threshold nonetheless. Quite apart from the possibility of escalation to general war is the question of relative military advantage under restraints that might be applicable to the use of nuclear weapons in limited war.

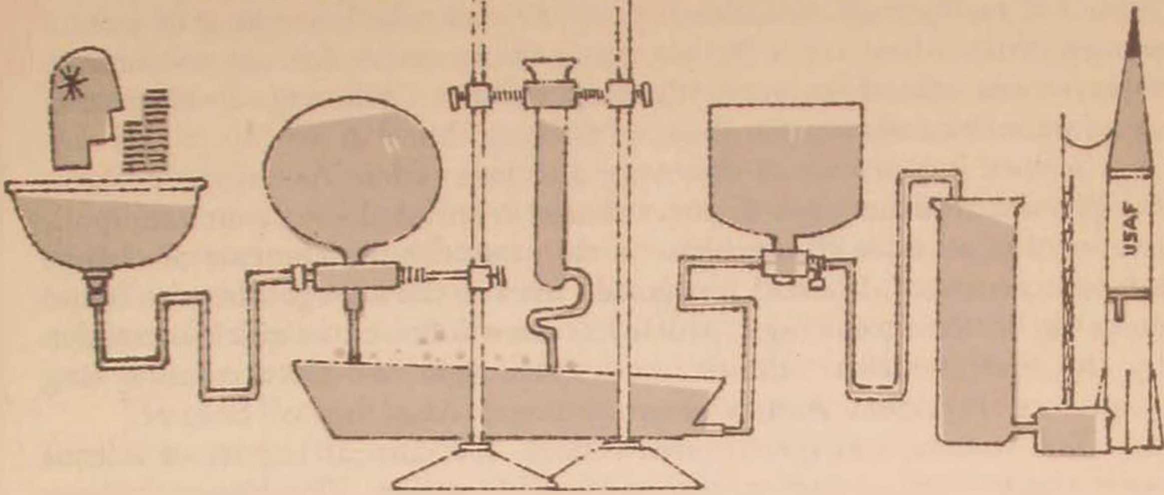
Twelve crisis-filled years after the end of our atomic monopoly, the pernicious idea still flourishes that with nuclear weapons we can buy military victories at bargain prices. The rationale: "One airplane can now drop the explosive equivalent of all the bombs dropped in World War II; therefore great fleets of bombers are no longer required." Forgotten apparently is the fact that an enemy airplane can do the same. Does anyone seriously believe we can less afford to build 50 thousand airplanes than to bury 50 million dead?

It may be that great armadas of airplanes, or spacecraft, are not so obsolete as they once appeared. In the final analysis, *mass* rather than nuclear firepower may become the basic determinant of victory in the air battle. And military strategists of the future might well ponder this space age paraphrase of Mackinder's famous dictums:

> Who wins the air battle controls aerospace:
> Who controls aerospace commands the world:
> Who commands the world controls *all* its nuclear weapons.

Armed Forces Staff College

Science in Defense



The Problem of Organization

Lieutenant John E. Lawyer, Jr.

ONLY in recent years has science seriously been thought to offer an important contribution to the processes of government. Of course new knowledge has always had something to do with the government; John Quincy Adams, for example, in his 1828 campaign proposed to establish a National Academy of Science. Just as the State of Pennsylvania had some concern with painting when it provided for the Pennsylvania Academy of Fine Arts, so it was felt that the United States perhaps had some part to play in encouraging science. But on the whole science was not a field which could contribute directly to the formation or execution of public policy.

The rapid growth of technology during the last century, the scientific and industrial revolution, could not help changing the relation of science to government. Generally this change was earliest manifested in fields connected with the military. Technical specialists had an important role in the development of better gunnery. The use of aircraft in World War I especially dramatized the potentials of scientific progress in the more belligerent aspects of international relations.

After the war was over, the Nation returned to normalcy and the importance of science in public policy receded from prominence. But if there was little public commotion over science in the years between wars, there was a strong undercurrent of concern. Occasionally, as in General Billy Mitchell's colorful fight for greater air power, the place of scientific innovation in the structure of things became a matter of wide controversy. But by and large the headlines of the Twenties and Thirties were concerned with business developments and crime in Chicago rather than events in the world of mathematics or chemistry.

During the Second World War air power once again emphasized the impact of technology on national policy. Finally the harnessing of atomic energy in the Manhattan Project made it impossible for any responsible Government official to ignore the importance of scientific developments as a factor determining the shape of the world.

Science is a process of discovery and innovation. As new facts about the physical universe are discovered and translated into concrete applications, the scientist changes the world around him. The rate of change seems exponential. We had just gotten used to the air age when we found ourselves in the atomic age, which has been followed in quick succession by the thermonuclear, missile, and space age. We have come a long way since President Adams' new National Academy of Science.

The structure of government reflects the current impact of science upon the formation and execution of public policy. The National Aeronautics and Space Administration, the Advanced Research Projects Agency, the President's Science Advisory Committee, the Director of Defense Research and Engineering, and several Special Assistants to the President are but a few of the new agencies and posts established to help relate science to government.

The Air Force likewise owes its very existence to advances in technology, specifically to the development of the airplane and aerial bombs as possibly decisive influences on world events. And like any modern institution, the Air Force has had to come to grips with the problem of how to integrate the new, the changing, and the unexpected into an established pattern. Innovation by nature is unpredictable, and planning the unpredictable is, to say the least, difficult—and vital. The society which most effectively utilizes the new energies which science puts into men's hands will shape the world to its own image.

Science cannot be defined precisely, any more than can art. Both are aspects of the application of the essentially mysterious process of man's creativity to the world he looks out upon. Government is an equally vague term. For precision, then, a discussion of science and government should be built on concrete examples.

The Air Force's ballistic missile program, the largest single military program ever undertaken by the United States, is a major attempt to relate science and a specific government agency. Several billion dollars have been spent on the missile program. The impact of the program on public policy resulted in the great defense debate of early 1960, and has inspired an outpouring of books dealing with strategy in the missile and nuclear era.

Being so important in our total national effort, the Air Force ballistic missile development program is significant as a case in point in this discussion of the relation of science and government.

The Air Force has used three different types of organization to manage its ballistic missile program. In the beginning the science management was handled by Convair as prime contractor. Next the Ramo-Wooldridge Corporation was hired as a private consultant to provide technical and management assistance to the Air Force on a contract basis. After experiencing some difficulty with this form of organization, in addition to Congressional disapproval, the Air Force established the Aerospace Corporation, a private, nonprofit organization under close Air Force control. A fourth possible type of organization is an in-house capability within the Air Force.

None of these examples are pure types, nor were they meant to be. A discussion in terms of pure types would be difficult to apply in a world where they so seldom occur. No doubt future schemes to organize science will continue to share much with those of the past, and the lines between one method of organization and another will still overlap.

The Air Force has been searching, though not always consciously, for better ways to integrate science into its organization. The four methods applicable in the ballistic missile program are some of the answers which have been developed over time. The most urgent need is not for more answers, but for means of evaluating those we already have.

The Test of Efficiency

It would require a massive amount of information, much of which must remain classified, to evaluate the various methods of science management which the Air Force has used. A more relevant goal would be an attempt to define some criteria by which a type of organization might be evaluated.

One criterion that has been applied to the missile program is efficiency. The purpose of a missile program is to develop a missile, and the form of organization which does this more efficiently than another is better than the other. This is the defense that was made for the Ramo-Wooldridge arrangement.[1] The problem is to determine the efficiency of a given means of organization.

It is also necessary to specify the area where efficiency is most important. One program may be efficient in terms of money but require an additional year of time. Another program may save time but divert scientific talent from other important projects. We must decide on which factors to economize. In the missile program as a whole, the most important factor, and the one to which we should sacrifice economies in other factors if necessary, is time.

In some development programs concurrent competitive efforts have proven a valuable yardstick for assessing each effort. An excellent case history is the development of aircraft engines within the Army Air Corps and the Navy.[2] The two efforts followed different approaches, each to some extent making up for the shortcomings in the other. Mr. Collbohm, president of the Rand Corporation, suggested something like this approach in his 1954 letter to the Von Neumann Committee protesting Ramo-Wooldridge's privileged position. Yet to assign the same missile project to two different groups, choosing the best system after both programs have run some length of time, becomes rather expensive. With aircraft engines the costs are comparatively low; with missiles costs quickly get prohibitive.

Infrastructure expenses mount up even more rapidly. To reduce lead time, base construction and affiliated projects must be undertaken concurrently with the development of the weapon system, restricting a pluralistic approach to missile development. If silos can only accommodate Missile A, the Air Force can hardly choose Missile B or Missile C for further development out of a three-model competitive effort. Nor can it build three silos for each one which will eventually be used. The more competing programs resemble each other—that is, the more they could use the same infrastructure—the less can be gained through a pluralistic effort.

The problem is to find standards of achievement in an area where they simply do not exist. Since technology is changing at an ever increasing rate, we cannot very well use past programs to measure present or future efforts. A highly dynamic state of technology also implies that we cannot use theoretical projections in place of an actual effort without a high degree of uncertainty. The rapid pace of scientific development denies us any assurance that our projections for 1970 are any more accurate than were our 1950 projections of what the 1960's would be like.

The unhopeful conclusion to which this lack of actual or ideal standards leads is that we cannot use results to measure the efficiency of a program with any degree of accuracy. But it is better to realize that certainty, or even an approximation of certainty, does not exist than to misapply the criterion of success.

If we cannot measure efficiency in terms of output, we can measure inputs under various systems. The basic assumption behind this working hypothesis is that as a general rule the more brains and resources are applied to a project, the likelier it is to develop better missiles. The two most important inputs in missile development are scientific talent and resources. We can, then, attempt to evaluate different forms of management organization by comparing their ability to provide technically competent personnel and to secure adequate resources.

In terms of personnel, three rough rules may be used in determining how effective a type of organization will be in attracting scientific personnel.

- The type of organization which offers higher material rewards will attract technical talent. These rewards may come in the form of high salaries, bonuses, or other financial payment. Stock options, because of their tax advantages, were an important factor in the structure of the Ramo-Wooldridge Corporation. Other material compensations, such as free health services or good-quality quarters at moderate cost, will contribute to the effectiveness of an organization.

- The type of organization which accords higher prestige to the scientifically trained person will attract technical talent. Since salary is an important element in prestige, this condition is related to the first. Even such matters as office size and furnishing may become prestige factors. Any form of official recognition of the especial value of technical training contributes to the scientist's satisfaction.

• Finally, the type of organization which gives a sense of personal accomplishment will attract technical talent. Thus the meaning of the uniform could be turned to advantage in building an in-house capability. On the other hand, one of the dissatisfactions expressed by scientific personnel, especially at the higher supervisory or planning levels, is that they seldom see direct results traceable to their own efforts and hence lack a feeling of participation in the project.

A second standard for judging the efficiency of a scientific organization is its ability to secure adequate resources. In practice "resources" boil down to money, since the missile program now has a high enough priority to get first claim on scarce raw materials. The difficulty is in defining adequacy. There is no simple way to determine whether enough, too little, or too much money is going into a particular project. It is possible to estimate within broad limits the economic utilities attached to alternative projects by calculating the cost of a program in relation to the cost of fulfilling the need without that particular program.[3] Yet this calculation is full of unknowns and at best serves as an indicator rather than a firm guide. Since some error seems unavoidable, it is better to err on the side of too much money rather than too little in the case of the ballistic missile program.

Public concern is strong enough to keep the steady stream of appropriations flowing from Congress to the missile effort at a fairly high level, no matter how the program is set up. But Congressional good will must be maintained, and the maxim for procuring resources is that the more Congress is satisfied with a particular form of organization, the easier it will be to get resources. Congressional pressure after the investigations into the Thompson-Ramo-Wooldridge Corporation led to the change from a profit-motivated corporation to the nonprofit Aerospace Corporation.[4]

These points, taken all together, may help to determine the purely mechanical efficiency of a given program. This criterion must be the foundation for any further evaluations of different types of organization for the management of the missile program.

The Test of Responsibility

In the ballistic missile program the Air Force has the responsibility for the largest single program which the United States has ever undertaken. Its magnitude in terms of dollars reflects its importance in absolute terms to the security of the American people. In addition to affecting our national security, the missile program affects hundreds of companies and through them the economic lives of millions of families.

Charles Francis Adams' report on the methods Massachusetts developed in regulating railroads.[6] Yet influential as this report was on the development of other government commissions, Mr. Landis' recent study on the Federal regulatory agencies[7] shows several areas in which the independent commissions developed away from the original concept.

And this, I think, is the historical parallel with the current situation. Today also we are faced with a whole new range of problems with which we have had little experience. A new instrument of public policy, the independent contractor, seems to be the main way we are meeting them. Possibly this is the logical extension of the independent commission in a society where the government is the active servant of the people rather than an impartial umpire over the forces of private enterprise. In any case the future development of the private nonprofit corporation under government contract depends on forces which can only be guessed at today—just as was the case with the independent regulatory commissions.

But there are certain features which the contract research corporation must retain to fulfill its functions. It must possess the technical competence which science management requires. It must be stable enough to build up the core of experience in the field where important choices must be made on incomplete evidence. It must be flexible enough to meet the challenges of pushing back the frontiers of the unknown. It must be independent of corporate, Congressional, and service pressures which would restrict its impartiality. It must be kept from misusing its power as a quasi-governmental agency serving a public function.

Two things especially must be remembered in connection with future types of science organization. First, the main problem is to obtain the men who are able to perform the functions of science management. Without quality personnel, no organizational scheme can solve the problem. The second consideration is that in light of the diversity of requirements which the contract research organization must meet, no institutional solution can be considered as final.

Harvard Defense Studies Program, Cambridge

Notes

1. Statement of The Honorable Joseph V. Charyk, Under Secretary of the Air Force, 6 May 1960, *Hearings before a Subcommittee of the Committee on Government Operations*, House of Representatives, 86th Congress, Second Session, (Washington: U.S. Government Printing Office, 1960), pp. 80-82.
2. Robert Schlaifer and S. D. Heron, *Development of Aircraft Engines and Fuels* (Andover, Mass.: Andover Press, 1950).
3. Charles J. Hitch and Roland N. McKean, *The Economics of Defense in the Nuclear Age* (Cambridge: Harvard University Press, 1960), pp. 243-265.
4. *Hearings, op. cit.*, p. 79.
5. *Ibid.*, p. 16.
6. Charles Francis Adams, Jr., *Railroads: Their Origin and Problems* (New York: G. P. Putnam's Sons, 1878).
7. James M. Landis, *Report on Regulatory Agencies to the President-elect*, submitted by the Chairman of the Subcommittee on Administrative Practice and Procedure of the Committee on the Judiciary of the United States Senate (Washington: U.S. Government Printing Office, 1960).

The Research Frontier...

BASIC RESEARCH BY AIR FORCE CAMBRIDGE RESEARCH LABORATORIES

A Quarterly Review Staff Brief

THE SCIENTIST . . . who discovers the precise position of oxygen atoms in a garnet lattice structure seems far removed from the Air Force objective of a communication system that will permit reliable and secure communications between any two points on the globe. The scientist . . . so engrossed in cataloguing solar prominences, does not seem especially concerned with the Air Force need to improve missile detection launchings occurring at any place on the earth."

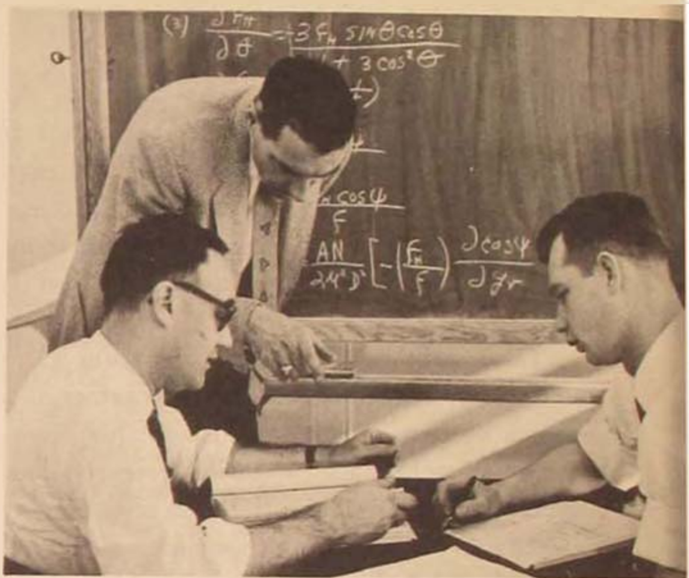
Thus Brigadier General Benjamin G. Holzman, Commander of the Air Force Cambridge Research Laboratories, in describing the basic research projects of two of the scientists in his command, emphasizes the seeming gap between current basic scientific research and present Air Force need. But he goes on to say that "both these scientists are extending by just so much the boundaries of human experience, and their essentially scientific pursuit is intimately related to Air Force problems of communications and detection and thus to the goal of maintaining a superior Air Force."

Formal recognition of the vital significance of such basic research to the Air Force came in April 1961 with the establishment of the Office of Aerospace Research. Then for the first time research was administered separately from developmental activities. The Air Force Cambridge Research Laboratories (AFCRL), the leading Air Force center for basic and applied research in electronics and geophysics, became a part of the Office of Aerospace Research at that time.

AFCRL, whose mission is to anticipate what techniques and equipment the Air Force will need from five to twenty years in the future, antedates this 1961 reorganization by more than a decade, for it was established in 1945 at Cambridge, Massachusetts. Now the AFCRL offices, laboratories, and principal research facilities are no longer at Cambridge but are located at Laurence G. Hanscom Field, which is about twenty miles from Boston and extends into the towns of Lincoln, Bedford, and Lexington.

At Hanscom Field the Cambridge Research Laboratories are in the midst of Air Force electronics research, development, and operations. This base is the headquarters of the Electronic Systems Division of the Air Force Systems Command, center of the so-called "Hanscom Complex." In addition to ESD and AFCRL the Hanscom Complex includes such independent organizations as MIT's Lincoln Laboratory and the MITRE Corporation. They all help to back

The main AFCRL laboratories at L. G. Hanscom Field, Massachusetts. Lincoln Laboratory, the MITRE Corporation, and the Electronic Systems Division of the Air Force Systems Command are also based at Hanscom.



A typical research conference at AFCRL. Basic research frequently requires nothing more than a desk, a blackboard, and inquiring minds.

up what ESD's former commander, Major General Kenneth P. Bergquist, referred to as the "aerospace control environment." AFCRL, then, is advantageously situated among some of the most significant electronics organizations in the Nation and has easy access to the great research facilities and libraries of the Boston–Cambridge area.

For most of its technical research problems, though, the AFCRL library is quite adequate. It contains more than 200,000 books and 500,000 technical and scientific reports, constituting one of the most extensive geophysics and electronics libraries in the country, which is exceeded in size only by those of several of our large universities.

In addition to its extensive research laboratories at Hanscom Field, AFCRL maintains many field sites for work in communications, weather observation, radar and radio astronomy, to name but a few. The largest of these sites is the Sacramento Peak Solar Observatory at Sunspot, New Mexico. Others are as far flung as Alaska, Hawaii, and Puerto Rico.

To staff these facilities AFCRL has about 1050 employees, of whom 650 are scientific personnel. It is these scientists who formulate or recognize ideas, approaches, and techniques in the fields of electronics and geophysics. They also investigate and exploit these areas of research for the Air Force. Besides the work done in its own facilities, AFCRL spends about $50 million a year to support approximately 1200 research contracts with various companies and universities. Usually these contracted research projects directly support the research conducted by AFCRL scientists.

Some of the more significant areas of research and experimentation at AFCRL concern electronics materials, upper atmosphere and space, the earth and information sciences, solar-terrestrial relationships, plasma physics, electromagnetic wave phenomena, meteorology, and energy conversion. Within these broad areas there are many more problems under attack than can possibly be described in any small compass. Yet even the few that we may briefly consider suggest the broad frontier of modern aerospace power, as wide as the encompassing curiosity of man's mind.

The Search for the Mind Machine

Amid the knowledge explosion of the mid-century no instruments of progress featured more importantly than the computers of the new order—the "thinking machines." Outstanding among the probings of the research frontier today is the continual effort for their improvement.

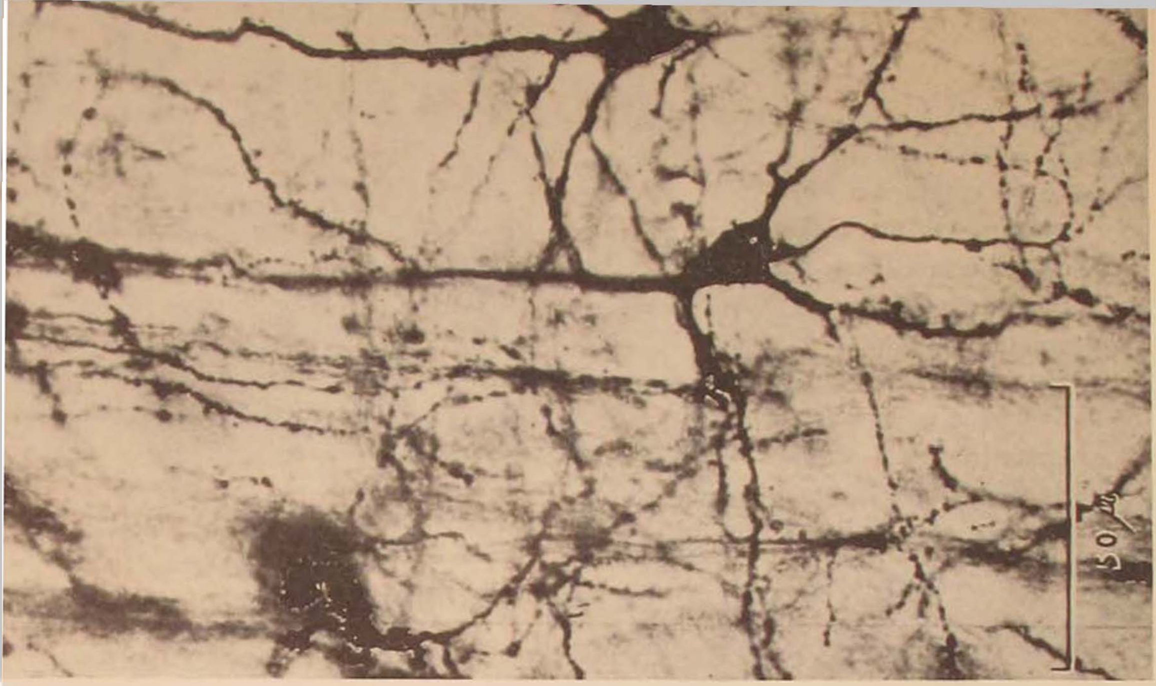
If in 20 or 30 years our intelligent machines exhibit true intelligence (as is now anticipated), they will probably not use present computer techniques. Instead they will have to use such techniques as rapid search, recognition, and association—all vital functions if future intelligent machines are to approach the performance of the human brain.

The physical terms of this biological system which has enabled man to learn, interpret, and understand so much of his universe are really very inadequately understood. Man must have a better understanding of these biological components if they are to furnish a key to future computers. Accordingly, the problem of signal propagation in neural systems has been investigated, and a conceptual model of a process for recognizing and ordering objects in a visual field has been evolved. This model, derived from biological rather than mathematical insights, helps to explain certain aspects of mental activity, for it duplicates many of the processes of the human brain.

The model, a two-part one, shows surprisingly broad capabilities, even though the parts retain only the essential characteristics of the biological counterpart.

The first part records and recognizes visual objects. To illustrate how neurons record for memory and future recognition, let us consider the pattern "O"—one of a multitude of geometric patterns that make up the objects in a person's visual field. The circular loop detected by the eye is not permanently imprinted. Instead, it has been suggested at AFCRL that the "O" is registered by the character of patterns generated by the "O" at successive time intervals in a neuronlike propagating space. Thus the record of each figure seen is a network that responds to a particular kind of waveform.

To understand how this plot is formed, we place the pattern contour, our "O," on a neuron plane, where the pattern surfaces act like radiators with constant energy density wavefronts propagating outwards. Imagine a grass fire instantaneously set at all points of a circular pattern; the fire would burn both



Neurons of the brain of a cat may provide the clue to more sophisticated computers. AFCRL computer scientists have worked in the past few years with neurophysiologists to learn more about the brains of mammals. Knowledge of neuron systems applied to "thinking machines" could result in computers which exhibit true intelligence.

inward to the center of the "O" and outward from its circumference. As the wavefront advances, even the straight segments of the radiating pattern assume a curvature, for the extent and nature of the curve are basic to the conceptual model.

If we assume that the "O" becomes a waveform, then we wish to associate it with similar waveforms (loops, rings, zeros, etc.) that we have experienced. Association, a basic part of creative mental activity, and recognition are explained by the second part of the conceptual model.

Behind the neuron plane of the model are "association elements," like matched filters that respond to waveforms of only a certain kind. If the association elements receive the proper waveform, they respond and recognize. This waveform is part of a general wavefront sweeping over the association elements, but only those modified by experience to recognize visual input data are affected.

A highly associative system results because information gathered at one point of the system is available to all other points. Prompt recognition and association of data from many parts of the system can be made only through such a propagating parallel search—quite a different process from the search of digital and analog techniques, which require direct connection.

Satellite Display System

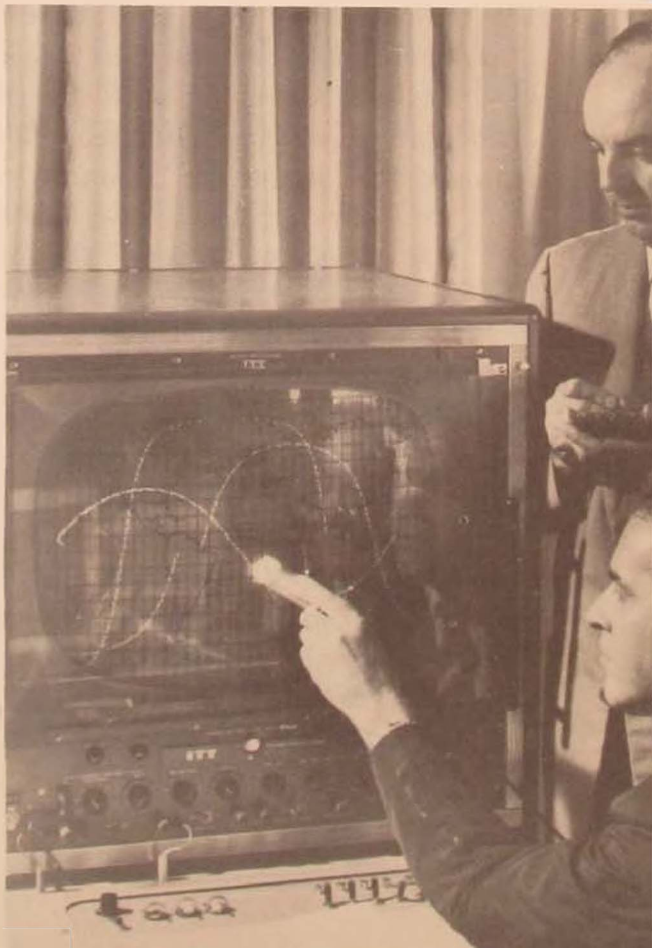
As more and more man-made objects are put into orbit about the earth, it becomes increasingly important to be able to show the position of one or more satellites at any given time as well as to display the position of any satellite at any arbitrarily chosen future time. A team of scientists at AFCRL has developed a system known as POESID (position of earth satellites in a digital display), which both tracks and visually demonstrates the progress of as many as six satellites simultaneously.

The POESID system uses a computer to keep track of the satellites. Then the tracks of these satellites are shown by a large cathode-ray tube which has a transparent map projection overlay of the earth on its screen. Intensified spots show the real-time positions of satellites on their respective tracks.

Punched teletype tape carrying satellite information serves as the input to the POESID system. This tape contains the identification of a specific satellite, the time and longitude of each south-to-north equator crossing, the time and longitude of each degree of latitude the satellite will cross, and the altitude at each degree of latitude. The system can display predicted positions up to nine days in advance. The operator programs this information on the tape to specific locations in a storage medium, and each predicted position in the storage device is automatically sampled and displayed. The operator may also select the satellites to be shown and may display from one to six of them.

By use of a photocell device called a light gun, a specific satellite may be identified from multiple tracks. Additional information about the satellite (such as the identification number, distance of apogee and perigee, type of scientific or military information transmitted from the satellite, data on launching, altitude, etc.) is shown when the operator points the light gun at the displayed target of particular interest.

The POESID system is used at the National Space Surveillance Control Center at Hanscom Field to augment control procedures.



POESID Display System tracking satellites. POESID (position of earth satellites in a digital display), developed by AFCRL engineers Fred Slack and Martley Mellows, tracks satellites by computer and shows their position on the map superimposed on a cathode-ray screen. Bright spots show real-time positions of satellites. The light gun identifies a specific satellite from multiple tracks.

Contrails can be suppressed. This B-47 carries contrail-suppression equipment developed by AFCRL. The systems attached to the exhausts of the left engines were testing when the picture was taken.

Contrail Suppression

Contrails usually form at altitudes above 25,000 feet when temperatures and atmospheric densities cause the solids formed by the combustion of jet fuels to combine with water vapor in the fuel exhaust to create comparatively large condensation particles. In their effort to prevent contrails, AFCRL researchers reasoned that if the size of water condensation particles from engine exhaust could be reduced to less than a half micron, they would not scatter visible light and thus would not be seen. The basic problem then was to find a chemical that would prevent condensation particles from growing larger than this maximum permissible size.

Much time and effort were devoted to the search for a jet fuel or fuel additive that would deter the growth of condensation particles. This search was abandoned in May 1961 when a new chemical and a new system, in which the chemical is added directly to the jet engine exhaust, were successfully tested. At first the new chemical had corrosive effects on materials, but this problem was solved later in the year. The empty contrail-suppression equipment for a large bomber weighs about 400 pounds. When the system is operating, the weight of the contrail-suppression chemical is about two per cent of that of the fuel being consumed.

The system and equipment have been successfully tested at Edwards AFB on both a B-47 and a B-52. This AFCRL contrail-suppression equipment has proved so effective that the Royal Air Force has decided to install it on one of its new bombers.

MAN AS DECISION-MAKER REVISITED

TEN years ago man—at least man in comparison to the very sophisticated computers then envisioned—seemed to be very nearly obsolete. Such jobs as the recognition of enemy aircraft and missiles, the evaluation of their threat, and the selection of particular defensive weapons to use against them could all be best performed by a computer. Man was too slow, his judgments subject to error.

Even before Project Mercury so dramatically showed that man can play a vital role in an age of missiles and computers, a joint study conducted by AFCRL and the Operational Applications Office of ESD indicated that man can do many defense jobs better and more economically than a computer. In arriving at this view an experimental control center was set up to simulate a defense environment. This center, equipped with control consoles, situation displays, light guns, etc., was designed to determine the extent of man's ability to make prompt and accurate defense decisions.

The objective of this joint project is to examine general decision-making processes for the benefit of future systems designers. At present we know more about the combat-environment performance of machines than of man. We can neither properly define his role relative to that of the machine nor fully use his unique capacity to make decisions until we are able to characterize his performance as that of a thoroughly experienced operator in the control center.

It would seem to be a simple matter to determine which jobs should be done by computer and which by the weapons controller, but it is not. Each raid is unique. The man-machine relationship that works for one defense situation could be entirely wrong for another. There is a "best" decision for each defense situation requiring a decision, and this "best" decision can be determined only after a complete analysis of the entire defensive exercise. Thus the performance of each control center operator can be evaluated against a "perfect" score.

Since establishing the experimental control center, AFCRL has run more than 1000 system exercises. In the simulated raid, a sector has been attacked by both aircraft and missiles, and the operator must assign fighters and missiles (each with a given kill probability) against a target. During the 45-minute exercise an operator is required to make hundreds of quick decisions.

To date the study has shown that the experience of the weapons controller is a much greater factor in arriving at the correct decision than had been anticipated. It had been reasoned that the performance of the controller would improve with experience, but it was also anticipated that his performance would level off at some given point. As yet there is little evidence of leveling off; operators continue to improve with added experience.

Presumably, then, man is capable of a much greater role as a decision-maker relative to machines than had formerly been believed. Hence future defense systems should consider man's full decision-making potential before assigning roles to the computer and to the weapons controller.

WINDS AND MISSILES

THE pursuit of perfection is one of the goals of the scientist, and though he never quite achieves the goal, he frequently draws closer to the mark.

Considering the effects of air density, friction, and wind, it is not likely that an ICBM would score a bull's-eye, even if it were possible to aim it "perfectly." Precision in predicting winds over the target area as well as knowledge of the interrelationship of these winds with the air density and missile design thus becomes important to determine how far off-target a missile will impact.

The critical factor in such a relationship is the wind over the target area. The problem that resulted concerned the possibility of predicting target winds from data observed at stations several hundred miles away. AFCRL scientists began by sampling the winter winds over a four-year period at 40 stations, all of which were at least 700 miles from a hypothetical target area. The samples were taken at various altitudes up to 13 miles. Two approaches were tried to relate the established wind patterns to the distant target winds on a new occasion: (1) sampling the station winds at 5 different levels up to 13 miles and (2) considering only the average wind and density over the 13-mile altitude. The first method was found to require 10 equations and the second only 2, but the lengthier system was more easily adapted for computing wind effects on missiles of different types.

One can see how effective the forecasts are upon accuracy by using a circle of probable error (CEP) centered over the target and of radius to contain one-half the impact points. The CEP would have a radius of 0.9 mile for a particular missile if the wind were ignored. This radius becomes 0.8 mile when a compensation is based on climatic (average seasonal) winds at various levels. (The station used had quite a low wind speed, thus the small contribution of climatology.) Yet both the methods of forecasting decreased the CEP to a 0.4-mile radius. When the distribution of impact points near the target is considered, the advantage of forecasting becomes still more evident.

Impact points within ½ mile of target	
No wind assumed	16%
Average seasonal winds considered	26%
Two forecasting methods	59% and 62%

Prediction of target wind ensures greater ICBM accuracy. AFCRL studies wind patterns from ground level up to altitudes of 300 miles or so. Here a sample smoke generator is used to indicate winds at ground level.

It is obvious, then, that wind forecasting techniques can make a significant improvement in accuracy over climatology, even though the target may be several hundred miles from the nearest observations.

Solar Proton Shower Hazard

Now that the location of the Van Allen radiation belts is known and apparently can be avoided, perhaps the greatest hazard facing space travelers will be fast solar protons. Solar proton radiation, which is intermittent and cannot be readily forecast over long periods, can be quite dangerous to the unprotected man and can also damage some sensitive instruments.

Since the least expensive defense against damage is to avoid proton showers, it is necessary to have reliable predictions of safe intervals. AFCRL's Sacramento Peak Observatory at Sunspot has been studying methods of predicting periods of solar proton showers since March 1961. The observatory has been making reliable 5-day predictions and is trying to extend the forecast period.

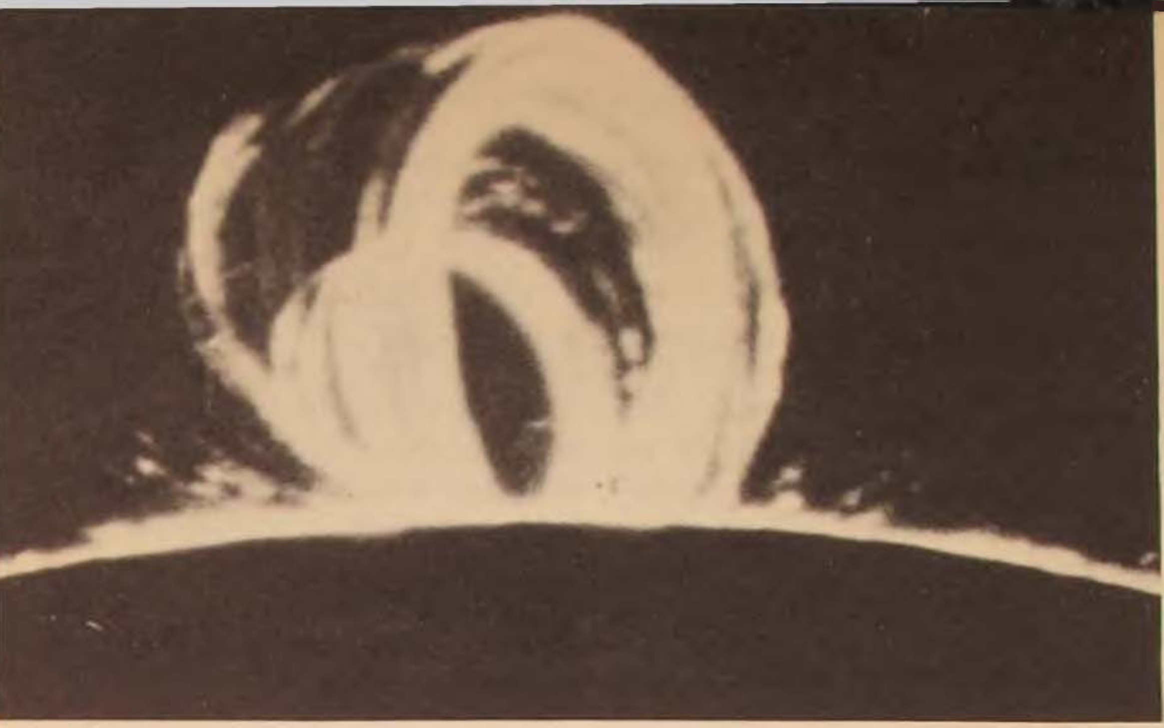
All dangerous proton showers emanate from solar flares, and they arrive at the earth anywhere from a half hour to six hours after the peak brightness of the flare. Not all solar flares produce proton showers (approximately one major flare in four produces these showers), and this of course complicates forecasting. Solar flares and sunspots are closely associated and share the same 11-year cycle pattern. During sunspot maximum, proton flares occur about once a month, making prediction difficult. As the last maximum was in 1957–58, a minimum is expected in 1964–65.

If space flights were scheduled without regard to solar protons, what would happen if 5 space flights of 5-day duration were made during a year of maximum sunspot activity? In such a year we may expect 13 proton showers, so that the probability of the space traveler entering at least one shower is .73. In ten flights the probabilities would rise to .93. Statistically, the traveler making 10 such 5-day flights would expect to encounter 2.5 proton showers.

The Sacramento Peak Observatory group, in its effort to predict safe intervals during which no proton showers occur, seeks direct indicators of potential proton showers. There are several such indicators. For example, all recorded proton showers have originated in active centers of the sun. These active centers are regions of sunspot groups, one or two hundred thousand kilometers in diameter. Only a few of the active centers produce large flares and still fewer emit dangerous proton showers. The trick, then, is to locate the dangerous shower in advance.

Other important clues are provided by the size and complexity of the sunspot group. There is still no definite indication in what stage of the development of these groups protons are most likely to be emitted. More sophisticated instruments are needed to reveal other characteristics. The Observatory will soon be able to use a differential photometer that will reveal the differences in brightness of the areas of the sun containing the sunspot groups.

A sunspot center with a complicated magnetic field produces on the average about five times as many flares as a center with a simple or unipolar field.



Solar flare photographed from AFCRL Sacramento Peak Observatory, New Mexico. High-energy solar protons, potentially a great hazard both to the unprotected space traveler and to scientific instruments in space, emanate from such flares. AFCRL scientists help mitigate this danger by developing proton shower prediction techniques.

Knowing this, the Observatory group has begun constructing an electronic Zeeman-effect magnetometer that will enable complete mapping of the longitudinal magnetic field of an active center.

Another potential indicator is the age of these active centers. Less than 10 per cent of the proton showers come in the first 15 days. Approximately 75 per cent of the showers come from centers 15 to 30 days old.

The occurrence of peculiar loop and surge prominences and coronal hot spots is among other features which AFCRL scientists believe may be flare indicators.

All these possible indicators of a proton shower must be properly weighted in any prediction system. A massive statistical analysis is therefore necessary to sort out the significant combinations. The Sacramento Peak group believes that further study of these indicators will result in substantial improvements in its prediction techniques.

More Precise Location of Land Masses

Although Johnston Island may figure prominently in future atmospheric atomic tests, scientists are still not certain of its exact position. They suspect that the spot assigned to it on the map may be in error by as much as 800 feet. Hawaii may be misplaced by 400 feet. Similar inaccuracies may mask the exact positions of the land masses of the world and the precise distances between them. AFCRL's Terrestrial Sciences Laboratory has therefore begun a series of experiments that may improve the geodesist's precision in locating positions and fixing distances. Particular attention is being given to the Pacific regions.

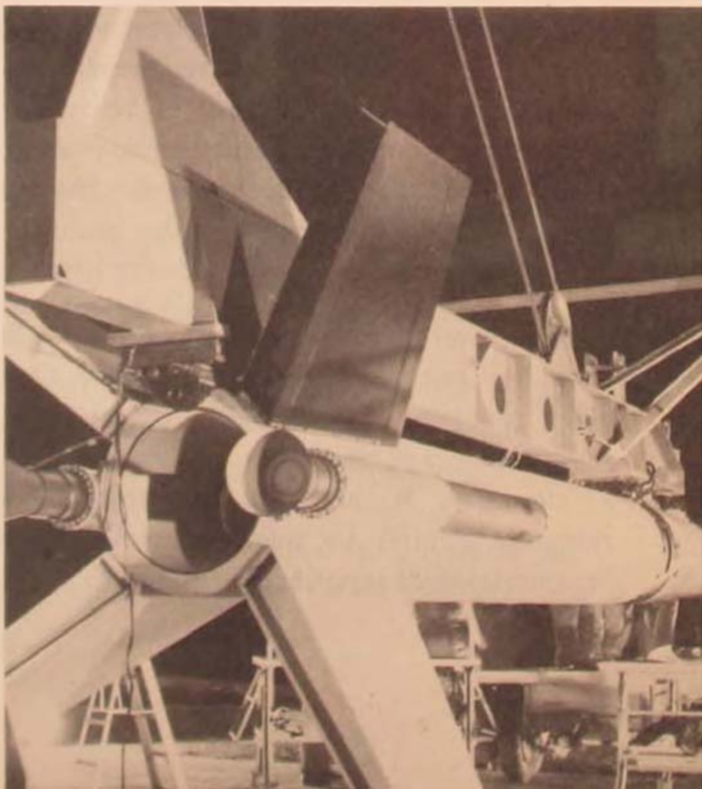
These studies make use of AFCRL's rocket-flash triangulation technique. High-intensity flash cartridges are ejected into the night sky, and the flashes are photographed against a star background by highly accurate cameras located at widely scattered sites around the Pacific.

On 8 December 1961 an Astrobee 1500 sounding rocket was fired from the Naval Missile Facility at Point Arguello, California. The rocket contained three 7-flash "Poppy" pyrotechnic cartridges developed by the Army's Picatinny Arsenal at Dover, New Jersey, and constructed at AFCRL. Each flash was designed to produce a peak light of 62 million candle power. The cartridges were programed to eject in three groups of seven during the rocket's flight and were timed to fire at altitudes of 900 miles, 1400 miles (apogee), and again at 920 miles during descent. The apogee point was about halfway between California and Hawaii.

This technique is actually a photogrammetric extension of classical surveying principles from two to three dimensions. The objective is to photograph the flashes and star background simultaneously from at least two stations whose geodetic coordinates are accurately known and also from any number of sites treated as unknowns. Since the celestial coordinates of the stars are precisely established, it is possible to "fix" the spatial coordinates of the flashes by intersection from the two known stations. Then it is possible to compute the positions of the other stations in terms of the known stations by determining the coordinates of the flashes and stars on the plates. If at each station two or more plates are taken of separate sections of the star background, positions of unknown stations can be computed without knowledge of local gravity. This elimination of gravity factors does away with a significant source of error present in other surveying techniques.

Sitka, Alaska; Spokane, Washington; and Lincoln and El Centro, California, served as the four "known" stations. Mauna Loa, Hawaii, and Kaena Point, Oahu, were the primary unknown sites, where two cameras were located. Still other sites were used to provide redundancy, to extend the technique for such special purposes as positioning a ship at sea, to determine if widely varying

Final prelaunch preparations are made on the Astrobee 1500 at Point Arguello, California. This high-altitude sounding rocket, follow-on to the 15-year-old Aerobee series, was first used last December in AFCRL's photogrammetric triangulation study to project three 7-flash "Poppy" pyrotechnic cartridges. The cartridges flared at 900 miles, 1400 miles (apogee), and at 920 miles during descent.



types of existing equipment could be used, and to investigate atmospheric turbulence and refraction problems. Visual sightings were made of the rocket from Hawaii, Johnston Island, Alaska, and California. Such studies can be expected to result ultimately in more precise maps.

Tektites and the Age of the Lunar Maria

Among many problems pursued by the Air Force, one concerning the nature of tektites may seem as remote as any from the realm of practical reality. Yet that study has provided information which may be of critical importance in the coming exploration of the moon.

In recent years some small glasslike objects called tektites have been subjected to close scientific study. Besides their peculiar composition, unlike any other rock found on earth, tektites have unusual geographical distribution (Czechoslovakia, Indonesia, Australia), and their shapes and surface markings indicate flight through the atmosphere. These characteristics have suggested that tektites are of extraterrestrial origin. Their normal isotopic ratios indicate, on the other hand, that they did not come from outside our solar system. The most likely extraterrestrial source of tektites within the solar system is the moon, and many investigators assume that they are melted fragments of the lunar crust blasted into space by meteorite impact and captured by the earth through the attraction of its magnetic field.

In an effort to learn more concerning their nature and origin AFCRL has contracted Massachusetts Institute of Technology to perform very high precision chemical analyses of the tektites. The MIT analyses have discovered for the first time the presence of measurable quantities of radiogenic strontium. Strontium 86-87 isotopic ratios indicate that if the tektites are derived from the most likely sources, such as chondritic, granitic, or tektitic material, the age of the parent material must be in the neighborhood of 200 to 500 million years. If tektites are fragments of the moon, then portions of the lunar crust from which they derive were last molten at that time.

Traditional theory of lunar thermal history holds that the final portions of the lunar crust to be melted were the maria and that this occurred billions, not a few hundred millions, of years ago. This new evidence by way of the tektites thus requires a complete re-evaluation of theories of the thermal history of the moon, and it also poses the interesting idea that possible indications of recent lunar history reside in the geologic record of the earth.

These brief descriptions reflect but eight of the scores of research projects currently pursued by the Air Force Cambridge Research Laboratories. The eight problems they concern and their experimental investigation are neither more significant nor more "dramatic" than others that might have been chosen as examples. Rather they are typical of the advanced positions taken on the research frontier by one major Air Force agency in pursuit of the goal of "maintaining a superior Air Force."

Air University Quarterly Review

Strategic Missiles and Basing Concepts

Major Kendall Russell

THE Air Force's present emphasis on ICBM weapons is due not so much to their capability to penetrate enemy defenses as to their adaptability to survival measures preceding launch. This factor assumed prime importance when the potential enemy also developed an ICBM capability which would enable him to strike U.S. bases with little or no warning. Air bases with their extensive facilities and concentrations of aircraft became in prospect extremely vulnerable. Missile systems, on the other hand, suggest economically feasible measures for adequate force survival in the face of this new threat. These survival measures manifest themselves in a variety of basing concepts. It is the purpose of this discussion to highlight the interrelationship of these basing concepts with over-all missile force effectiveness.

There are many exhaustive treatments of the various ramifications and requirements for a successful policy of deterrence. Three of these requirements will be considered to the extent that they apply to missile force effectiveness, particularly as to how they influence the process of selecting the preferred basing concepts for missile systems. These three requirements are:

(1) Survivability—the capability of the force to counterattack after sustaining an initial enemy attack

(2) The capability to destroy targets—the yield, accuracy, reliability of the systems, the numbers comprising the force, and the nature of the targets

(3) The credibility of their employment—the degree to which the enemy and others believe the force would be used and under what provocations.

None of these factors will be completely assessed here, but some of their more important influences on preferred basing concepts of missile systems will be highlighted and some conclusions attempted. The

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This article is based on a staff study prepared by the author as a part of his academic work while a student at the Command and Staff College, Air University.

approach is philosophical and not tailored to a particular missile frame. The idea is that concept should come first and the vehicle should be designed to fit the most desirable basing concept.

survivability

A force which appears to an enemy as vulnerable to elimination by surprise attack cannot provide an acceptable deterrent. The survivability of the force must be obvious, to ensure that its ability to counterattack is unquestioned. Survivability tactics embrace dispersal, hardening, deception (including hidden, mobile, and decoy bases), warning and recall, active defense, and numbers. Each of these defensive measures warrants discussion.

Dispersal. Dispersal should be an axiom of the missile age. In an era when an enemy can strike with little or no warning it is not sensible to create lucrative targets by concentrating our forces. Dispersal should be considered from the point of view of the relative cost of what we have invested at a particular point versus the investment required of the enemy to destroy it. Such an approach can bankrupt an enemy who attempts to challenge our entire force. Lucrative targets are magnets for enemy research and development efforts; therefore survival concepts which involve high investment per location are especially vulnerable to loss of effectiveness through the enemy's technological advances. Dispersal takes advantage of the inherent fast-reaction capability of modern missiles in such a manner that the enemy would have to plan on striking many places simultaneously. Such a massive attack maximizes our possibility of obtaining warning through Midas and BMEWS type systems.

Hardening. Hardening is undertaken to reduce vulnerability of systems to nuclear weapon effects. As applied to missiles, hardening has been contemptuously called a Maginot Line concept. The analogy is not valid as applied to ICBM's. Offensively the ICBM represents something of an ultimate in mobility—its range is such that it is continuously engaged with the enemy and cannot be "outflanked" or avoided.

The accompanying table indicates the megaton yield required of a

Table 1
Yield Required for 90% Kill Probability

CEP (nm)	2	1	0.5	0.25
Hardness (psi)	Yield (mt)			
2	0.2	0.03	0.004	0.0008
25	45	5	0.6	0.08
100	200	25	3	0.4

single warhead to ensure a 90 per cent kill probability of a point target for indicated levels of hardness and for various delivery accuracies. The hardness levels of 2, 25, and 100 pounds per square inch correspond respectively to the likely vulnerability to moderate damage of a completely unhardened system, of the early hard Atlas, and of the early Titan. Besides indicating the increased yield required to destroy increasingly hard targets, the table demonstrates that even extremely accurate offensive weapons require yields in the hundreds-of-kilotons range against hard targets. Also, for particular enemy weapon capabilities, as defined by his yield and accuracy, hardening requires him to expend a greater number of weapons to achieve the necessary destruction. Table 2 provides illustrative examples.

Table 2
Number of Weapons Required
for 90% Kill Probability

Hardness (psi)	10 mt, 1 nm CEP, 80% System Reliability	10 mt, 2 nm CEP, 80% System Reliability
2	2	2
25	2	4
100	3	11

Hardening diminishes the distance required between two point targets so that a weapon of the designated yield cannot destroy more than one, as is shown in Table 3. The extreme distances required for soft or unhardened targets should be noted, also the considerable reduction permitted by even moderate levels of hardness. The effect is squared for area deployment of a large force.

Table 3
Required Separation Distance

Hardness (psi)	10 mt	100 mt
2	25 nm	54 nm
25	4.7	10
100	2.7	5.3

If sites are hardened to only 2 psi, an area of 1,000,000 square miles is required to deploy a missile force of 1600 missiles against a 10-mt threat in order to expose not more than one missile to a single enemy warhead. If the basing is hardened to 100 psi, the deployment area is reduced to 11,664 square miles (as can be figured from Table 3). Obviously it is not practical to consider completely dispersing a fixed missile force of this size within the United States, an area of approximately 3,000,000 square miles, unless the force is hardened. The area required for the dispersed hardened force is only one tenth the area of Nevada.

Hardening costs money, but, depending upon the system, it is not necessarily very expensive. Recently a contract was let for the construction of 150 Minuteman hard sites plus 15 hard launch control centers, for a total construction cost of $61 million. This is approximately $400,000 per missile. A soft site could not cost much less, considering necessary security and environmental protection as well as launch requirements. Unfortunately the general impression is that hardening is extremely expensive. This impression has been created by the experience with the Atlas and Titan missiles, whose large size, complex cryogenic fueling systems, and on-site manning requirements have indeed necessitated unusually expensive bases.

Dispersal also costs money. If a large force is spread over an enormous area, support costs for maintenance, security, and missile delivery are compounded. Aside from reducing the target's vulnerability, hardening pays for itself by savings in dispersal costs; indeed for a large force hardening is required if only to make dispersal feasible.

Hardening also virtually eliminates other than nuclear threats to the force. The enemy should not be permitted a situation in which he could threaten our nuclear retaliatory force by overt or covert means short of a major commitment of his prime force. Sabotage is an ever-present possibility. Hardening requires heavy, airtight accesses, which are reasonably tamperproof. This feature permits unmanned missile sites, with consequent savings in manpower and costs.

Hardening has one large disadvantage common to all fixed systems—the enemy knows where you are. It loses in effectiveness as enemy accuracies improve, although it is still desirable because of its interrelationship with dispersal.

Deception. Deception presumes that somehow you can prevent the enemy from determining your position, by mobility or concealment or by a profusion of decoy bases. As a survival measure deception has one fundamental shortcoming: if the enemy is no longer fooled, its value diminishes to zero. The point at which the enemy has devised methods for locating hidden systems, tracking mobile systems, or ignoring decoys may not be identifiable. Thus a nation could believe that its posture was effectively deterrent when in fact it no longer was.

Hiding bases within the continental United States is not practical, considering our type of society. The use of decoy bases is also probably impractical. Mobility is practical and was programed for a portion of the Minuteman force. The primary attractiveness of mobility is that its effectiveness is independent of enemy improvements in accuracy. However, a mobile force is subject to enemy intelligence and reconnaissance efforts and to area attack.

The ultimate size of a soft mobile force depends on the size of the area available for its deployment. An obvious tactic in challenging a land mobile system is to increase the yield of the attacking system, as opposed to improving accuracy as when challenging a hardened force. A 50-mt weapon produces a destruction area against soft targets of some 1600 square miles; a few thousand such weapons could blanket the country. Once a mobile force becomes so large that the enemy cannot ignore it and must target it, additional mobile systems in the same area would not add to his targeting problem. As far as he is concerned, the same number of weapons covers the area. If some hardening can be incorporated into the mobile concept, the enemy weapon requirement is drastically increased, and consequently the size of the mobile force appropriate for deployment in a given area is increased.

Mobile systems require more personnel and costs than fixed systems. The transporting vehicle must be procured and maintained, whether it is a ship, submarine, airplane, or train. Extra people must be involved in operating the transporting vehicle and its supporting equipment and facilities. Additional people, vehicles, facilities, and equipment have an impact throughout the training and logistic pipelines. These extra costs must be justified on the basis of a profit in survivability.

Furthermore mobility compounds operational and technical problems. For example the guidance problem may be considered. Unless target-seeking guidance is used, a mobile system adds the problems of navigation and fire control. An inertially guided missile must know where it is; it must have an accurate local vertical reference and an accurate azimuth reference—problems of no consequence for fixed systems. For mobile weapons the required navigation system can be quite complex. For the seaborne systems the methods that provide vertical and azimuth reference can be even more troublesome and potential sources of appreciable errors. An error of one degree in azimuth reference results in a 100-mile miss at 6000-mile range.

Before leaving the subject of mobility, we should note that airborne alert is a form of mobility as a survival measure. Considered purely as a survival measure it makes little difference at what speed the aircraft travels while loitering. Therefore, if the prime purpose of the aircraft is to act as a missile platform, its speed capability in this particular context is not important. A cargo type can be as effective as a supersonic aircraft in this role, given sufficient range in its missile.

Warning and Recall. Warning and recall should be discussed as a pair. In most cases both capabilities are required simultaneously to provide an acceptable survival tactic. If no recall capability exists, then there must be 100 per cent confidence in the warning indication; and conversely, if warning is not 100 per cent certain, then the recall capability must be complete. Otherwise false alarms may precipitate the very war that was to be deterred. In view of the intent of an aggressor to exploit surprise, reliance on warning alone is no longer acceptable.

To capitalize on warning and recall as a force-survival method obviously requires a high degree of organization and centralized positive control. Missiles thus far cannot be recalled any more than a bomb already dropped from a bomb bay or a bullet fired from a gun. But modern missiles are capable of extremely fast reaction, especially those fueled with solid propellants. It is extremely desirable to be able to capitalize on this capability in the eventuality that an unqualified warning is obtained, for the enemy can never be certain that we will not have warning. On the other hand it is not desirable to base survivability solely on this fast-reaction ability. This tactic could create a hair-trigger situation under which the temptation for the enemy to undertake a pre-emptive attack to destroy the threat might become unbearable.

Active Defense. The introduction of nuclear weapons in warfare caused air defense to become inadequate for protection of the offensive force without other means of survivability, as the defense would have to approach 100 per cent effectiveness. The ICBM has further compounded the air defense problem to the point that feasibility of attaining even low survival capability is challenged. Dr. Edward Teller suggests that the situation is not likely to change, that vast sums can be spent on active missile defense only to be countered simply and cheaply by the offense.

There is little question of a shift in balance of power in favor of the side that first perfected an effective defense. The trick, of course, is doing it. Research is certainly appropriate. But since deterrence is the primary objective, more deterrence and hence more protection may well be bought through investment in offensive systems than in marginally effective, and very expensive, active defense.

Numbers. The old principle of numbers is considered here as a survival tactic. One can become so engrossed in survival measures for individual systems that the nonsubtle approach of creating a force too big for an enemy to handle is easily overlooked. Of course this approach must include dispersal. As previously indicated, it would probably also involve some hardening to allow dispersal and provide its side benefits.

Where today SAC represents a relatively small number of targets to any attacker, the incorporation of missiles, dispersed, provides the opportunity to increase this number manyfold, compounding the opposing targeting problem in proportion. Too often the comparison of basing concepts is approached from the viewpoint of single systems rather than of total force. For example, there is little doubt that a fixed, soft missile has less survivability than a mobile, hardened missile. But if one could buy five fixed, dispersed, soft missiles for the price of one mobile, hardened missile and if the enemy had only three missiles, then the soft system would have greater survivability.

target destruction ability

The capability of systems to destroy targets is primarily defined by their accuracy, range, yield, and reliability, the nature of the target system, and the numbers available. It is not the intention here to treat target destruction ability at length other than concerning its influence on the selection of a basing concept. Each of the related factors will be assessed from this point of view.

Accuracy. If it were important to the argument, a considerable discussion could be made of accuracy as a function of range, of fixed or mobile bases, of airborne or submersible bases. The problem of accuracy is a technical one, and one apparently capable of solution for most cases within the foreseeable future. Highly accurate systems are predicted, and the appropriate development approach is known. Some of the complications with regard to mobile basing versus fixed basing have been mentioned, but the principal impact of these complications is on cost and possibly on reliability, at least in the long run.

Range and Yield. Range and yield may be associated because from the point of view of this discussion they are important only in sizing the missile. Missile technology provides for extremely heavy payloads and extreme ranges, as is evident from some of the Soviet accomplishments with very large satellites. Orbiting systems represent something of an ultimate in range, if measured to the perspective of the earth. Offhand, no known restrictions limit the size of a missile; space people are talking of vehicles weighing millions of pounds.

Size has an impact on basing concept. It is difficult to envisage very large systems as tactically mobile. Smaller systems, of course, are more adaptable. The mobile Minuteman is an example of a land mobile system. Skybolt is an example of an airborne mobile ballistic missile system. Polaris is the seaborne system. Modern technology is such that a missile can be sized to provide useful range and payload and to be deployable within the constraints of a wide variety of basing concepts.

Reliability. Reliability has a direct impact on the relative desirability of fixed or mobile basing. First of all, a mobile system may be subjected to varying degrees of shock and vibration for extended periods of time. Secondly, there is the interaction of mobility and the guidance problem previously mentioned. And thirdly, from the point of view of reliability a hardened site gives very nearly the ideal basing. Hardening demands underground emplacement. This in turn provides a stable environment for the missile which is conducive to long shelf life. Temperature and humidity are easily controlled.

Reliability has another influence. It must be considered from the standpoint of peacetime as well as wartime operation. Exotic basing concepts, such as bombs in orbit, may be ruled out on the basis of the peacetime reliability problem, real or presumed. At least the burden of proof rests on such concepts that operation can be safe from accidental launch over indefinite periods.

Nature of the Target System. In forming a weapon system concept a good place to start is the intended target system. It is desirable that the force be capable of engaging the widest variety of targets to provide the greatest flexibility. The targets determine the required combinations of yield and accuracy. The target system determines the number of weapons required on target. The total number required, of course, is also influenced by the desired probability of target destruction.

If we are to think in terms of counterforce, then it is particularly necessary to assess the responsiveness of the force to command and control in order that optimum tactics can be employed, whether these optimum tactics involve salvo or selective launch.

Numbers. The last parameter affecting target-destruction ability is the number of weapons available for commitment, which has definite influence on the selection of a basing concept. If the budget available for the strategic mission is expended so as to maximize the number of weapons available, it provides great flexibility. The maximum force can engage the largest number of targets, be massed against difficult targets, be used to saturate defenses, or be employed discretely—by firing some and withholding some elements.

As the enemy attempts to build survivability into his force, he will undoubtedly exploit dispersal. Large numbers of weapons will be required to provide the capability to engage this force.

credibility

We are committed to major military action under certain circumstances short of direct attack upon the United States. For example, our commitment to NATO is that an attack against one member is an attack against all. The NATO defense policy relies upon a "sword and shield" strategy, the shield being the NATO tactical forces and the sword being the U.S. Strategic Air Command. Hesitation on the part of an aggressor to attack a European NATO member is not so much a function of the survival capability of SAC as of SAC's offensive power if direct attack upon the United States or its forces is not immediately involved.

It is important that a potential aggressor hold credible the surety and power of this counteroffensive response. The over-all force size is dollar limited, and the alternatives of expenditures within dollar ceilings determine our posture. If the basing concept selected for the strategic offensive force should be so expensive as to compromise the total number of weapons available, then the basing concept compromises the credibility of our response. It is not necessary for the aggressor to initiate any type of military action to reap a military profit from this compromised position. The degree to which our allies believe in our resolve to come to their aid through the employment of SAC, for example, may affect resolve to remain committed to a defensive alliance, may influence actions in the U.N., or add to the possibility of bilateral accommodations external to the alliance. A concept which maximizes the number of weapons in the offensive force also maximizes the credibility of going to the aid of another nation.

Another aspect of the credibility of response is also important to basing concepts. Most often, considerations of force survival are concerned with a massive simultaneous assault. Other forms of attack may be invited by the basing concepts adopted. For example, it has been advocated that the strategic offensive power of the U.S. be placed aboard nuclear-powered submarines and nuclear-powered seaplanes based outside the United States. Attack upon such a force, it was reasoned, would not cause concomitant damage to the population and economy of the U.S. proper.

A force thus based would face, however, a very real threat of piecemeal attack. Our response to a large simultaneous attack on this force would probably be unequivocal, but our response to a piecemeal attack may not. The Soviets have shown little reluctance to shoot down one of our aircraft from time to time. The loss of a missile-armed submarine on patrol is different, but in the view of a potential enemy how much is it different in keying response?

Certainly the vehicle commander cannot be authorized to launch his missiles of his own volition when under attack, thus possibly subjecting the U.S. to direct attack. Ability to communicate that he is under attack is not at all certain. Our first indication of loss of the submarine may not be received for some time, and the determination that the failure to report was due to covert or even overt attack by the enemy may not be immediately possible. It is hardly credible that such a loss, whether or not it could be immediately and conclusively demonstrated to be due to overt action, would bring certain massive counterattack.

Our response might be in the form of counterattacking the local threat, but the local threat could be only a minelayer, killer submarine, long-range interceptor, or other relatively low-cost weapon system. We would have lost a significant unit of our capability at little risk and cost to the enemy. Lately a number of writers have alluded to the possibility of a private naval war between the Polaris fleet and hostile antisubmarine forces. But the primary purpose of our strategic systems is to deter war. We cannot afford to risk a substantial portion of our deterrent capability to a series of small, indecisive actions.

The foregoing reservations are generally applicable to all systems whose basing is divorced from the fundamental sovereignty of the United States itself. If deterrence is to be maximized, the offensive force must be intimately associated with what it is to protect, so that our response to an attack on our deterrent force is clear and credible to everyone. Too much has been made of the idea that "when Polaris is attacked, civilians don't get hurt." The enemy would not attack submarines with ballistic missiles or strategic air forces. He would attack them with submarines, mines, or surface forces, freeing his entire missile force and long-range bombardment force to attack the U.S. directly. On the other hand, basing of our strategic force in this country in sparsely settled areas draws the enemy's fire away from the population, since he cannot effectively challenge the protection provided by such a force unless he attacks it and defeats it.

numbers

One central theme has permeated all three aspects of our discussion of force effectiveness—numbers: dispersed numbers for survivability; numbers for saturating defenses, engaging the largest number of targets, and maximizing target destruction; numbers for maximizing the credibility of initiating hostilities if the United States is sufficiently provoked; numbers to stiffen the resolve of allies. There is nothing very novel in these observations about numbers of weapons, but the fact is that they are often not appreciated.

When a new weapon system concept is evolved, the designer has a choice. He may put emphasis on survivability or on target effectiveness. Polaris is an example of the former emphasis; the manned bomber is an example of the latter. But do these alternate possibilities of emphasis really pose a dilemma? By buying numbers of missiles, and dispersing them, one can have his cake and eat it too. Minuteman is an adaptable system. The Minuteman concept envisions a missile that is designed for mass production and reliability, that eliminates on-site manning requirements through the exploitation of automation, that minimizes field maintenance, and that permits remote control of many missiles from one center. All these measures have the object of reducing the investment per site to a minimum and therefore maximizing the number of missiles that can be procured within a given budget. It is interesting to note that, in quoting the Air Force's ten top priorities, General White, then Chief of Staff, stressed that ICBM's subsequent to Minuteman should be "even smaller, less complex, and less costly missiles, possessing comparable or improved range, accuracy, reliability, and load-carrying characteristics."

The idea of evolving some form of basing concept that will provide complete, reliable survivability under all conditions is fascinating to all military thinkers. All sorts of concepts are considered: orbiting satellites, submersible barges, even sites behind the moon. But the idea that the principle of mass can be repealed over an extended period by resorting to novel tricks ignores the rate of technical progress. A more appropriate approach is to ensure that the loss of a particular base is not cataclysmic or even serious. Such an approach to effectiveness is least susceptible to obsolescence.

Those weapon systems which have become obsolete since the dawn of the nuclear weapon era have done so because of loss of capability to survive either on the ground or in penetrating defenses. Consider the B-29 and B-36. Payload, range, reliability, and accuracy were in general satisfactory. Survival considerations caused their obsolescence. If we apply this lesson to a dispersed missile concept which is primarily designed for minimum cost per site, it is difficult to predict a point when the force would become obsolete. Modular improvements within the fundamental concept would be practical and economic. Improved propellant capabilities would provide greater payloads for increased yield, for inclusion of penetration aids, for sophisticated re-entry vehicles capable of maneuvering, and for greater range. Improved guidance for improved accuracies could be adopted without altering the concept. Complete redesign of the system is not required for one of these improvements, or for all, and they can be phased in piecemeal. One of the greatest improvements would be to lessen the cost per missile so that for any given budget more weapons can be deployed, thus increasing the enemy's targeting problem and increasing our offensive power.

Development costs for modern systems are exceedingly high, and they constitute a major fraction of the total buy-out costs for a weapon system. It makes good sense to amortize these costs over a large production run. It is sobering to compare the total increase in national strength by applying funds to buying more dispersed missiles in lieu of undertaking some new developments.

Some may read into these words the thought that the nuclear-armed, solid-propellant, U.S.-based ICBM is being touted as an ultimate weapon. Nothing is an ultimate weapon, though it does appear that this type ICBM represents something of a plateau. But paradoxically this appearance of a plateau does not relieve the urgency of gaining a space capability. In actuality that urgency is magnified. Space capability is required not for the deployment of weapons—at least not in the immediate future—but to support the numbers concept by those tasks that probably can best be done from space, such as reconnaissance, warning, and perhaps command and control.

The numbers principle as an approach to military superiority is a completely natural one for the United States. World War II was won through the quantitative approach. Mass production is this country's area of expertise, and second-generation missiles with their solid propellants are amenable to mass production. Dispersed numbers compel the enemy to take an uneconomical approach to counterforce. Even if he were capable of producing systems with essentially perfect accuracy, reliability alone would force him to build more than a one-for-one missile force. To undertake the task of simultaneously striking each of our sites, he must satisfy himself that our entire force could not react to the obvious warning which such a massive attack would provide. This assumption would ignore existing technology and programed capabilities. Regardless of enemy weapon characteristics, our greatest surety of adeweapon systems do not possess the same degree of inflexibility. Aircraft, in particular, can be effectively armed with the amount of destructive power appropriate to the situation, are amenable to repeated use, and can seek out targets. The allusions to aircraft, ships, submarines, etc., in this article were only in the limited context of their value as long-range missile basing platforms and blithefully ignored their other potentialities.

Survivability, either on the ground or in the air, has been the principal factor influencing the obsolescence of weapon systems since the advent of nuclear weapons. A force which can tolerate the loss of individual portions without seriously affecting its over-all capability is relatively immune to this type of obsolescence. A large, completely dispersed force having minimum investment per site meets this criterion. Such a force should include hardening, to facilitate dispersal, to improve survivability, to enhance reliability and security, and to reduce manning requirements.

Systems which rely on deception for survivability are fundamentally subject to loss of effectiveness through technical progress. Since this progress is unpredictable, such systems are subject to sudden loss of capability.

Passive defense in itself represents no effectiveness in the target area. If adequate survivability is ensured through large, dispersed numbers, then the investment in survival also enhances effectiveness in the target area. The force is optimized for both strike-first and strike-second situations. Optimization for strike-first situations is of primary importance to deterrence of all provocative acts short of overt attack on the United States. Passive defense measures are important only to strike-second or counterattack situations not involving warning.

To make the deterrent force immune from piecemeal attack and engagement in indecisive actions requires that it be based in the United States.

The preponderance of the long-range missile force should be characterized by complete dispersal, hardening, capability of rapid response to command, basing within the United States, minimum investment per site, and adequate numbers.

Headquarters United States Air Force

CHINESE MILITARY DOCTRINE: TRANSITION OR CONFUSION?

Dr. Kenneth R. Whiting

Mao Tse-tung has the unusual distinction of being not only the fount of political ideology in Communist China but also the creator and high priest of its military doctrine. The present military doctrine, however, did not spring full-fledged from the brow of Mao but was put together bit by bit, each piece tested and tried during his 20-year war with Chiang Kai-shek. The story of this drawn-out conflict between the two modern giants of China is not only fascinating in itself, but it is also essential to an understanding of present Chinese military doctrine.

In the 1923–1927 period the Chinese Communists, at the urging of the Comintern, worked within the Kuomintang, the controlling party in China. By 1927, however, Chiang and the more conservative members of the Kuomintang realized that the Communists were pushing the movement much further to the left than they wished to go. They turned on the Communists, finally driving them out. The Stalin-directed Comintern policy was wrecked in China, and any hope of a revolution based on the urban proletariat disappeared.

Mao Tse-tung, who had earlier run afoul of the Comintern line by advocating a revolution based primarily on the peasants, now controlled the most viable Communist center in the Hunan and Kiangsi mountainous area. In early 1928 Chu Teh joined Mao, bringing with him the sadly depleted remnants of one of the rebellious Communist units, and the famous Mao–Chu team was born. Between 1928 and 1934 they built up a fairly large army, solidly based on the peasants of the area. Chu Teh, apparently a skilled organizer and leader, seems never to have questioned Mao's over-all leadership. Chu was always fully conscious of the absolute necessity of solid political training for his soldiers, and Mao fully appreciated the necessity of force as a basis for political action. It was during this period that Mao worked out much of his doctrine of guerrilla and mobile warfare that we shall later spell out in detail.

While Mao and Chu were organizing, training, and indoctrinating their peasant troops in the Hunan–Kiangsi mountains, Chiang Kai-shek was developing his Kuomintang army along entirely different lines. In the early 1930's a continual stream of German military advisers, even including the great Von Seeckt at one time, trained the Nationalist troops. It is very questionable whether Chiang's German-trained army was at all the answer to his problems, for such an army presupposed a rather large industrial base. When, between 1931 and 1945, the Japanese grabbed off what industry China had, Chiang quate missile survival is through a preponderance of numbers suitably dispersed; and it is the surety that is important. No other approach is immune to technological obsolescence.

force mix

Thus far a case has been presented for concentrating on a system in support of the general-war deterrent mission which has the following characteristics. It is based in the United States. It is responsive to command—capable of reacting to warning, capable of salvo tactics, and capable of being employed discretely. It presents an enemy with the greatest targeting problem numerically. It is optimized for both the strike-first and strike-second situation. Minuteman closely approximates these characteristics.

The ICBM is a revolutionary weapon, more revolutionary than is often realized. The doctrine for it is still in the formative stage. It is having difficulty avoiding conceptual treatment as a high-speed, high-flying aircraft. In many instances a person who recognizes the extreme value of ballistic missiles sees them primarily as means of improving the capabilities of whatever vehicle he has long been associated with. Airplane people want to strap them to airplanes, surface-ship people want to mount them on surface ships, submariners want them on submarines. In each case the carrying vehicle's capabilities would indeed be drastically improved. But does the missile need these vehicles? After all, the airplane, ship, or submarine amounts to what in missile jargon is called a first stage. Care is required to ensure that these marriages offer something to the missile and do not merely force on it the shortcomings of the carrying vehicle. Submarines, ships, and aircraft are expensive missile-launching pads and sometimes vulnerable ones. The support requirements are huge, and the pressures to perpetuate their existence are tremendous, both within the military and in industry.

The many advantages of the Polaris system are well known, but let us consider for a moment a few of the shortcomings of the concept. Submarines are difficult to sink, but they are not impossible to sink. Technical progress favors improved antisubmarine warfare capabilities. A variety of means is available. Mines provide one, killer submarines another. The Navy proposes to deploy 45 Polaris submarines armed with 16 missiles each at a total cost of $9 billion (not including funds for defensive submarines). For this same cost one could deploy thousands of Minuteman missiles. If pure forces were involved, in one case the enemy would have 45 targets that he must reckon with, some fixed in port, others at sea. In the other case he would have thousands of targets, each capable of fast reaction. Each Minuteman may not be as difficult a target as each Polaris submarine, but the investment required to challenge each Minuteman is likely to cost an enemy more than the Minuteman costs us, considering the accuracy and yield required of him to dig it out of its hole plus his problems of reliability and surprise. If targets can be created for less investment than is required to threaten them, then an approach to adequate survivability is ensured.

Not the least of the virtues of the Polaris is the fact that it became operational in late 1960. Also it presents a threat to any potential enemy, requiring counteractions on his part of an entirely different character than those required by the manned bomber force or the ICBM force. The argument for a mixed force is a very valid one. A mixed force creates an extremely difficult problem for the enemy, who must strike different type forces, widely dispersed, without the initiation of action against one providing warning to another. Also, and perhaps more importantly, the mixed offensive force dilutes the enemy's research and development effort by forcing him to pursue many defensive programs which do not necessarily complement one another. Simultaneous technical solutions to all his problems are not to be anticipated.

Contributing to such problems of the enemy is the Skybolt system, consisting of solid-propellant ballistic missiles launched from bomber aircraft. The Skybolt system does not represent an optimum basing concept, primarily because of its lack of dispersal. The Skybolt missile accepts many of the shortcomings of the manned aircraft that bears it, but at the same time it gains one distinct advantage—it can be launched from aboard the aircraft under positive control even under low-quality warning situations. The enemy's defensive problem is compounded.

The proper proportions to comprise a force mix can be controversial. What should not be controversial is that the system providing the greatest capability per dollar, or best cost effectiveness, should make up the principal proportion. A system providing less cost effectiveness should be built up only to the point that its total force size represents a sufficient capability that the enemy cannot afford to ignore it, if he is to consider initiating general war. Beyond this point, funds are better employed in the less expensive system. The more expensive system would have already posed to the enemy the research and development effort and the offensive timing problem and thus would have made its major contribution. As an example, this reasoning would indicate that the Polaris force should continue its buildup until Minuteman becomes available in numbers, but not beyond this point. From there the Minuteman force should be enlarged as required, and the then existing Polaris force should be maintained to complement it.

Before closing this treatise it is necessary to admit that only an artificial and much oversimplified situation has been discussed. The real world is far more complex. Weapon systems have been discussed principally in the role of deterrent to all-out general war. Certainly there are other degrees of conflict that the Nation desires to deter or have the capability to fight. ICBM's have inherent inflexibility—they cannot be reused; they are only effective when employing high-yield nuclear warheads; they can only challenge a set of coordinates. Other types of weapon systems do not possess the same degree of inflexibility. Aircraft, in particular, can be effectively armed with the amount of destructive power appropriate to the situation, are amenable to repeated use, and can seek out targets. The allusions to aircraft, ships, submarines, etc., in this article were only in the limited context of their value as long-range missile basing platforms and blithefully ignored their other potentialities.

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Headquarters United States Air Force

Military Opinion Abroad...

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MAO TSE-TUNG has the unusual distinction of being not only the fount of political ideology in Communist China but also the creator and high priest of its military doctrine. The present military doctrine, however, did not spring full-fledged from the brow of Mao but was put together bit by bit, each piece tested and tried during his 20-year war with Chiang Kai-shek. The story of this drawn-out conflict between the two modern giants of China is not only fascinating in itself, but it is also essential to an understanding of present Chinese military doctrine.

In the 1923–1927 period the Chinese Communists, at the urging of the Comintern, worked within the Kuomintang, the controlling party in China. By 1927, however, Chiang and the more conservative members of the Kuomintang realized that the Communists were pushing the movement much further to the left than they wished to go. They turned on the Communists, finally driving them out. The Stalin-directed Comintern policy was wrecked in China, and any hope of a revolution based on the urban proletariat disappeared.

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While Mao and Chu were organizing, training, and indoctrinating their peasant troops in the Hunan–Kiangsi mountains, Chiang Kai-shek was developing his Kuomintang army along entirely different lines. In the early 1930's a continual stream of German military advisers, even including the great Von Seeckt at one time, trained the Nationalist troops. It is very questionable whether Chiang's German-trained army was at all the answer to his problems, for such an army presupposed a rather large industrial base. When, between 1931 and 1945, the Japanese grabbed off what industry China had, Chiang found himself entirely dependent upon outside sources of supply and armament. Furthermore Chiang seemed either inept at or uninterested in blending the support of his professional army into the huge mass of the peasantry.

Chiang used his German-trained army against Mao in the 1930's and was unsuccessful in his first three tries. Finally in 1934, aided by his German military advisers, he surrounded the Communist area, built roads and concentric rings of blockhouses, and put an intolerable pressure on Mao's forces. The Communists broke out of the encirclement and started on their famous Long March, a distance of about 6000 miles, finally ending up in the northwest Chinese province of Shensi. Chiang had captured the real estate, but he had failed to annihilate the enemy. In a country as vast as China, capturing terrain is a useless pastime. The only effective strategy in the Chinese situation would have been to encircle and annihilate the enemy's forces, not merely push them into another area.

In Shensi the Communists rebuilt their army, again basing it in the peasantry, and they confined themselves to guerrilla and mobile warfare. Their military forces were effective enough to keep the area out of Kuomintang control. By this time Mao had evolved a military doctrine, and it was working. Fortunately Mao has spelled this doctrine out in some detail.

In Volume II of Mao's *Collected Works* there are two long articles, totaling about 200 pages, in which he describes his doctrine. One is entitled "Strategic Problems in the Anti-Japanese Guerrilla War" and the other "On Protracted War." In addition there is a long section in Edgar Snow's *Red Star over China* in which he sums up his conversations with Mao about military doctrine. In spite of its bulk, the main points of Mao's doctrine can be covered in a relatively short space, for Mao, like most Communist writers, is extremely repetitious and hammers away at a few important ideas over and over again.

Mao began his discussion of war by getting down to fundamentals: wars are fought for survival and are won by annihilating the enemy. He had the killer instinct. Any effective doctrine must be tailored to the time, place, and conditions then prevailing. Thus in China in the 1930's and 1940's, Mao's doctrine was concerned with fighting against an enemy, either the Japanese or the Kuomintang, that had superior weapons and a superiority in regular forces. In short, his is a doctrine for an undeveloped "nation" fighting an industrialized nation. Mao's biggest asset was the immense size of China, its relatively primitive communications, and its enormous population. His enemy could not control it all. The war must perforce be a protracted one. Mao admits that this doctrine would not apply to a smaller and more advanced country.

Mao divides the protracted war into three phases: (1) the enemy's strategic offensive opposed by a strategic defensive, (2) the enemy on the strategic defensive and friendly preparation for the counteroffensive. (3) the friendly strategic counteroffensive and the enemy's strategic retreat.

Having assumed that in phase one the enemy cannot occupy all of China, the weaker force should avoid positional warfare, fight a mobile war with its regular troops, and supplement this with guerrilla actions. The farther the enemy penetrates, the more he has to disperse his offensive and the bigger his rear becomes; thereby guerrilla warfare is made more effective. Eventually the enemy has to stop his advance, try to consolidate at strategic points, and attempt to cope with the guerrillas. Mao continually stresses avoidance of an effort to hold cities or territory unless victory is absolutely certain. On the other hand the strategic defensive must not degenerate into "flightism." Numerous engagements must be fought and as many of the enemy destroyed as possible. But only engagements should be fought in which a temporary overwhelming superiority makes victory reasonably certain.

Phase two finds the enemy trying to pacify and consolidate his occupied area. He spends his energy holding onto the big cities and protecting his lines of communication. The main form of opposition to him now is guerrilla warfare. This is the critical stage, says Mao, and it is a painful period; but it is in this stage that the nation has to really exert itself.

Guerrilla warfare, however, is for Mao not just hit-or-miss action. It has its own strategy, its own logic. It entails fighting numerous offensives in which the guerrillas concentrate preponderant forces against small enemy units. The guerrillas must encircle the enemy unit and annihilate it, or at least inflict very large losses on it. They should not engage in any battle that cannot be quickly decided. They should concentrate, strike, and disperse; be flexible at all times. Guerrilla operations are the mire in which an army dependent upon technological superiority bogs down. Whenever possible, guerrilla activities should be closely coordinated with actions of the regular forces addressed to fighting mobile warfare. Radio communications are essential to such coordination. (Mao had no air force, but the Russians in their guerrilla operations in World War II vividly demonstrated the value of aircraft in supplying and coordinating guerrilla operations.)

The guerrillas must have relatively safe base areas—and here we come to the heart of Mao's mastery of guerrilla warfare. He points out that roving peasant wars, such as the great Taiping rebellion, have always failed. To be successful, the guerrilla force must have a base area in which the peasant population is friendly and cooperative. Therefore cooperation between the guerrillas and the masses of the peasants is fundamental to success. There should be no confiscation without compensation, no rape, no pillage—these "don't's" are dogma. The peasant masses act as the supply base, the reconnaissance, and the source of recruitment. Only the solid backing of the peasantry can make guerrilla warfare a success. As the combination of extensive guerrilla actions and limited mobile warfare wears down the enemy, the resisting forces grow and their popular base expands.

At this time the strategic situation shifts into phase three. Now mobile warfare becomes the main form of war, and guerrilla actions again become supplementary. This is the strategic counteroffensive, and if its leaders have built well during phase two, they should be able to annihilate the enemy in this final phase. But even now positional warfare should be avoided as much as possible. Cities are surrounded by controlling the countryside, and eventually the enemy's morale breaks or he is goaded into attacking at a strategic disadvantage.

Katzenbach has admirably summed up the philosophy underlying Mao's military doctrine.[1] He reduces military doctrine to six components—three tangible and three intangible. The tangible components are weapon systems, logistics in the widest sense, and manpower. The intangibles are space, time, and will. Industrialized nations tend to emphasize the tangible components, but Mao was forced to put his greatest emphasis on the intangibles. After all, in addition to manpower, these were all he had.

Mao saw his primary problem as political mobilization, the creation of the will to resist it. As he put it:

> The people are like water and the army is like a fish . . . With the common people of the whole country mobilized, we shall create a vast sea of humanity and drown the enemy in it.

In brief, his military problem was how to use the asset of space to gain the time needed to carry out the political mobilization. Unlike his opponents, Mao was not striving to get the war over. His task was to keep it going. He avoided a military decision in order to gain the time needed by the army to carry out its political role, for Mao's army was not only a fighting force but also a tool for agitating the masses, for organizing them, and for welding them into a solid base for political power. To quote Katzenbach: "What Lenin did on the subject of imperialism and Marx on capitalism, Mao has done for anti-industrial warfare."

Mao and his military leaders worked out this doctrine while in the Hunan-Kiangsi mountains, on the Long March, and in Shensi. They applied it against the Japanese between 1937 and 1945. By 1945 they had built up large forces, had consolidated their hold over large regions, and in early 1946—with Soviet connivance—they secured a large part of the armament surrendered by the Japanese forces. They then used the same doctrine against Chiang Kai-shek's armies, and by 1949 they controlled all of mainland China.

Since 1949 the Chinese Communists have been working furiously to make China an industrialized nation. In other words, they are trying to change the very conditions under which Mao's doctrine works best. An industrial economy and improved communications destroy the milieu in which guerrilla actions and mobile warfare flourish.

It is not strange that a doctrinal struggle has ensued. In October 1950 Lin Piao and his Chinese "volunteers" entered the Korean War. After a striking initial victory they found themselves bogged down in the dreaded positional warfare. Guerrilla actions and mobile warfare did not work too well under these conditions, that is, against a modern army and air force in a narrow geographical area. Moreover Mao's doctrine looked even more shaky when it failed to provide an answer to the problem of getting to Taiwan with the U.S. Seventh Fleet patrolling the Taiwan Strait.

The Chinese Communists now had the largest armed forces in Asia—but precisely at the time when the industrialized nations were undergoing a revolution in weapons and strategy. As the Russians were doing, the Chinese Communists played down the effectiveness of nuclear weapons between 1945 and 1955. This doctrinal line was probably partly for propagandistic reasons and partly out of sheer ignorance about their efficacy. It was not until the middle of 1955 that Marshal Liu Po-cheng admitted that "surprise attack" with nuclear weapons could affect the outcome of a war. The Soviets began to publish a similar view in their military journals for the first time in that same year.

Many of the top officers of the General Staff of the People's Liberation Army (PLA) began to agitate for a better-trained and better-equipped regular army, a larger air force, and a more effective air defense capability. These they wanted even if the equipment had to be purchased abroad. Furthermore they even hinted that less Party meddling in the PLA would be a good thing. Apparently the experience of the Korean War, the repercussions of the doctrinal dispute then going on in the Soviet Union, and the frustration engendered by the inability of the Chinese Communists to take Taiwan had shaken the faith of the professionals in the efficacy of Mao's doctrinal teachings in the new age.

During this same period the Party leaders were interested in reducing defense expenditures, mainly by cutting the size of the standing army, in order to get on with the economic reconstruction of China and launch into the new plans for industrialization. The Party leaders seemed willing to rely on the Soviets as a deterrent abroad while they were carrying out their domestic policy. The dispute rumbled on until mid-1958, when Chu Teh hit the General Staff group hard. He claimed that they were putting too much emphasis upon surprise and the destructive power of the new weapons. He was especially irate at their charge of too much Party control.

The timing of the attack is significant. The Soviets had just carried out a breakthrough in military technology with their successful firing of an ICBM and launching of their sputniks. This success made the efficacy of the Soviet deterrent much more convincing. The Chinese Communist Party leaders felt that "the wind was definitely blowing from the East." To the General Staff there was also another aspect that must be considered. An increase of Soviet control over Chinese military strategy and foreign policy seemed inevitable.

The Party then shook up the General Staff drastically. Su Yu, Chief of the General Staff, was replaced by Huang Ko-cheng, the Vice-Minister of Defense and a strong Party man (also a member of the Secretariat). In September a "generals-to-the-ranks" program was inaugurated, requiring officers to put in a month each year as enlisted men. The program was supposed to bring closer understanding between the officer corps and the enlisted personnel. Use of the regular army in construction work also was increased.

The situation deteriorated, however, and by mid-1959 it was obvious that communication between the professional military and the Party had almost ceased. Even the rank and file of the PLA, mostly of peasant stock, were getting restive about the new "communes." Furthermore the miserable showing of the Chicom Air Force in the Taiwan Strait crisis of 1958 had been an eye-opener for the professional officers. The result was that in September 1959 Lin Piao became Minister of National Defense and Lo Jui-ching became Chief of the General Staff.

Lin is regarded as the Chicom's best strategist and logistics expert. He organized and ran the Red Army Academy during the hard days of 1935–1945 in Shensi, organized the Manchurian Front in 1945–1947, led the attack by that force on Chiang's armies, and headed the initial Chinese attack in Korea in 1950. He had been out of action because of illness between 1951 and 1958, and as a result he was more or less a neutral in the great debate then going on. He was also a man of great prestige. The Party leaders apparently felt that he was their best bet to bridge the gap that had developed between them and the professional officer corps. Lo Jui-ching had been head of the security forces, and it was felt that he could get the rank and file straightened out.

Lin Piao published an article in September 1959 that is a masterpiece of compromise between the positions held by the opposing sides. He urged a better attitude toward the "communes," stated that the PLA would continue to work on construction projects, and maintained that the "generals-to-the-ranks" policy would be continued. Machines notwithstanding, he held that man is still the most important factor in warfare and urged more reading of Mao's works on that subject. On the other hand Lin admitted that there was a need for more technical equipment in the PLA and that it certainly needed modernization. It also needed a better and more centralized command system. In other words, Lin stood for the continuation of firm Party control over the PLA, but over a much stronger PLA.

ALL this reduces to saying that the PLA is now in a transitional stage—or perhaps a confused stage—in its military doctrine. Mao's doctrine no longer fits the new circumstances, but the economic and technological level of Chinese society is not advanced enough to allow it to shift to an entirely new doctrine. The main military features of China today, as formerly, are enormous supplies of manpower, a large geographical expanse, and very poor communications. China is still a primitive agricultural society with a large peasant base. If China becomes more industrialized, if communications are improved substantially, and if urbanization grows markedly, then the military doctrine will have to change to accord with these developments.

But the revolution in weapon systems and concomitant strategy outside China means that the Chinese cannot shift military doctrine very far without possession of nuclear weapons and delivery capability, either obtained from the Soviets or produced indigenously. And they seem to have given up hope of getting nuclear weapons from the Soviets and now realize that they will have to go it alone. In 1958, Liu Ya-lou, Commander of the PLA Air Force, summarized the situation:

> China's working class and scientists will certainly be able to make the most up-to-date aircraft and atomic bombs in the not distant future. By that time, in addition to the political factor in which we always occupy an absolutely predominant position, we can use atomic weapons and rockets . . . in coping with the enemies who dare to invade our country and undermine world peace. By that time, another new turning point will probably be reached in the international situation.[2]

The present controversy between Peiping and Moscow would seem to preclude any chance of China's getting either the latest types of weapons or guidance in their use from the Soviet Union. This controversy in essence lies in a difference between Mao and Khrushchev about how aggressive the Communist world-wide policy should be. Mao feels that the Soviets now have a big edge in weapons and that under this canopy they can act far more aggressively than they are doing. Khrushchev on the other hand feels that he is doing rather well under the "peaceful coexistence" policy, and he is probably less convinced than Mao that he has such a large superiority in weapons.

Mao apparently can see nothing but good coming out of a more aggressive Communist policy. His military doctrine, if applied to the world situation, would undoubtedly posit the Communist bloc as now in phase three, the strategic offensive. Thus Khrushchev's revisionist heresy of "peaceful coexistence" looks like sheer nonsense to Mao. China needs a tougher policy to cover her expansion into and control over more of Asia. She needs the picture of a hostile capitalist world to justify the extreme pressures being put on the Chinese people. A more aggressive and hence more dangerous Communist world-wide foreign policy would probably force the Soviets to endow the Chinese with more aid as well as more and better weapon systems.

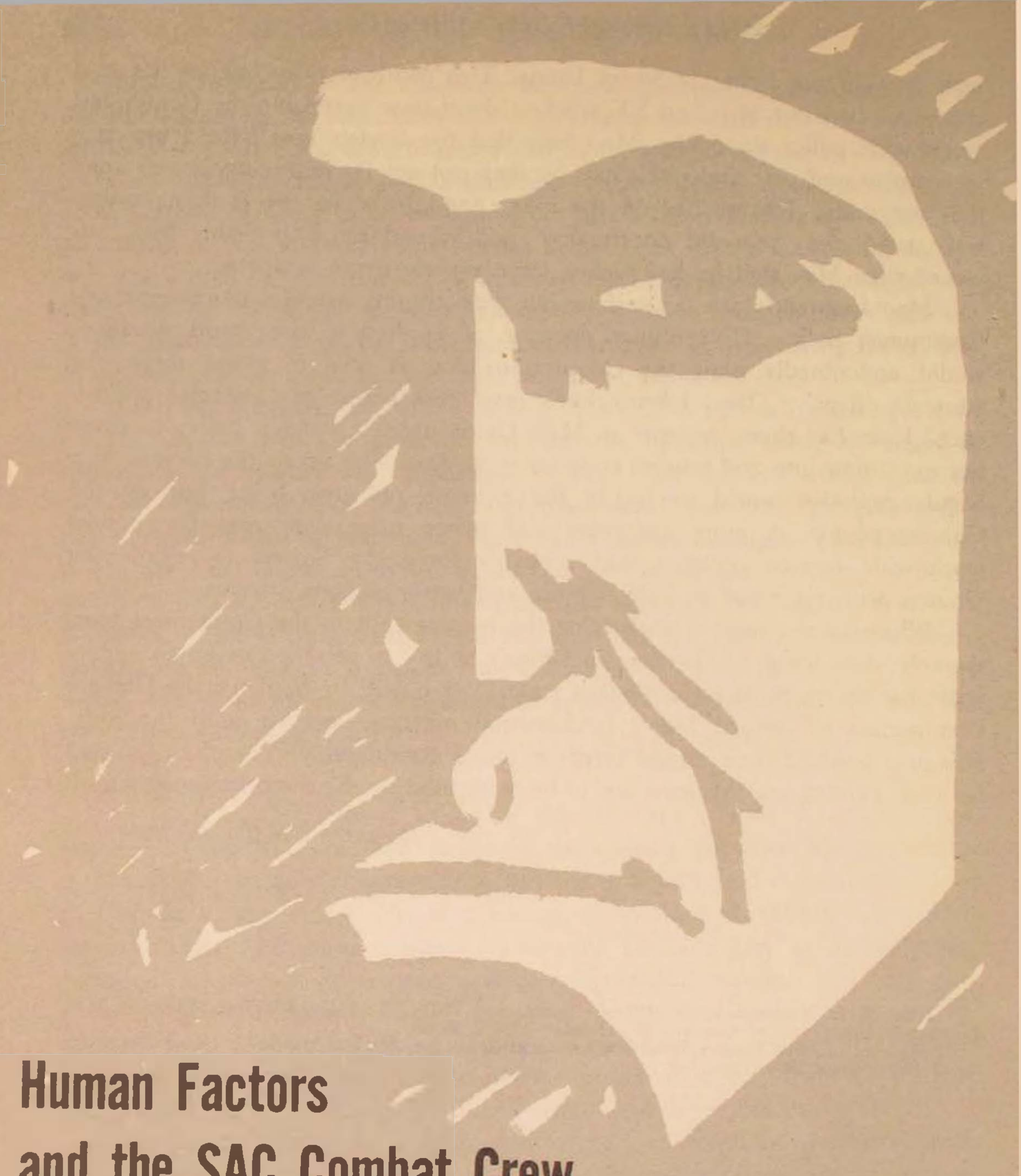
Whatever the reasons underlying the present split in the Communist bloc, the split does mean a slowdown in China's ability to get the Soviets to underwrite her rearmament on a modern scale. And it will be hard for the Chinese Communists to discard Mao's fundamental military doctrine until the technological level of their armed forces is raised considerably. Therefore tensions between Peiping and Moscow are to be welcomed by the noncommunist world.

Research Studies Institute

Notes

1. Dr. E. L. Katzenbach, Jr., "Time, Space, and Will: The Politico-Military Views of Mao Tse-tung," *Marine Corps Gazette*, 10 (October 1956), 36–40.

2. Quoted in Alice Langley Hsieh, "Communist China and Nuclear Warfare," *China Quarterly*, No. 2 (April–June 1960), pp. 7–8.



Human Factors and the SAC Combat Crew

MAJOR WILLIAM G. HURST

IN THE course of naming the ten top Air Force priorities General Thomas D. White once stated during his time as Chief of Staff that concentration on hardware must not obscure "the one common denominator of success in any field," which was to be found in people. "Individual intelligence, initiative, courage, and judgment have not been outdated by push buttons and fantastic technical performance."[1]

General White's statement enumerates the qualitative criteria for Air Force personnel. In the following pages an attempt will be made to analyze these criteria in application to the Strategic Air Command combat crew. The aim is to determine the effect of certain human-factor elements on the performance of the crews and hence on the ability of SAC to execute the Emergency War Order. Specifically the aim is to discover what factors are not evaluated, to what extent realism is achieved in the present training and evaluation, and how a more thorough evaluation can be accomplished.

The fact that a body of men has completed the requisite training to win a flying rating and a commission is a general indication of their intelligence. But initiative, courage, and judgment are qualities in a man's peculiar psychological make-up. Initiative, for example, can be traced directly to the individual's motivation and his attitude towards his work. Motivation, why an individual does what he does, is in fact basic to many reactions, and both courage and judgment can be influenced greatly by the stresses and strains that are imposed upon a man.

The Factors and the Mission

At the end of World War II Colonel R. C. Anderson, an Army Air Forces psychiatrist, raised some very important considerations concerning the motivation of combat pilots and their success in combat. He pointed out that the ability of the individual to learn to fly is not necessarily germane to the problem. Some men have learned to fly even in the absence of any desire to learn. All types of men have been both successful and unsuccessful in combat. The important fact, Anderson noted, is that men with different kinds of motivation have shown different levels of resistance to stress, a circumstance corroborated by Navy pilot-selection testing during World War II. In validating the motivational criteria of the tests at a later stage in the war, the Navy had found that men who had tested high in motivation toward becoming pilots had been very successful in combat.[2] The relation of motivation to stress endurance opened the door to further research.

During the Korean War the Air Force Personnel and Training Research Center studied the attitudes of B-29 crews while in training and while in the combat zone. The purpose of this research was twofold: (1) to find out what effect the crews' attitudes had on combat performance, and (2) to determine if tests could be devised that would reveal the attitudes of the crews. The studies, completed in 1956, showed that crew attitudes as measured by tests in training and in the combat zone correlated significantly with combat performance. The conclusion was that good attitudes in training predict good combat performance and that predictions can be based upon written tests.[3]

This article is based on a staff study prepared by the author as a part of his academic work while a student at the Command and Staff College, Air University, in the class of 1961.

As pointed out by Anderson, the importance of aircrew motivation is in the effect upon the individual's resistance to stress. The impact of stress has been described by James Deese of Johns Hopkins University:

> While stress does not always produce deterioration of skill (indeed, it may often improve it), it does so often enough to be of great danger in military life where stresses are severe and frequent. This is, of course, very serious, since a man may perform very badly in combat on a skill which he did very well at during training.[4]

Consequently it becomes incumbent upon flight supervisors to identify those persons who are abnormally susceptible to the effects of stress. Failure to identify them can leave very weak links in a combat crew structure.

Physiological changes as a result of stress are quite common. Loss of body weight due to perspiration is one of the more easily observed changes. More subtle and accurate indicators of stress are changes in the blood or urine caused by internal glandular activity. Colonel Thaddeus J. Domanski of the USAF School of Aviation Medicine and Colonel Vance H. Marchbanks, a SAC flight surgeon, have done extensive research in measuring these physiological changes. Domanski studied the changes in the blood eosinophile count as signification of a stress-producing situation. His subjects were the aircrews on B-29's, B-47's, and F-86's. The F-86 investigations were carried out during an air offensive in Korea.

The theme of Domanski's work can be expressed in semimathematical form: stress plus a susceptible individual equals a stress response. In this equation "stress refers to the duties, conditions, and circumstances imposed upon the individual." The stress response is the physiologic change occurring within the susceptible individual. To obtain a successful measure of the stress response, the stress conditions must be relatively standardized. For example, under certain emergency conditions, such as a mechanical malfunction or a circumstance requiring the crew to bail out, a stress response can be expected from almost anyone. The exception would be a rarity. On a routine mission with no abnormal stimulants present, a stress response is normally absent. This situation was found to be true even on F-86 missions in the combat area where engagement with the enemy was expected but not encountered. Where a pilot had a stress response, his superiors had previously and independently marked him as "weak" or "inexperienced," indicating an ineffectual crewman. Note that physiological measurement is an objective method free from any personal factor that could influence a subjective rating.[5] This suggests a means for determining whether or not a given crew is combat-ready, a subject that will be discussed more fully later.

Domanski also demonstrated that certain aircraft are more stress-inducing than others. In his comparative analysis of B-29 and B-47 training missions, 61 per cent of the B-47 student aircraft commanders showed a stress response as compared to 28 per cent of the B-29 students. The instructor pilots exhibited the same comparative responses as their students, with only slight variations in percentages. Another fact observed was that only 22 per cent of the B-47 students reflected a stress response on their solo mission whereas on the next instructional mission the figure went right back up to above 60 per cent. A reasonable hypothesis may be made that when the added requirement to learn and be evaluated on a new skill is removed, the normal pilot does not show a stress response.[6]

Marchbanks' work was done along similar lines except that he used only B-52 crews and was measuring 17-hydroxycorticosteroid (17-OH-CS) levels in the urine as an indication of a stress response. He concluded that "urinary excretion of 17-OH-CS served as a favorable index for evaluation of stress in flying personnel." His studies considered stress as evidenced by fatigue mainly on long missions (over 20 hours).[7]

When the subject of fatigue is examined, it becomes difficult to identify objectively what fatigue is as distinguished from what it does. John L. Kennedy of the Department of Psychology, Tufts College, states that "modern research studies on human fatigue emphasize the importance of motivation, monotony, and vigilance as variables rather than exhaustion or continuous decrement of performance in time."[8] On the other hand Domanski identifies the stress response associated with fatigue as being principally dependent upon the sheer duration of an activity. Andrews and Hackman go further and identify three different types of fatigue: objective, subjective, and physiological.[9] For the purpose of this article a working definition may be synthesized: Fatigue is that condition wherein the human mechanism, physical or mental, fails to respond promptly to a stimulus and a lower standard of performance results.

Kennedy points out that "the characteristic sign of human fatigue is a lapse in vigilance in an otherwise adequate performance." This same observation was made by D. C. Fraser of the RAF Institute of Aviation Medicine during his studies of fatigue in aircrews.[10] Fraser also found that judgment becomes variable or undependable during periods of stress and that the judgment factor is closely allied to "timing," which Sir Fredrick Bartlett of Cambridge University marked as being one of the first attributes to suffer when man becomes fatigued.[11] Andrews and Hackman found that very tired men unknowingly accept and are satisfied with a lower standard of performance but still believe that they are doing as well as when they were fresh. In other words, men frequently are unable to tell that they are fatigued to the point of inefficiency. Fraser observed a similar condition when the subjective statements of crews did not always agree with the results of objective testing.

The fatigue factor can be introduced in many ways. Certainly any outward expression of boredom, anxiety, or tiredness is a sign of fatigue whether the subject admits fatigue or not. Bartlett considers the speed at which one has to work and the number of tasks that have to be accomplished as two key factors. He says that anxiety is one of the most potent factors contributing to fatigue.[12] And anxiety can find its way to a man's mind simply through his waiting for something to happen.

Fatigue is doubly dangerous to deal with, because an individual's vigilance, judgment, and timing all are degraded and because he may not be aware of his fatigue and its consequences. For the combat crew this circumstance poses a psychological dilemma. The physical demands of the crewman's job are not great, but he does have to endure long periods of relative inactivity both on the ground and in the air. Extended and repetitious periods of alert duty may be boring, and boredom can degenerate into apathy and anxiety. On the one mission the alert crew may have to fly, the expected fatigue of the long flight, according to Fraser, will be reinforced by that preceding the flight. The accumulated stress could be excessive without even considering the environment into which the crew is flying.

The foregoing facts, vital as they are to this study, leave one question unanswered: How much influence will these factors have upon SAC's crews if the Emergency War Order has to be executed? Unfortunately it would be almost impossible to obtain the answer in terms of so many feet of bombing error or so many miles of navigation inaccuracy, but prior research does allow some answer in regard to the number of men that may be affected.

A large sample of returning World War II combat crews was subjected to studies of fear in combat during 1944. The reported data are significant to this study, even though fear is not here treated as a separate subject. If the feeling of fear is sufficiently strong (fear being one manifestation of anxiety), there is a close enough relationship between fear, stress, and stress response to make the data meaningful.

Of 4504 persons examined, 1985 were officer crew members primarily from bomber units. Only the officer group will be considered here. Two of the findings are significant: 83 per cent of the group acknowledged fear on their first combat mission, while 62 per cent said that they were afraid on more than 50 per cent of the missions they flew; and 84 per cent reported that the strength of the fear was equal to or greater than any experienced previously.[13] The findings can now be reduced to more meaningful figures and related to the SAC crews.

The present SAC crew structure is made up of men with combat experience and men with none. Crews without combat experience can be expected to react in a manner similar to that of World War II crews flying their first combat mission. The combat-experienced crews of SAC will probably resemble the crews of World War II that flew a complete combat tour. By mathematically combining the percentage factors of crews reporting fear with the figures on strength of fear, we obtain an answer representing that portion of crews who will probably experience a strong stress response. By this process 70 per cent of the inexperienced SAC crews and 26 per cent of the combat-experienced SAC crews can be predicted to show a significant stress response. Stress response as an exceedingly serious influence on combat effectiveness has been discussed.

A deliberate attempt has been made to keep these estimates conservative. For example, the fact that the B-47 is a more stress-inducing aircraft compared to the conventional World War II aircraft has been disregarded. However, the figures in the preceding paragraph are acknowledged to be a straight arithmetical extrapolation, and other unknown elements in today's situation could cause them to be changed one way or another. A separate study could, and maybe should, be devoted to this subject area alone. As the figures stand, they indicate the potentially critical situation to which this study is devoted.

The effect of human factors upon the quality of performance of the SAC crews can be viewed from another angle. SAC expects a crew to attack its target and place a bomb within a certain distance of its aimed point of impact. No more and no less is expected of the crew. (This fact may be deduced from a study of the reports on SAC penetration capabilities. Only one circular error probable, CEP, figure is used for manned aircraft. Regardless of how the figure is derived or what specific value it represents, the figure remains as one standard of performance.[14]) Human factors may, however, either enhance or detract from the ability of the crew. If the capability of the crew is enhanced, as by highly motivated members, the crew will have a better chance of doing what is expected of it. On the other hand if the crew is affected adversely, its capability is degraded and it may be unable to achieve the minimum expected results. In short, the minimum and maximum of what is desired comprise one standard of performance. Therefore the degrading characteristics of human factors assume an overriding importance.

The over-all effect upon the existing SAC crew inventory will depend upon the relative combat-experience level of the force, upon whether "weak" crewmen are screened out or eliminated from the program, and upon whether the training environment adequately duplicates the combat situation to make up for the nonveterans' lack of combat experience.

As time goes on it is reasonable to assume that younger non-combat-experienced men will predominate in the cockpit. Because this experience factor is a constantly changing one, a specific quantitative answer to the question of qualitative performance will not be attempted. However, "weak" individuals can be inadequate for either technical or psychological reasons ("technical" referring to knowledge of the aircraft, systems, tactics, and procedures and the ability to demonstrate that knowledge in the air as well as in the classroom). It is the identification of the weak group that must be pursued actively.

Present SAC Evaluation Methods

The SAC program for the evaluation of combat crews is divided into four parts: the qualitative screening of potential crew resources, individual and crew training, the strategic standardization program, and unit exercises. The ensuing discussion covers these four areas plus the role of the flight surgeon in the crew-evaluation process.

Potential crew members are measured first against the qualitative criteria listed in SAC Regulation 51-19, Minimum Requirements for Initial Checkout and Recheck of Aircrew Members and Aircrews, (for each type of aircraft in the appropriate annex, e.g., Annex I for B-58's, Annex II for B-52's). As previously noted, this screening is only a check of the individual's general qualifications in terms of aeronautical rating, flying hours, and experience. The rest of the regulation spells out what the individual must accomplish to become solo-qualified in a specific type of SAC aircraft.

Individual and crew training, as a whole, is broken into two broad areas—ground training and air training. SAC Regulation 50-24, Recurring Ground Training Requirement, covers an entire spectrum of skills from handgun firing to tactical doctrine. A specific standard is set for each item taught, and the standard must be met before the crew member is considered qualified. In most cases additional regulations or manuals amplify the specific requirements. For example, SAC Regulation 50-46 governs the use of training devices, including flight simulators.

Air training is divided into three phases: pre-solo, combat readiness, and crew training. Pre-solo training is guided by SAC Regulation 51-19. When the individual has completed the quantitative requirements, has the instructor's approval, passes the pre-solo tests and flight check, and has been interviewed personally by the wing commander, he is considered solo-qualified. After each crew member is solo-qualified, the entire crew is brought together to work as a team towards becoming combat-ready. SAC Regulation 50-43 governs the training of the crew until it has achieved combat-ready status. During the entire time that a crew is combat-ready its training is conducted under SAC Regulation 50-8, Training Program for Strategic Air Command Units and Aircrews. Under this regulation both quantitative and qualitative requirements must be met, and on a time schedule. All items must be accomplished on a quarterly basis; if not, the crew is placed on probational status. If the probation is not cleared, the crew is declared nonready or is disbanded. There are other ways by which a crew may invite probation under SAC Manual 51-1, *SAC Aircrew Probation*. All these deficiencies are technical in nature and are generally revealed through the standardization program.

The heart of the crew evaluation program in SAC is the strategic standardization system as described in SAC Manual 51-4, *Standardization Program*. An excellent history of the evolution of the system is presented by Colonel Alan F. Adams in his Air War College thesis of 1958 entitled, "A New Concept for Evaluating SAC Combat Crews." Colonel Adams emphasizes the difficulties encountered by SAC in achieving a true standardization of crew performance and how the program has arrived at its present high state of development. He attaches great importance to the program as a key means for CINCSAC to be able to determine the combat capability of the command.

As now defined in SAC Manual 51-4, the goals of the program are to ensure standardization of performance of SAC flying personnel, and to evaluate operating techniques and procedures with regard to the effectiveness of unit standardization programs, the effectiveness of the training program, and the degree of proficiency possessed by flying personnel to meet all operational commitments. A review of the grading forms will show, however, that there is no place for evaluating the crew's motivation, attitude, effects of stress or strain, and vulnerability to the effects of fatigue. On the many standardization checks received by the author while in SAC, the evaluators were very careful to establish that they were evaluating only actual performance. By so doing, the evaluator is able to minimize the fears of the crew that subjective factors may influence the grading. This desire to maintain the grading on an objective basis is sound, but it is limiting. The system is blocked from checking anything other than specific performance and procedural techniques, and the key element in the SAC evaluation program does not measure the effects of the human factors.

Under SAC Regulation 50-16, Team Scrimmage Exercises, team scrimmage missions are designed to provide commanders with a means of evaluating the capability of the unit to perform the Emergency War Order. As the author interprets that regulation, again the emphasis is on objective evaluation of technical capabilities. Within Eighth Air Force units, commanders are not allowed to waive any of the provisions of SAC Regulation 62-19, Crew Rest and Fatigue. This restriction indicates awareness of the influence of the fatigue factor, but the application is in the interest of flying safety rather than operational capability. Although flying safety is enhanced, the operational factors being measured will not reflect the effect of fatigue.

A detailed examination of all the regulations and manuals cited in the preceding paragraphs will not reveal any reference to the effect of human factors upon combat performance. There are no procedures for measuring, testing, or evaluating the crews as to the effects of motivation, attitude, and stress. The emphasis in the system is definitely placed upon an objective and uniform method of achieving the desired standard of performance. By this omission, human factors are not a part of the SAC operations evaluation program. Quite possibly, because of the psychological nature of human factors, the flight surgeon is the one to look to for this phase of the evaluation of crews.

Air Force Regulation 160-69, Aircrew Effectiveness Programs, delineates the program to be conducted by the flight surgeon. This regulation levies a heavy responsibility upon the flight surgeon to "keep well informed of the current attitudes and mental stamina of flying personnel as well as the psychological stress to which they are exposed. He must become personally acquainted with all flying personnel."

Brigadier General J. H. Moore, Commander of the 4th Tactical Fighter Wing, puts his finger on the problem of becoming "personally acquainted": he points out that there simply are not enough flight surgeons in the field to do the job.[15] Headquarters Eighth Air Force made the same observation in its report on Project Flitesurgeon, establishing that only 21 per cent of the flight surgeon's time was available to spend with rated personnel and less than 15 per cent on the flight line.[16] It is reasonable to assume that the flight surgeon cannot fulfill his responsibilities through the use of this "personal acquaintance" technique.

SAC's instructions to its flight surgeons are contained in SAC Supplement No. 1 to Air Force Regulation 160-69. This amplifying guidance, however, pertains only to the administrative procedures to be followed in submitting the report required by the basic regulation. The author was unable to find any other information that would help the flight surgeon to establish an effective program of psychological evaluation. Although the requirement has been established, no means are given for transforming it into reality. Crewmen who are psychologically nontypical are not subjected to screening and can exist in the SAC crew inventory in unknown numbers.

Training Environment versus Combat Environment

As pointed out earlier, skills that are developed in training are not always used well in combat. Military commanders give recognition to this fact in various ways. During World War II infantry troops received tactical training under fire with live ammunition. Here the purpose was to accustom the men to realistic conditions approaching actual combat. General Omar Bradley's approach was to assign new troops to "quiet sectors" whenever possible, so that they could become accustomed to battle with a minimum of shock and stress.

Unfortunately there are no "quiet sectors" in which to train SAC's combat crews. Today the quiet sector is found in the day-to-day training environment. If the time comes for the crew to go into combat, it will go directly from its peacetime posture. The transition into the violence of a nuclear battle will be almost instantaneous. Consequently knowledge of what to expect in battle and how to deal with it is of considerable importance.

Training missions during peacetime obviously are devoid of enemy action. An entire spectrum of regulations has evolved to create a safe environment within which to conduct peacetime training. The same provisions will not necessarily hold firm on D-day. For example, it is unlikely that the SAC alert force will be withheld from striking because of nonavailability of a suitable alternate landing field as required by AFR 60-16 on air traffic, base clearance, and general flight restrictions. Nor will the crews be flying over low-level routes previously surveyed from the air to ensure that small airports, unplotted obstructions, and populous areas are avoided. Military necessity will dictate that the missions be flown even with a reduced margin of safety. However, SAC has stated that flying safety is the primary consideration in accomplishing low-altitude training.[17] Hence a conflict exists between what the crew must do in combat and the limitations placed upon training.

If the assumption is made that normal training missions tax the abilities of crews, then the words of Colonel H. G. Moseley, Chief of the Aero Medical Safety Division, deserve some attention. "If the machine strains human ability under normal conditions of flight, it will exceed human limitations during periods of adversity." A study of the secondary or contributing causes of "pilot error" accidents shows that the accident rate shoots up when the pilot is confronted with unusual conditions.[18] In short, the more stressful the conditions the less likely is satisfactory performance. It is unreasonable to think that combat performance will not suffer in the same way. The need for realistic training is apparent.

The Army has paid considerable attention to realistic training in special combat training courses. Tank crews are graded on their ability to conduct accurate firing amid a series of explosions nearby. A squad leader is graded on how fast he can clear a malfunctioning gun that is covered with blood and bits of flesh from the maimed "bodies" surrounding the position. An excellent treatment of these techniques has been written by Lieutenant Colonel Robert B. Rigg.[19]

The research conducted for this article has failed to uncover similar Air Force programs relative to training in the air. The Wright Air Development Division (predecessor of Aeronautical Systems Division, AFSC) gave recognition to the fact that a problem exists in creating a realistic environment and yet maintaining high safety standards. The solution recommended by WADD involves the use of electronic trainers or simulators in a concept referred to as "full-mission training."[20] This concept is the logical extension of the use of ground-based trainers to develop skills that cannot be safely duplicated in the air.

The B-47 flight simulator is a good example of this type of device. In it procedures for such emergency situations as fires, fuel system failures, landing-gear malfunctions, and the like can be taught safely. But the B-47 simulator is only a "part-task" device; that is, it only trains a part of the crew (the pilot and copilot) in a part of their over-all job. SAC restricts the use of these simulators to training in the following areas: emergency procedures, instrument flight, initial low-level indoctrination, and initial crew coordination training. "Full-mission training" envisions the use of the entire crew in a trainer that enables developing complete crew skills in all areas.

At the present time SAC possesses only one trainer that fits the description of a full-mission device, and that is for the B-58. As reflected in the training course outlines,[21] this trainer is still under the same general restrictions as all other SAC trainers. One mission, three hours in duration, is "flown" for the entire crew, the rest of the course being devoted to instrument and emergency procedures training. No mention is made of flying a complete combat-mission profile.

Both the B-47 and B-52 programs use "part-task" trainers only. In addition to the basic flight simulator for each type of aircraft they also have the AN/APG-T1A gunnery trainer and the AN/APQ-T2A bomb/navigation trainer. These part-task trainers require the addition of an intricate electrical interconnection system before they can be used as a full-mission device. Such a system is, by itself, an expensive item, at some $60,000;[22] but when compared to the cost of a single B-52 crew, some $3,013,336,[23] the cost of the system is not prohibitive. In addition these devices might save on the number of flying hours expended in the training program.

There are limitations to the use of a crossbreed system of this type. The limitations are those of the individual components. For example, the APQ-T2A bomb/navigation trainer has a limited low-altitude capability, hence the interconnected system can do no better than the performance of that one piece of equipment.[24] Nevertheless the capability to have the entire crew working on an integrated mission is vitally important.

The results of the individual part-task training cannot give a complete picture of the crew capabilities even if all the individual performances are added up to a total for the crew. As Paul S. Dwyer of the University of Michigan reports, "the measure of group effectiveness differs appreciably from the average measures of effectiveness of the members composing the group."[25]

The outstanding ingenuity shown by the Training Devices Section at Castle AFB, California, is an excellent example of what can be accomplished through the interconnecting of various training devices. In addition to interlocking the B-52 simulator and bomb/navigation trainer, they have incorporated the gunnery trainer and a device to give a visual presentation of the runway as the "aircraft" breaks out of the overcast and continues to touchdown.[26] Further endeavors along these same lines might include the use of high-intensity strobe lights to simulate the flash of bombs. The rough-air feature can realistically duplicate shock-wave arrival. Simulating battle damage would involve nothing more than present emergency procedures, with the possible addition of smoke and odors representing different types of malfunctions. The application of training aids of this kind could go a long way toward creating a realistic combat training environment.

A complete combat-mission profile that will bring many of the human factors into play can be "flown" in the B-58 trainer or in integrated part-task trainers. If, without advance notice, the members of a combat crew on alert are relieved from alert and taken directly to the trainer with all their mission flight-planning data, they can then "fly" a realistic but simulated sortie. The fatigue factor would be present, and certain stress elements would be simulated naturally incident to unexpectedly doing something new. Such a test can give a good insight into the full-mission training problem.

The full-mission trainer offers a means to create a reasonably realistic environment within which to develop complete combat skills. It will not compromise current safety standards, and the cost is not out of proportion to the benefits gained. At the present time this appears to be the most suitable means for accomplishing full-mission training.

Improving the Evaluation of Combat Crews

Since the present training program does not compensate for the degrading aspects of human factors, a new question must be answered. How can SAC obtain the greatest assurance that human factors will not adversely influence operational capabilities? Two approaches to the problem can be used concurrently: selecting the best possible personnel for assignment to combat crew duty through testing, and making them more resistant to stress.[27]

Candidates for the Project Mercury man-in-space program went through one of the most complete and strenuous evaluations to which airmen have ever been subjected. Accordingly the results of that program offer valuable guidance for this discussion.

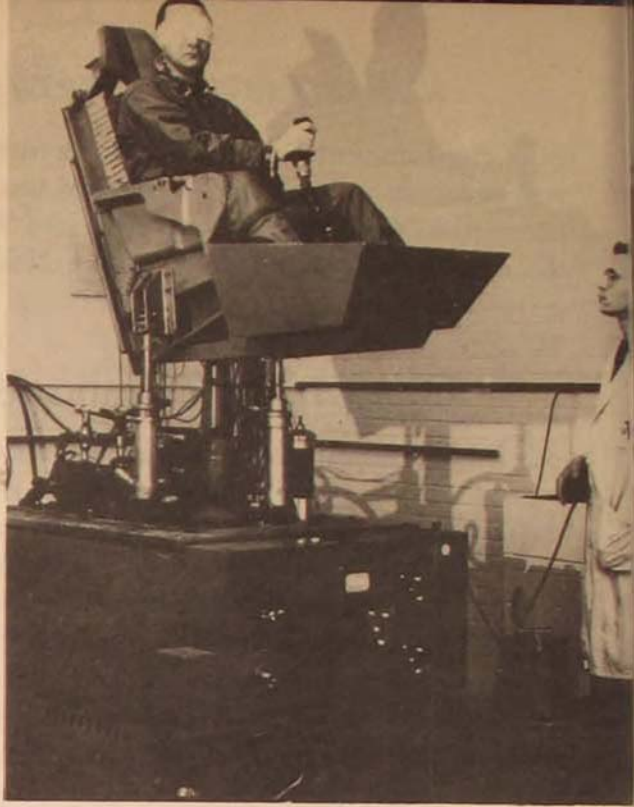
The preliminary screening criteria for the candidates were quite similar to those presently used to select SAC combat crewmen. Candidates had to be "medically acceptable and technically capable." The general criteria required them to be a rated pilot in the Department of Defense with 1500 hours of flying time, to possess an engineering degree, to be a graduate of a military test pilot school, and to be less than 5 feet 11 inches tall. Of the 110 men that met the criteria, 55 volunteered for the program. Preliminary interviews and psychological tests eliminated another 23. The final battery of physiological and psychological tests was administered to the remaining 32 men. One more candidate was dropped without explanation. The information used in this study represents the results obtained on the last 31 men. From the original number, 7 were finally selected as the best qualified for the program.

The selection committee worked on several assumptions, one of which has a direct interpretation for this study: that is, a mature test pilot could disguise his feelings very well even in the presence of severe psychological stress. An experienced SAC crewman might be considered in the same light. Recognizing the ability of the man to mask his feelings, tests had to be designed that would reveal those who were really stable and reliable.

In its conclusions the committee found that psychological stability was the most important single item to be evaluated. Even the severe physiological tests (centrifuge "flights," heat chamber, isolation tests, etc.) were considered important only to the extent that they influenced the psychological reaction of the candidate. In addition, intelligence, maturity, and motivation were considered vital areas to be assessed before reaching a conclusion on a candidate.[28]

From a practical viewpoint the physiological and psychological test-

heat

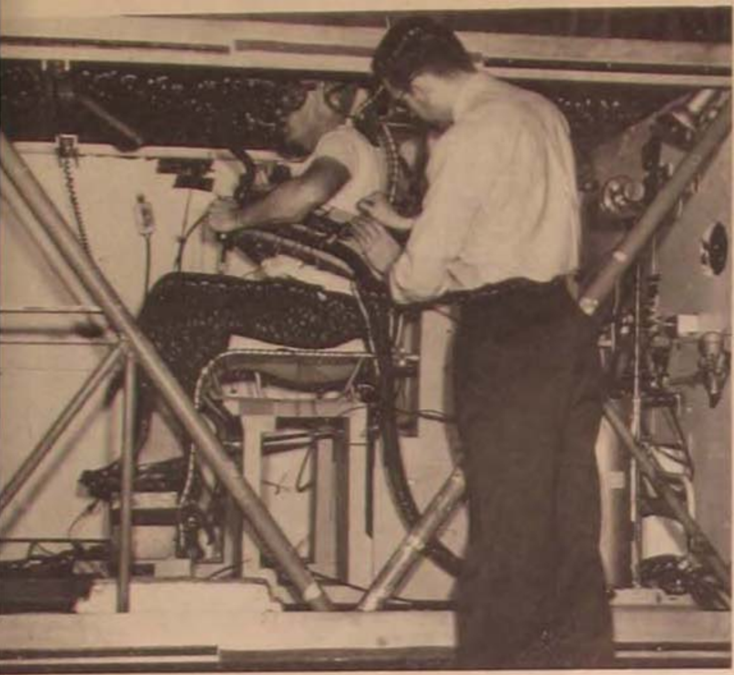


equilibrium

ing conducted on Project Mercury candidates would be hard to duplicate at a SAC base. The tests were so complex as to require the employment of well-qualified psychologists and the use of facilities at both the Lovelace Foundation in Albuquerque, New Mexico, and the Aero Medical Laboratories at Wright-Patterson AFB, Ohio. Note though that this most advanced crew evaluation program in which the Air Force has participated has seen fit to identify the psychological profile of the crewman as the most important criterion for stressful duty.

Several Air Force research projects have shown how written tests can be used as valid predictors of combat performance. Attitude measurements have been used successfully towards this end. Written tests were administered to men going through survival training at Stead AFB and were correlated during field exercise and later in actual combat in Korea. These tests also proved to be a good index of performance in air combat.[29]

In 1956 Drs. S. B. Sells and David K. Trites of the School of Aviation Medicine developed a battery of personality tests to be administered to incoming pilot personnel.[30] These tests were designed to find out which of the men would adapt to the stresses of the rated Air Force officer. Sells and Trites were able to report that from 5 to 20 per cent of the 2070 persons who were tested and cross-validated only through primary training could have been eliminated as a result of the tests. These tests were different from others in one main respect. The aim was to identify only those men whose capacity to adjust to stressful conditions was so poor that success would be unlikely when compared to the majority. In other words, they were looking for the poorest of a



acceleration

treadmill

ard step test

Stress Tests

As part of the process of selecting the Mercury astronauts, the Aero Medical Laboratories of the Wright Air Development Center in 1959 conducted tests to determine the men's reactions to some of the stress situations that might be encountered in orbiting the earth in a rocket-launched capsule.

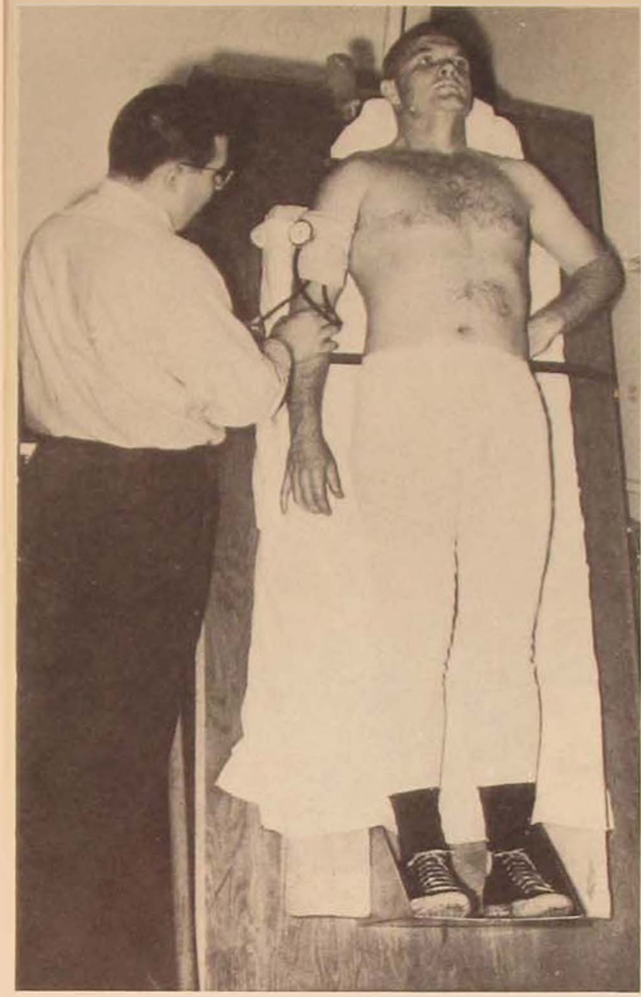
—Two hours in a chamber at 130° F. tests the reaction of the subject's heart and body functions while under the stress of unusual heat.

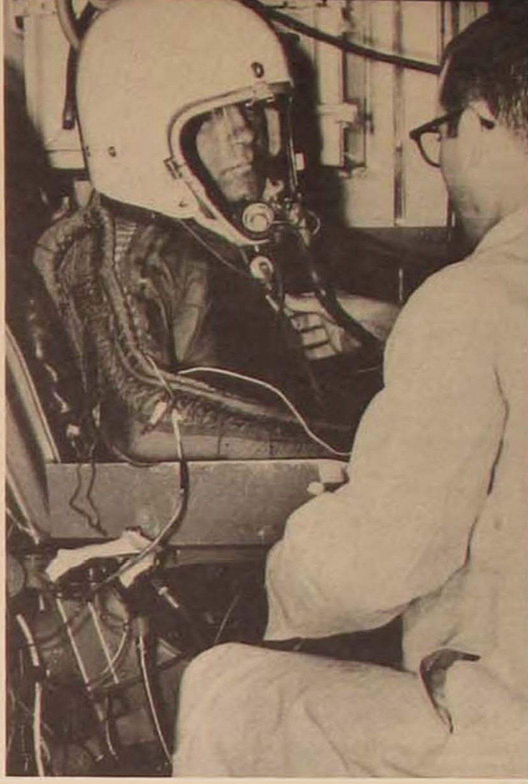
—Seated on a chair that rotates simultaneously on two axes, the subject is checked for ability to keep the chair on an even keel by operating a control stick, with and without vibration, with and without a blindfold.

—Acceleration in a centrifuge, with the seat inclining at various angles, tests the subject's reaction to multiple gravity forces.

—The subject walks a treadmill at a constant rate, and the treadmill is elevated one degree steeper each minute. The time it takes for his heartbeat to reach 180 per minute is another index to his degree of physical fitness.

—In the well-known Harvard step test, the subject goes up on a 20-inch step and down again once every two seconds for five minutes. His reactions to this strenuous exercise are an indication of his physical fitness and endurance.





partial-pressure suit

tilt table

isolation

—Remaining in a dark, soundproof room for three hours tests the subject's response to the absence of external stimuli.

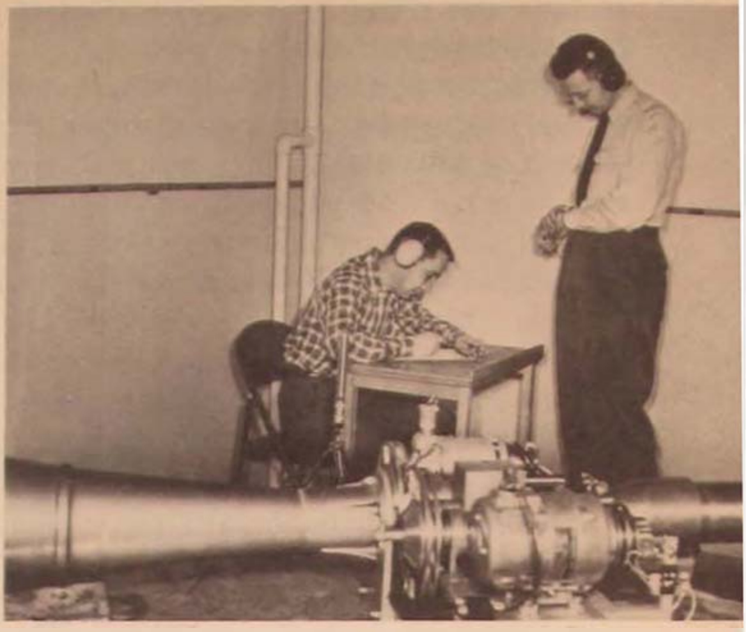
—Strapped to a tilt table, the subject is held at various angles to check his heart compensation for unusual positions of the body for extended periods.

—In an MC-1 partial-pressure suit the subject is taken in a pressure chamber to a simulated altitude of 65,000 feet. The test lasts one hour. The results are a measure of efficiency of the heart and breathing systems at low ambient pressures.

—Twelve signals on a panel simulate complex behavior situations and test the subject's ability to respond reliably.

—The subject is exposed to a variety of sound frequencies to determine his reaction to unusual noise and his susceptibility to high-frequency tones.

complex behavior simulator



noise

group whereas Project Mercury was looking for the best. In either case it is evident that tests can be developed, administered, and used to select those persons most likely to succeed in a stressful environment. Such tests can provide the basis for a permanent record of the individual's psychological profile, answering objectively questions concerning the man's motivation, attitude, and interest in his duty. In this way the flight surgeon will have a tool with which to administer his responsibilities as outlined in AFR 160-69.

Domanski and Marchbanks have shown that physiological tests can be used to determine whether or not a crew has been subjected to stress. Combining the results of these tests with Domanski's finding that an experienced crew will not show a stress response on a normal mission provides a medium for determining when a crew is psychologically ready to assume combat status. The flight surgeon could meet the crew at postflight debriefing, take appropriate biological samples, and by interrogation determine the stressful nature of the flight. The psychological readiness of the crew should be indicated by the absence of a stress response if the flight was free from unusual conditions. Coupling psychological readiness with technical competence (as determined by the standardization board) will give a more complete and accurate index of combat readiness.

The commander's or supervisor's subjective evaluation of his personnel is also a valid measure of individual capabilities. All the research projects previously mentioned used subjective evaluations in one way or another. However, evaluations of this type occasionally are colored by differing personality factors or varying opinions as to what constitutes an adequate performance. Thus the subjective method, by itself, cannot give a completely accurate picture.

While any one of the testing procedures discussed has certain faults as an independent and sole measure of the psychological profile, a battery of tests and ratings can give significant results. Combinations of psychological and physiological tests plus personal evaluations were the basis of the Project Mercury selection process. Application of a similar but simplified procedure, using the facilities found on a SAC base, is possible. Written tests are not difficult to administer nor are the subjective evaluations by commanders or supervisors. Analysis of biological samples may present more of a problem, but at worst the samples could be sent to a suitable laboratory. When the results of the complete battery of tests and ratings are correlated a useful psychological profile emerges.

Essentially then, the aircrew evaluation program should accomplish the following: select for training only those personnel who are technically and psychologically suitable for combat crew duty; advance to combat-ready status technically qualified crews when physiological and other tests indicate that they are psychologically ready; and retain only those crew members whose technical proficiency and psychological profiles indicate a sustained combat potential.

From the author's experience as a SAC crew member and combat crew supervisor, most crews have a reluctance to being evaluated in a simulator although these same crews do not object to in-flight evaluations and they also acknowledge the great value of simulator *training*. These personal observations are in agreement with the findings of the Air Force Personnel and Training Research Center.[31] In addition, the special simulator equipment upon which objective evaluations would have to be conducted is very expensive to produce and to man with properly qualified personnel.[32] Consequently the simulator finds its greatest value as a training device. The full-mission trainer should not be used as a part of the psychological evaluation of crews. It should be used only for learning skills in an environment that cannot be achieved through in-flight training activity because of safety factors or the necessity for simulated incidents.

HUMAN factors indisputably are key elements in the quality of combat crew performance. SAC's capability to execute the Emergency War Order may be open to some degradation because these factors are not considered *objectively* in the selection and retention of combat personnel. The doubt can be erased only by pursuing actively a program that considers both the technical and the psychological capabilities of the crew structure.

Today, as the force structure of the Air Force is changing to a mix of manned aircraft and missiles, many rated personnel are becoming excess to the requirements for cockpit positions. These people can be used to absorb the impact of introducing the psychological criteria into the combat crew evaluation program.

The former Chief of Staff of the Air Force has stated the requirement for personnel with the very qualities of individual intelligence, initiative, courage, and judgment that now can be measured or predicted. It is the responsibility of command to translate the results of human-factors research into operating programs that will provide the type of people needed for combat crews.

Command and Staff College

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THE COMMUNICATIONS-ELECTRONICS DOCTRINE

Lieutenant Colonel Herbert Herman and
Major Alph L. Westley

"Those people who cannot grow with us will not be with us. . . ."

When General LeMay said this he was speaking primarily about the requirement for a refined educational base for all Air Force officers. However, the statement can leave no doubt that the diploma is but the key to open the door to further knowledge. The word "grow" is particularly informative, and it implies some professional undertakings that only the individual can accomplish. They cannot be done for him.

On the other hand, the nourishment of professionalism must be made as convenient as possible. There is no particular advantage to be gained by obliging all to persistent labor at documentary research. The scope of the subject matter is great, comprehensive libraries are not readily available in the field, and most important there is not time. These matters of need, scope, and time have been the fundamental reasons for the establishment of the Communications-Electronics Doctrinal (CED) series of Air Force Manuals described in this article.

The explosive burgeoning of aerospace communications-electronics has reached such proportions as to challenge the position of any other single supporting activity in magnitude of cost, effort, facilities, personnel, and use of national resources. According to General Samuel E. Anderson, formerly commander of the Air Force Logistics Command, a sizable slice of the entire national economy is poured into the electronics industry. The following random examples serve to illustrate this assertion.

About half of the multibillion-dollar cost of defense goes into electronics, which includes ground systems such as BMEWS, DEW, and SAGE as well as a substantial part of the cost of missiles and aircraft. In 1960 approximately 32 per cent of the 7.9-billion-dollar AFLC budget was devoted to electronic items. This 32 per cent did not include installation, maintenance, or training costs, which were estimated to account for another half billion dollars. Of training costs, over $90 million is invested in major items for the electronics training facility at Keesler Air Force Base alone. Installation jobs total over 12,000, requiring a Rand 1105 computer just to keep track of their status. By any yardstick the communications facilities of the AIRCOM establishment dwarf any similar combination of commercial facilities. The AIRCOM net transmits over 26 million messages a year, which if stacked would reach an altitude of 10,000 feet. The net includes over 4½ million miles of leased circuits—enough to go around the earth 168 times. Ten billion words are transmitted annually. Over 8½ million weather messages alone are transmitted every year. Capital investments in this system, which has stations in 38 countries, run into hundreds of millions, without an end in sight. One airman out of eight is directly involved in a primary communications-electronics job. Thousands more are involved in the support of C-E functions. Recently the stature of the communications-electronics field was further recognized by the creation of the new major command, the Air Force Communications Service.

C-E activities are so integral with aerospace operations that it is difficult and rather academic to attempt to isolate them from the wide spectrum of activities with which they are intimately associated. The range of activity, the extent of required knowledge, the engineering, the planning, operating, and maintenance experience, the professional background—all have long ago exceeded the scope of experience that could reasonably be expected of a particular Air Force communications-electronics specialist. Many a C-E officer has spent his career within a single type of activity, as in the former Airways and Air Communications Service, within Air Defense Command, or with tactical organizations. Even within these functional groupings the sheer quantity of C-E hardware, the complexity of systems, the magnitude of the over-all system, and the necessary specialized engineering experience have tended to breed specialists —the "GCA man," the "Comm Center" specialist, the "heavy-radar man," the "ADC air/ground expert," the "organization commander," and even the much-maligned "headquarters type." This specialization, however decried by the agencies who prefer to do things by neat rows of broader AFSC numbers, was the natural circumvention of the formidability of technical erudition in a field where an engineer can spend a lifetime on antennas alone without uncovering all the information already available.

the problem of professionalism

Despite the inevitability of functional shredout, it restricted the flexibility of the manpower. In a dynamic Air Force situation, excessive shredout of management personnel specialties is tantamount to planned obsolescence, such as that reputed to characterize certain commercial products. And planned obsolescence in the technical skills so critical to an electronic technology is palpably uneconomic and self-defeating. Clearly some solution other than over-specialization is required.

One ameliorating influence has been the somewhat reluctant decline of the naive idea held over from World Wars I and II that the C-E officer was fundamentally a commissioned electronic mechanic who was prepared to disassemble and reassemble a complex electronic device as if it were an M-1 rifle. While vestiges of this forlorn belief can still be discerned, it has been largely replaced by a more mature concept of the C-E officer as the management engineer who, although not trained as an expert on a particular equipment, has the professional competence to plan, utilize, arrange, and manage the C-E function as a whole.

But even with such a modified professional profile, problems remained. As suggested previously, isolation of the C-E career from the general military

The USAF CED Manuals

AFM Nr.	*Title*
100-10	Master Index
100-11	Basic Concepts, Missions and Functions with Communications-Electronics Applications
100-12	C-E Publications and Training
100-13	Communications-Electronics Policy
100-14	Communications-Electronics Organization
100-15	Military Affiliate Radio System
100-16	Utilization of USAF Communications Services
100-17	Planning and Preparation of C-E Plans
100-18	C-E Programing and Implementation
100-19	Engineering and Installation of Fixed C-E Equipments and Systems (GEEIA)
100-20	Wire Communications Systems Planning
100-21	Communications Operating Principles and Practices
100-22	Commercial Communications Services
100-23	Radio Communications System Planning
100-24	Radio Communications System Operation
100-25	Astronautics Communications-Electronics
100-26	Navigational Aids Planning and Operation
100-27	ACW System Planning
100-28	Ground Radar Evaluation
100-29	Electromagnetic Wave Propagation Planning
100-30	Frequency Management
100-31	Communications Systems Management
100-32	USAF Aerospace Communications Complex (AIRCOM)
100-33	Army, Navy, and Commercial Communications Systems
100-34	Management of Commercial Communications
100-35	Mutual Electromagnetic Interference
100-36	C-E Supply and Maintenance
100-37	Electric Power for C-E Facilities
100-38	C-E Charts, Symbols, Formulas, and Tables
100-39	C-E Terminology, Definitions, and Abbreviations
100-40	(Reserved for future use)
100-41	Airborne Communications-Electronics
100-42	C-E Command & Control Systems, Tactical and Air Defense
100-43	Electronic Warfare
100-44	Vulnerability and Recuperability of C-E Facilities
100-45	C-E Security Instructions
100-46	Characteristics and Use of Chaff
100-47	(Reserved for future use)
100-48	Ballistic Missile Early Warning System (BMEWS)
100-49	(Reserved for future use)
100-50	Classified CED Extracts

environment is unrealistic. The C-E officer must be a competent, all-round military management engineer who is knowledgeable not only throughout the range of C-E functions but also in related military activities. Thus, while relieved of the necessity of soldering-iron dexterity, he must be conversant with other than the purely engineering aspects of his field to accomplish his mission —be it tactics, doctrine, policy, planning, programing, publications, personnel, maintenance, organizations, installations, navigation, electronic warfare, system management, command and control systems, or the interface problems of C-E system compatibility.

A curriculum to provide such a kaleidoscopic coverage would represent an ambitious objective for a four-year college course, even if not complicated by the problems of supplementing the inadequate academic engineering foundation of thousands of C-E officers already in the field. Nevertheless this is the fundamental task assigned to a little-known group of eight CED project officers in the Research Studies Institute, Air University, a group otherwise identified by the prosaic title of AU Project 4736. That project produces the "100-series" of 40 CED Air Force Manuals on subjects which run the gamut of C-E activity from the mundane business of publications to the sophistication of astronautics.

evolution of the CED

The requirement for an encyclopedic set of C-E references was recognized over ten years ago by the Air Force, when it issued the necessary instructions for the establishment of a system of C-E manuals. The CED of today can trace its origin to an action of the Army Air Forces Board in Orlando, Florida, in 1945, to study the need for redocumentation of communications policies, requirements, and operating procedures pertinent to communications-electronics activities within the Air Force. Obviously the Air Force could not continue to depend on Signal Corps publications, which were designed primarily for land rather than air operations.

One of the first official specific actions was a letter from then Brigadier General F. L. Ankenbrandt, Director of Communications, Army Air Forces, in July 1946 to all senior communications and signal officers assigned to the Army Air Forces, in which he requested that a proposed outline for an Air Force communications manual be examined and comments furnished. This single manual was to replace the corresponding Signal Corps publication, Field Manual 1-45. The letter from General Ankenbrandt emphasized the pressing need for the preparation of manuals on communications doctrine and requested Air University to undertake a study of the problem with a view to providing an over-all program of manuals on basic AAF communications doctrine suitable for use as texts in AAF schools and extension courses and for reference purposes by operational units.

A conference on the subject recommended that four manuals be published: Air Force Communications-Electronics Doctrine, Policy and Requirements; Air Force Telecommunications and Electronics Systems; Air Force Communications and Electronics Instructions; and an Air Force Telecommunications and Electronics Equipment Handbook. A staff study documenting the conclusions of the conference stated:

> . . . the proposed document should incorporate communications SOPs and SOIs for over-all Air Force or interservice communications. This is accomplished now at Theater, Task Force, or even command level in various ways. As a result, we find almost as many procedures as there are echelons of command. As a result, standards of efficiency, of training and operations, and of maintenance are all adversely affected; planning is hampered. Standardization is of utmost importance when long-range aircraft are used to carry on global warfare.

This conference was followed shortly by a request to prepare a radar manual covering all AAF radar equipment, to include employment, technical, and logistical information. A conference called to determine contents concluded that the various projects covering communications instructions, radar, and aircraft warning and control should be discontinued and in place thereof a single project covering the entire field of communications and electronics should be established.

In April 1948 a program for publication of manuals was submitted to Headquarters USAF for approval, and in the same month USAF gave Air University the responsibility for preparation of the four manuals. Initially no appreciable progress was made because of lack of personnel and inability to ensure stabilized assignment of personnel. It was not until 1950 that personnel were authorized on a permanent basis. In December 1951 Air University received a directive authorizing the Communications-Electronics Instructions (CEI) series of publications, including authorization for expenditure of funds for contract editing and illustration. In 1958 the CEI was converted to the Air Force Manual system under the new title of Communications-Electronics Doctrine (CED). This change also removed these manuals from the registered-document list and distribution, thereby greatly facilitating access by using agencies. Subjects were regrouped in a manner that allowed publication of most of the information in unclassified form. Only the last ten manuals of the Doctrine, 100-41 through 100-50, are now classified.

The selection of subjects and titles is officially established by Headquarters USAF. In actual practice the need for a CED manual frequently is proposed by a major command; in other cases the march of events will suggest the need, as in the case of AFM 100-25, *Astronautics Communications-Electronics*. In the process of preparation material is contributed by the using agency or command and sometimes is actually prepared in draft form by it. Normally research, assembly, and publication processes are carried out by the CED project office either in-house or by contract with nongovernment agencies. Printing is done by the Government Printing Office. Distribution is on the same basis as for other Air Force Manuals—those who need them must ask for them. There is no automatic distribution system either to organizations or to C-E officers.

objectives of the system

The configuration and terms of reference of the CED system may be summarized as follows:

- The CED system provides, in a single, cross-referenced, quarterly indexed set of volumes a compendium of the information, references, and planning guides required by the communications-electronics officer for the functioning of Air Force systems.

- The CED is the primary, consolidated directive documentation for all Air Force communications activities. Where it does not give all the essential information on a subject, it gives references to other sources that are readily available.
- The CED is oriented toward the engineering and functional management of C-E facilities and therefore does not contain the detailed procedural instructions characterizing Allied communications publications and Joint Army–Navy–Air Force publications, nor does it contain the plethoric detail of Technical Order instructions. The depth of treatment and the amount of detail will vary from manual to manual or even from one edition of a manual to the next, depending upon the extant information on the subject and the need for information.
- The CED is a dynamic encyclopedia of communications-electronics, kept current by changes as they occur, by complete revision and republication, by retirement of obsolete manuals, or by the addition of new subjects as in the recent case of *Astronautics Communications-Electronics* (AFM 100-25) and *Mutual Electromagnetic Interference* (AFM 100-35).
- The CED manuals define the parameters of the subjects and the depth of knowledge with which the C-E officer is expected to be conversant.

The selection of subject for each manual is primarily intended to be responsive to the individual rather than to a particular command. The objective is to provide and arrange material so that the user can read rather than be obliged to research the information he needs. While duplication is avoided, it is occasionally necessary to recapitulate, summarize, consolidate, or reassemble information available in other publications. If this were not done, the CED manuals would be reduced to a bibliography.

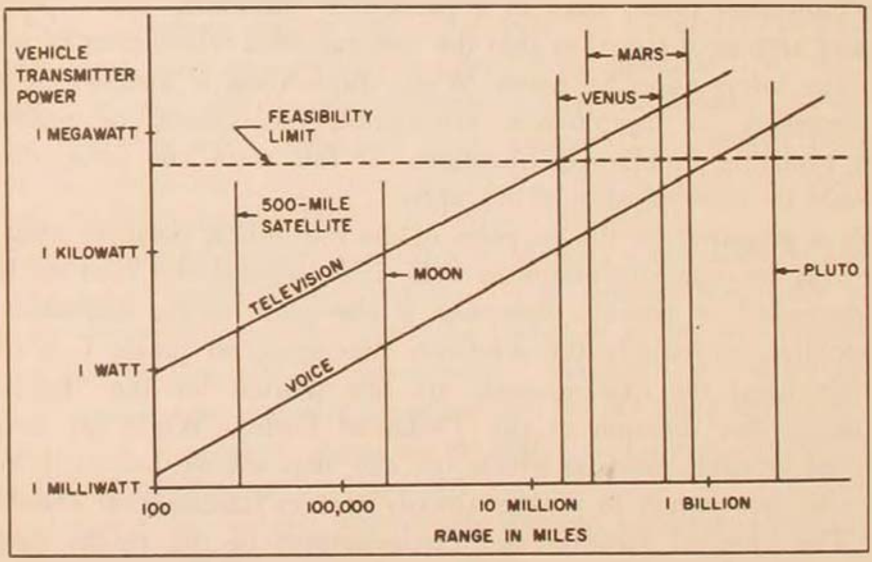
The CED is prepared for the purposes of the staff officer down to wing level so that he may become conversant in C-E fields beyond the confines of his particular command or activity. Attention is also given to the individual C-E officer personally, particularly the relatively inexperienced junior C-E officer. On the other hand the CED manuals are not written for the "hardware" specialist; this is the function of the Technical Order. While the non-C-E officer will find valuable material within the CED, it is written primarily for the C-E officer who is assumed to possess already certain fundamental knowledges and skills. The physical location and circumstances of the reader also are considered in deciding upon content. The C-E career field is notorious for the number of its isolated duty stations. At such locations it is obviously impossible to maintain even the most spartan reference library. It is therefore imperative that instructions on the business of the C-E officer be complete and available in a single reference.

Another consideration influencing content is the point of view. The point of view from which the CED is written is that of Headquarters United States Air Force. The CED is directive in nature, and any other directives covered in other publications are rescinded when they are included in the CED.

A third consideration is general pertinence. Usually the information contained in the CED will be that which applies to more than one command. When it deals with a subject peculiar to one command, it will treat this subject in general manner. As an example, the instructions applicable to SAGE which would be required by a C-E officer in the SAGE system occupy several shelves. Obviously this much detail could not be included in the CED, but it should contain sufficient information to inform C-E officers in other commands of the system functioning, information flow, capabilities, and limitations of SAGE.

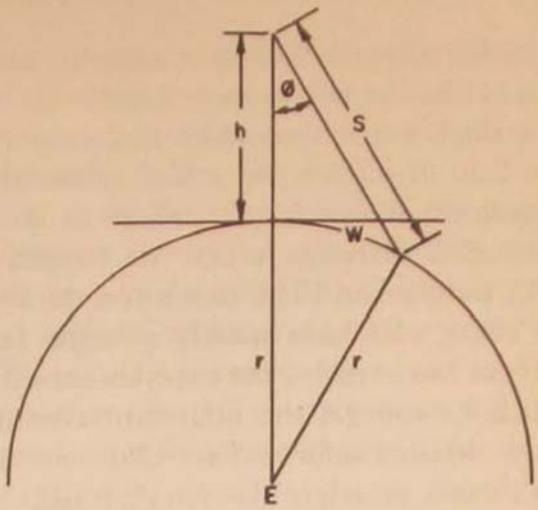
A fourth consideration is the unity of the CED. Most readers at one time or another have been exasperated by reading material which had so many cascading references that any continuity of thought was impossible. In many cases such references would involve a trip to the T.O. library or an attempt to obtain or to justify issue of manuals and publications not immediately available. In the CED every effort is made to avoid the necessity for such excursions. A brief quotation, summary, or recapitulation is given in the text so that the reader is not obliged to disrupt his reading process by researching several references—only to find perhaps that the researched information is not pertinent to his purpose.

A fifth consideration is the need for descriptive information on C-E activities for the benefit of the C-E officer whose duties hinder the broadening of his professional horizons by other educational means. The CED may be used



Power requirements for early space vehicles probably will range from a few watts to a few kilowatts, with durations ranging from a few hours to several months. Later, power in the megawatt range will be required to drive ionic, photonic, or other advanced propulsion units for periods ranging from a few days for lunar missions to many months for interplanetary missions. During and following launch, power activates boost-stage separation devices, ignites new stages, pumps and controls fuel, and energizes guidance controls and various C-E subsystems. In flight, power is used to extend antennas, operate nose-cone components, and perform other operations incident to accomplishing the mission. Throughout the useful life of the vehicle, power is required for communication, electronic countermeasures, and intelligence gathering—and the vehicle's useful life will in all probability be determined by the life of the power system.

Surveillance by satellite will be extremely valuable because of the vast area that can be covered rapidly and the possibility of cyclic operation. The extent of ground coverage by any surveillance system—camera, radar, electronic, infrared—at a specified altitude can be computed with the equation shown, in which W *is width of ground coverage,* h *is satellite altitude,* S *is slant range,* ϕ *is viewing angle, and* r *is earth radius. In the accompanying table the equation has been worked out for certain altitudes ranging from 100 to 10,000 miles.*



$$W = \frac{\pi r}{180}\left[\sin^{-1}\left(\frac{r+h}{r}\sin\phi\right)-\phi\right]$$

Distances, Viewing Angles, and Ground Coverage for Satellite Altitudes

Satellite Altitude, h (miles)	Viewing Angle, ϕ (degrees)	Slant Range, S (miles)	Ground Coverage, W (miles)
100	30	116	58
	45	143	101
	60	208	180
200	30	233	116
	45	290	205
	60	436	378
300	30	351	176
	45	442	312
	60	690	599
500	30	590	296
	45	758	538
	60	1349	1186
1000	30	1208	607
	45	1667	1198
	53	3021	2558
2000	41.6	4496	3342
5000	26.2	8093	4410
10,000	16.5	13,448	5075

as basic reference and text material for professional self-education. While the CED project is not in the business of textbook writing per se, it does provide in a single convenient series of documents the outline and the standard of what the field of interest for a C-E officer should be. The CED is certainly the only convenient source for the officer at the isolated location to educate himself in those C-E activities which are beyond the immediate scope of his particular duty assignment. The CED serves as an encyclopedic reference point, not only for those who have merely a vague familiarity with a certain aspect of C-E systems but even for the experienced officer who needs a convenient source from which he can get the information he needs or references to other sources for more detailed information. Old-time Air Force communicators will remember with some nostalgia the familiar sight of C-E officers reporting for duty with footlockers crammed with a heterogeneous collection of Army manuals, command instructions, commercial bulletins, textbooks, training manuals, and personal notes. Happily the CED has taken the place of that collection.

"CED 2500"

The nature of the CED effort is well illustrated in "CED 2500," which is the informal title for AFM 100-25, *Astronautics Communications-Electronics*. Representing four years of research and study, this is the first Air Force manual to provide in unclassified form both general and technical coverage of aerospace

Frequency Allocations for Space Communications

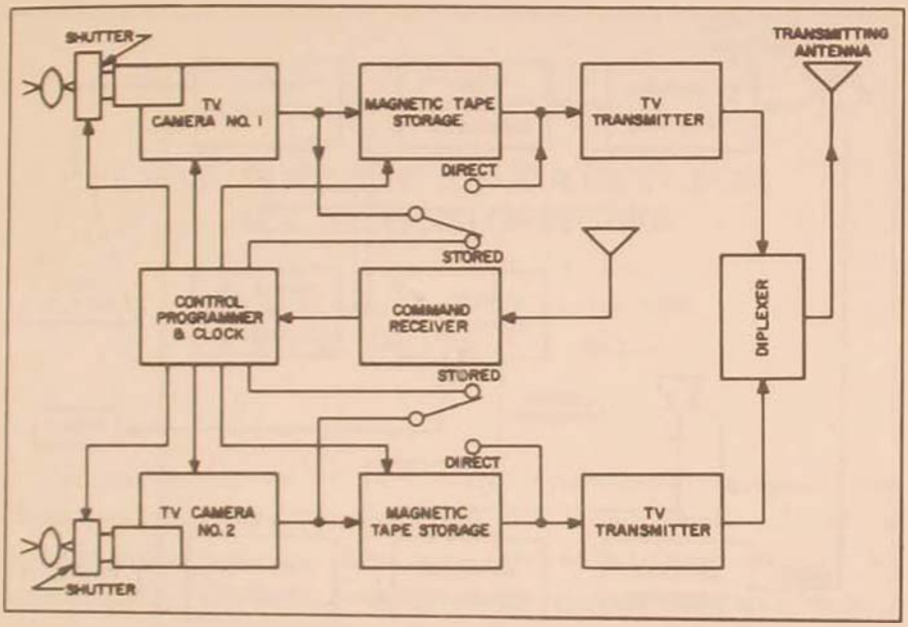
Frequency (mc)	Primary Use	Secondary Use
19.99 to 20.01	standard frequency	space, earth–space
39.986 to 40.002	fixed, mobile	space, earth–space
136 to 137	space, fixed, mobile, earth–space	
183.1 to 184.1	fixed, mobile, broadcasting	space, earth–space
1427 to 1429	space, fixed, mobile, earth–space	
1700 to 1710	fixed, mobile	space, earth–space
2290 to 2300	fixed, mobile	space, earth–space
8400 to 8500	fixed, mobile	space, earth–space
15,150 to 15,250	space, earth–space	fixed, mobile
31,500 to 31,800	space, earth–space	fixed, mobile

During the 1959 Administrative Radio Conference in Geneva several frequenc[y] channels were allocated for earth–space and space–space communications. Some o[f] these assignments are shared between services, but the need for space frequencies ha[s] been recognized and future assignments will be made as the space exploration progra[m] expands. Stations of a secondary use must not cause harmful interference to stations o[f] primary use and cannot claim protection from harmful interference by a primary use.

communications-electronics, including the astronautic C-E systems now in use and those planned for the future. It pulls together related information ranging from a review of fundamentals of the space environment to a practical consideration of supply and maintenance concepts in the C-E field.

The first of its six sections examines basic C-E concepts and the trends toward obtaining maximum operating lifetimes, efficiency, and reliability with minimum power, weight, and size. This section describes the C-E systems—telemetering, communication, guidance, tracking, and navigational—that play major roles in the conquest of space. The discussion covers the design of C-E systems for both satellites and space vehicles as affected by equipment and frequency considerations, power requirements, human factors, and ground facilities.

The second section presents C-E component considerations as threefold: the design technique of miniaturization, increased receiver sensitivity through newly developed receiver circuits, and primary energy sources of power for astronautic C-E equipment. Text and diagram present engineering data on tunnel diodes, micromodules, traveling-wave tubes, masers and parametric amplifiers, solar energy devices, fuel cell construction, thermionic emission devices, and the like.

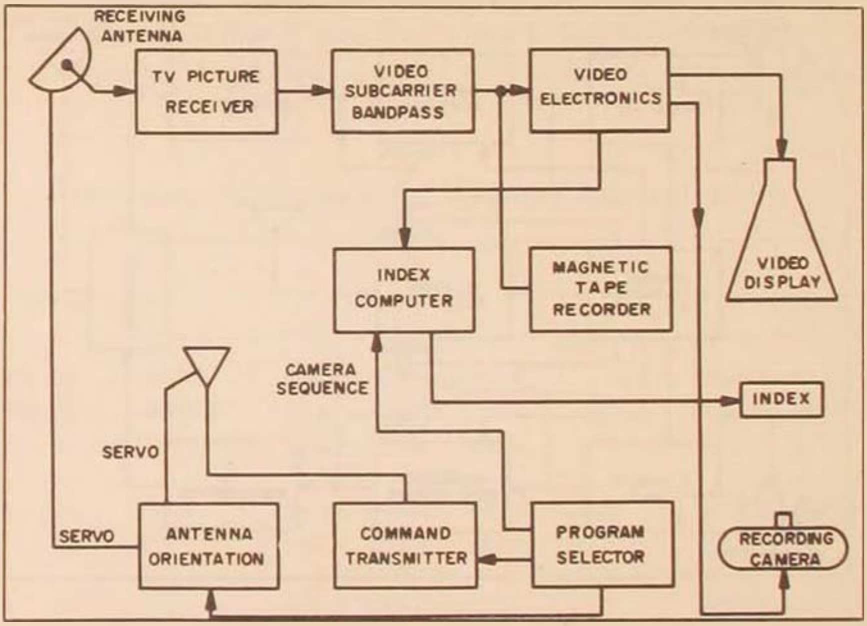


Tiros I takes cloud photographs with two half-inch vidicon television cameras. One of the cameras has a wide-angle lens for viewing areas of cloud cover nearly 800 miles square. The second camera has a narrow-angle lens of better resolution over areas measuring approximately 100 by 135 miles. Each camera and its associated equipment operates independently, so that failure in one will not affect the operation of the other. The photographs made by the cameras are kept for delayed transmission to earth in magnetic tape storage, each having a capacity for 32 frames. Two 2-watt FM transmitters of 235 mc frequency (one for each camera chain) send the pictures to earth. Precision electronic-clock mechanisms, which are triggered by command signals from ground stations, control the operating sequence of the cameras, recorders, and transmitters. Power to operate the equipment is provided by small nickel-cadmium storage batteries charged by more than 9000 solar cells covering the top and sides of the satellite.

The third section puts C-E concepts and equipment into an operational setting, that of functional astronautics C-E systems for satellites and space vehicles. Four areas for possible application to military satellite systems are discussed—surveillance, bombing, metal balloon satellites, and satellite detection systems. C-E in aerospace operations is treated in other aspects: in relation to lunar flight, interplanetary flight, man-made space stations, extraterrestrial bases; the frequency spectrum and specific frequency allocations for space communication; the effects of distance, velocity, acceleration, vibration, temperature, etc.

Section four deals with the efforts being made through research and development to achieve reliability in C-E components. The discussion covers the effects of nuclear radiation on electronic parts; the trend toward use of solid-state materials and toward monolithic blocks of equipment to perform a complete electronic function (molectronics); the role of electronic circuitry in measuring man's physiological variables; and C-E support at satellite launching and tracking sites.

Section five describes existing astronautic C-E systems and the role they play in getting worthwhile results from such satellite and space programs as



Tiros I is within communication range of its ground receiving stations at Fort Monmouth, New Jersey, and Kaena Point, Hawaii, for only a small portion of each orbit. During this time a command signal from the ground station causes the stored information to be read from the tapes into the satellite transmitters and relayed to earth. As the cloud-cover pictures are received, they are displayed by television, and a magnetic tape recording system provides a permanent record. Since automatic operation of the Tiros I television camera systems requires numerous instructions to be transmitted in rapid sequence, complete sets of instructions are preprogramed at each ground station. Before ceasing effective photodata transmission on 17 June 1960, Tiros I relayed nearly 23,000 cloud-cover pictures, which were used in making actual weather maps.

Vanguard, Explorer, Pioneer, Tiros, Echo, Score, Courier, BMEWS, Mercury, X-15, Dyna-Soar. Diagrams present satellite instrumentation, mission sequence, ground station equipment, and operational layouts of defense systems.

The last section of the manual offers a 65-item bibliography on astronautics communications-electronics, followed by a six-page alphabetical subject index that greatly simplifies reference to the varied subject matter of the manual.

Perhaps the unique achievement of "CED 2500" is the narrative form in which the assembled information has been presented so that the individual may simply read it. Of professional importance, the manual keeps a firm connection to military applications and integrates C-E devices with systems. Its readability, broad scope, and military relevance make it an important professional document available to C-E officers whether they are located in the big centers of C-E activity or at the most remote field of assignment.

Research Studies Institute

WAR COLLEGE EDUCATION FOR ALL SENIOR OFFICERS

Colonel John A. McCann and
Colonel Edward A. Jurkens

SINCE the advent of vastly expanded explorations in space, our Nation has found it necessary to accelerate the development of technologically sophisticated weapon systems. New concepts of national security have been formulated and new roles have been given to military men and their machines.

The full potential of complex and powerful modern aerospace forces can be realized only with educated, dedicated, and experienced military leaders. Education plays a vital role in providing military men the knowledge and competencies prerequisite to leadership in this age marked by expanded horizons of science. This is the role of the War College. The military education of an officer of the United States Air Force is never complete without graduation from this senior school.

The resident program of the War College dates from 1946, the year Air University was activated at Maxwell Air Force Base. The idea for a War College correspondence course was approved in 1947. By October 1949 the text materials and administrative arrangements were ready to make the War College curriculum available to nonresident students by means of the correspondence method. Enrollment was open to active-duty regular and reserve officers as well as reserve officers not on active duty. Foreseeing USAF requirements for an increased number of officers with top-level military education, the War College has recently achieved a "breakthrough" in academic methods by creating an additional course specifically designed for senior officers on active duty who are unable to attend the resident school at Maxwell. This course, War College Associate Course, makes use of a unique concept of student-operated seminars at selected Air Force bases.

mission and philosophy of the War College

The mission of the War College is to prepare senior officers for high command and staff duty and to develop a sound understanding of the elements of national power, to ensure the most effective development and employment of aerospace power.

Some of the most important fundamentals of the educational philosophy of the War College have been summed up by Major General Leo P. Dahl, Commandant of the War College:

- primacy of interest in strategy as affected by all the elements of national power
- emphasis on the total environment within which military power must operate
- concern with the need for flexibility and adaptability in an era of change
- reliance of the War College on personal dedication and motivation in an atmosphere of graduate-level instruction
- stress upon academic freedom with all its responsibilities as well as its rewards
- belief that excellence in performance should be identified and recognized.

Advanced education in the War College resident and nonresident programs is centered about the knowledge, skills, and attitudes necessary for the progressive maintenance and employment of total aerospace power. Consequently the curriculum is general in nature and provides for both an immediate and a long-term yield for the Air Force. The content of the curriculum and the plan of presentation are dynamic and meet changing Air Force and student needs. Instructional methods to achieve content objectives are selected and programed to provide the most appropriate student learning experiences. Opportunities are also provided for students to derive learning benefits from a maximum of experience-sharing between students of varying backgrounds and to further their individual career capabilities. In addition the atmosphere of academic and personal freedom in the War College encourages both independent and cooperative learning activities, as well as ethical and disciplined behavior.

It has been traditional with professional military schools to prepare for war in time of peace. This preparation has become increasingly important within the past two decades. Traditional military functions have expanded enormously. First, senior officers have become more concerned with foreign policy—the purposes for which military forces will be used and the terms under which they will be deployed. Second, senior officers have had to concern themselves with a greater number of military support functions. Problems such as finance, supply, research and development, public relations, manpower, management, and the like have grown more complex and more demanding of the senior officer's time and attention. Both these developments are reflected in the nonresident program curriculum, which is also designed to prepare senior officers to function in the complex roles which they are required to play in American society.

the nonresident program

Many officers have asked: "If graduation from the War College is so essential for developing competencies for high-level command and planning functions, why can't all senior officers be enrolled in the War College?" As a matter of fact, they can. To be sure, not all senior officers can be transferred to the resident school at Maxwell Air Force Base; but the War College can and does go to the officer in the field. The War College nonresident program, through its Extension Course and Associate Course, makes it possible for the officer half a world away from Air University to take advantage of the War College course.

The War College nonresident program, as an integral part of the War College, parallels as closely as possible the educational philosophy and program of the resident school. The objectives of the nonresident program are:

- To expand the student's understanding of the nature and scope of international relations and the current world conflict; the basic concepts for the employment of military forces—particularly aerospace forces—in cold, limited, and general wars; and the application of these considerations to current and future national and military policies and strategies for the attainment of United States and Free World objectives.

- to develop an appreciation of current problems facing the United States Air Force, with emphasis on those pertaining to aerospace.

- To expand the student's ability to analyze, appraise, and develop sound solutions to problems and to project them effectively in oral and written presentations.

Extension Course. For some years the War College Extension Course has made the curriculum of the resident program available to active-duty regular and reserve officers who were unable to participate in the resident program at Maxwell. In the Extension Course the student achieves learning objectives comparable to those of the resident program by completing the specified reading assignments and then preparing a written paper to demonstrate assimilation and comprehension of the study materials. Each student's work receives a personal evaluation by the War College faculty. The student's achievement is assessed by both the quality of his writing exercises and his scores on objective examinations.

Student self-satisfaction is the key to the successful completion of the War College Extension Course. Every effort is made by the War College faculty to exploit each student's individual experience and capacity for improving his career potential. Individual effort in the correspondence method has the unique advantage of permitting study at any hour or place.

Associate Course. The recently activated War College Associate Course enables qualified officers to benefit from seminar experience even though they are far removed from the resident school. Already more than twenty seminars have been organized, and ultimately the program will be extended to approximately sixty bases. Each seminar will give fifteen students the opportunity to participate actively and continuously for the two-year period required to complete the program.

The Associate Course combines the advantages of guided self-study with those of group discussion. By establishing War College seminars at selected Air Force bases a successful marriage of group and individual learning techniques was consummated to achieve more comprehensive results in the understanding and appreciation of course materials.

The advantages of the Associate Course seminar methodology are several. It places emphasis on individual preparation and study as a prelude to group participation and discussion. It provides discussion among the members of the group, in which each member ventures his opinions and reactions, states his ideas, compares, criticizes, and learns from the thinking and experience of others. It motivates an individual through the shared interests and activity of others. It develops leadership abilities in participants.

The Associate Course is designed specifically for senior officers on active duty. These officers meet once a week for a two-hour period to participate in a specifically designed version of the War College resident curriculum. The course is divided into two broad areas: the seminar program, which is a group effort in a guided course of study, and the thesis program, which is an individual research project.

The seminar portion of the course is to be completed in two years, during which students are required to make oral presentations in their seminars and to submit written papers for evaluation by the War College faculty.

The principal individual effort is a thesis on some aspect of aerospace power, introduced into the curriculum at the end of the first year of the seminar program. During the second year a student may write his thesis in conjunction with his seminar work and thereby complete the entire course in two years. Those students who prefer to work on their theses after completing the seminar schedule will require three years for graduation.

Academic supervision by the War College faculty for the Associate Course seminars conducted away from Maxwell is channeled through the student seminar chairman by correspondence, telephone, and frequent visits.

Experimental seminar group at Maxwell AFB initiates War College Associate Course program. Similar groups are being organized at many other bases world wide to permit nonresident study leading to War College graduation. Enrollment in each seminar is limited to 15 qualified senior officers or civil service employees of equivalent rank.

The Associate Course seminar is a unique experiment in graduate-level education and has aroused considerable interest among civilian educators as a possible method of keeping other professional groups abreast of rapid advancements of knowledge in their professions.

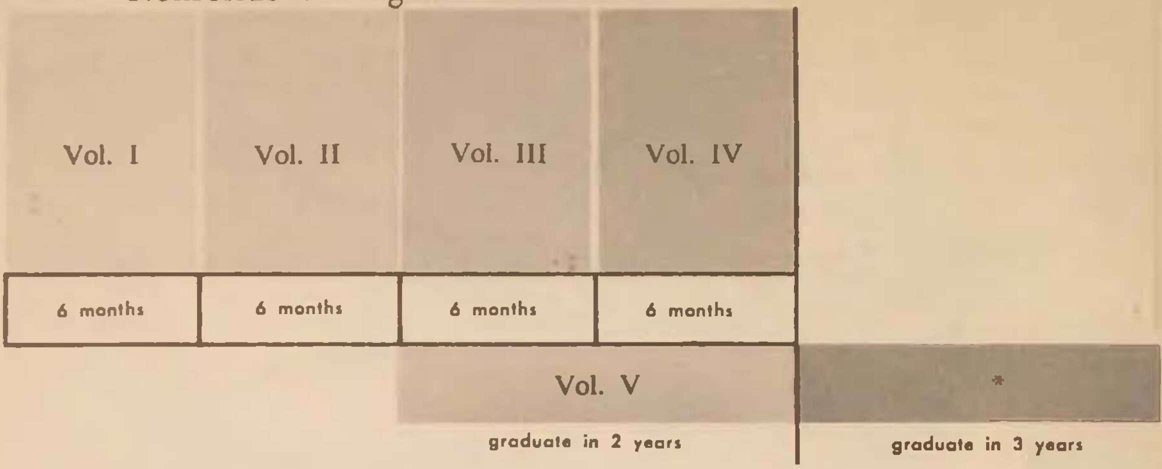
The nonresident course materials

Although the curriculum for the nonresident program parallels as closely as possible the resident course of the War College, some modifications are necessary in the manner of presenting materials to the student. To achieve learning objectives comparable to those of the resident program, the nonresident student must rely heavily on an intensive reading and writing discipline.

Study and instructional materials, guidance, and evaluation are provided for both the nonresident courses by the War College. The text for each unit of the course, in the form of a chapter, contains all the study materials: a statement of the lesson objective, an introduction to the subject being studied, suggested topics for study, required readings, and a list of references for those desiring to do supplementary reading. All the study materials issued to individual students may be retained by them.

Curriculum materials for the War College nonresident courses are divided into five volumes.

Nonresident Program Curriculum



** The War College Associate Course Curriculum covers the four major subject-matter areas (Volumes I through IV) of the resident course. A 10,000-word thesis is written during the second study year or in a third year following the seminar instruction.*

Volume I, *International Relations and the Current World Conflict,* acquaints students with the elements of power, i.e., political, economic, military, and psychosocial. The interrelationship and interdependence of these elements of power to the understanding of military power are stressed. In addition this first volume reviews the current conflict in world areas by examining the contemporary posture of selected nations and the actions, reactions, and commitments of the major power groups.

Volume II, *Formulation of National Security Policy,* analyzes those factors, both within and outside the Department of Defense, that affect the formulation of national security policy. It also deals with the complex machinery at the highest decision-making levels for the implementation of national security policy. The subjects treated include the roles of selected Federal agencies in the formulation of national security policy; social, economic, and political factors influencing national policy; the responsibilities and functions of the Department of Defense and the Joint Chiefs of Staff; and service roles and missions, doctrines, and concepts.

Volume III, *The Influence of Science and Technology and Weapon Systems on National Security Policy,* introduces the student to the major influences affecting national security policy, including analyses of the predictions made by leading scientists and engineers to determine what may be expected from science and technology in the future; characteristics of change that may be anticipated in future weapon systems; and the scientific and military potential of space.

Volume IV, *Military and National Strategy,* guides the student through an exploration of current concepts and future projections of military and national strategy. In this volume the military strategies and capabilities of the United States and the Allied nations are analyzed and evaluated. Proposals for future national strategy are considered. Pertinent subject areas include current and alternative United States military strategies for cold war, limited war, and general war; capabilities and planned employment of forces and agencies available to implement these strategies; concepts for future military strategy; problems pertaining to national security in the future; and proposals for United States security and world peace.

Volume V, *The Thesis Program,* presents the organized research and writing program designed to supplement the entire curriculum. Previous written requirements covered specific topics. At this point the student is encouraged to focus his attention on one subject, to examine one military problem, taking into account, where appropriate, the political, economic, technological, and psychosocial factors studied throughout the course.

In the selection of a subject and development of the thesis, emphasis is placed on the disciplined examination of a significant aerospace problem dealing with national security or military policy, plans, or strategy. Topics for theses must be approved by the War College faculty. Each student is expected to prepare a paper of approximately 10,000 words on a subject in which he has had some practical experience or one that is in consonance with his educational interests. He receives individual faculty guidance and counsel during the thesis phase of his study program.

The general objectives of the thesis program are:

- To increase the professional knowledge of senior officers by means of disciplined examination of significant problems dealing with military strategy.
- To provide senior officers with an opportunity to contribute views on subjects affecting national security.
- To increase the senior officer's ability to analyze and evaluate ideas and to write effectively about them.

Files of theses written in the Associate and Extension Courses are maintained in the document section of the Air University Library as an additional authoritative source for students of national security and military affairs.

Suggestions for the conduct of the Associate Course seminars are published separately in seminar guides. Seminars are supplied with additional materials such as maps, books, manuals, magazines, and pamphlets.

GRADUATION from or participation in a nonresident course does not preclude selection for the resident course of the War College. As relatively few of the thousands of eligible officers will be selected for the resident course, the nonresident program represents the sole opportunity for the majority of ambitious senior officers to undertake the War College curriculum.

An officer completing the Associate or Extension Course will receive a diploma indicating graduation from the appropriate War College course. This information will also be entered on his personnel record. Regular officers will have their graduation from the War College Associate Course noted in the *Air Force Register* by a distinctive symbol.

Appropriate completion certificates and point credit for inactive-duty reservists are awarded for completion of each phase of the Extension Course.

Test seminars of the Associate Course were established in 1961 at Maxwell, Langley, Wright-Patterson, and Lincoln Air Force Bases. These test seminars are now completing the third volume of text materials. Excellent reception of the new concept for expanding the opportunities for War College graduate-level education has been evidenced by both the students and their commanders. In response the War College plans to establish seminars at other stateside Air Force bases and overseas as expeditiously as possible. Enrollment in the Associate and Extension Courses is expected to exceed a thousand students by mid-1962. The day is fast approaching when the Air Force can expect every eligible senior officer to complete War College education.

War College

The Quarterly Review Contributors

John J. McLaughlin has been Administrative Assistant to each Secretary of the Air Force since creation of the position in 1947. He was with the U.S. Civil Service Commission from 1940 to 1942, then in the Personnel Office of Air Corps and Army Air Forces Headquarters until he entered the U.S. Navy in August 1943. His oversea duty was mainly with the Submarine Training Pacific Fleet. After termination of his active military service in March 1946, he returned to civil service with the Army Air Forces and soon was chosen by Stuart Symington, first Secretary of the Air Force, for the key position in the new Department of the Air Force which he now holds. In 1956 Mr. McLaughlin received the Exceptional Civilian Service Award from the fourth Secretary of the Air Force, Donald A. Quarles.

Major General Perry B. Griffith (USMA) is Deputy Inspector General for Safety, Hq USAF, his organization being stationed at Norton AFB, California, and Kirtland AFB, New Mexico. He was originally commissioned in the Cavalry in 1934 but soon took flying training and gained his pilot rating. During World War II he served in the Canal Zone as commander of antisubmarine units, later of the Galapagos Islands, still later of Gowen Field, Idaho, Bowman Field, Kentucky, and a patrol unit in the Pacific. Postwar assignments have been as a wing commander, Caribbean Command; as student, Air War College; as staff officer on several atomic test operations in 1951–52, on conclusion of which he became Deputy Assistant for Atomic Energy, Hq USAF, a three-year tour broken only by a special mission to Far East Air Forces and a combat mission to Korea. He served as Deputy for Air in the 1956 atomic test Operation Redwing at Eniwetok, and as Chief of Staff, Joint Task Force Seven, on the 1958 Operation Hardtack. He was Commander, 836th Air Division, Tactical Air Command, from 1958 until his present assignment in 1960.

Colonel Albert P. Sights, Jr. (USMA) is Director, Faculty Group C, Armed Forces Staff College. During World War II he served in the flying training and flexible gunnery training programs and as Inspector General, Twentieth Air Force, Guam. Subsequent assignments have been as Chief, Personnel and Administration, Wright-Patterson AFB; as Base Commander, Patrick AFB; and as Inspector General, Nouasseur Air Depot, Casablanca. Colonel Sights graduated from the Armed Forces Staff College in 1950 and from the Air War College in 1956, after which he was an International Politico-Military Affairs Officer in the Directorate of Plans, Hq USAF, until his current assignment.

Lieutenant John E. Lawyer, Jr. (B.A., Harvard University) is currently undergoing navigator training at James Connally AFB, Texas. Upon graduation from Harvard with honors in 1960, he received a direct regular commission through AFROTC. He was the first undergraduate admitted to the Harvard Defense Studies Program. He was subsequently awarded a fellowship at the Harvard Graduate School of Public Administration, where he was a member of the first Science and Public Policy Seminar. In 1960 he was appointed to the Executive Trainee Program of the Office of the Secretary of Defense, in consequence of which he served several duty tours in the Office of the Director of Defense Research and Engineering.

Major Kendall Russell (USMA; M.S., Purdue University) is a Systems Staff Officer, Directorate of Systems Acquisition, DCS/Systems and Logistics, Hq USAF. After receiving his master's degree in nuclear physics in 1950, he was assigned to Hq Air Research and Development Command, where he participated in the nuclear weapons effects program until 1956. From then until 1960 he was a member of the Advanced Systems Planning and Analysis Office, Air Force Ballistic Missile Division, Los Angeles. Major Russell is a 1961 graduate of the Command and Staff College.

Dr. Kenneth R. Whiting (Ph.D., Harvard University) is a member of the Research Studies Institute and of the faculty, Air University. He formerly taught Russian history at Tufts College. Dr. Whiting is the author of numerous studies and monographs on Russian subjects, including *Readings in Soviet Military Theory, Essays on Soviet Problems of Nationality and Industrial Management, Iron Ore Resources of the U.S.S.R.*, and *Materials on the Soviet Petroleum Industry*. He has also contributed two chapters to Asher Lee's book, *The Soviet Air Force*, and an article in Eugene Emme's recent book, *Readings on Air Power*. He is a regular contributor to the *Quarterly Review*.

Major William G. Hurst is Air Training Command Representative at the Air Force Special Weapons Center, Kirtland AFB, New Mexico. He enlisted in the 160th Infantry in 1939, completed flying training as a staff sergeant pilot in 1942, then served as a troop-carrier pilot with the 315th Troop Carrier Group in England, North Africa, Europe, and the Caribbean, 1942–1945. He was commissioned in 1944. He went on inactive duty in 1945, was recalled in 1948, and has since served as Flight Instructor and Director of Academic Training, Central Instructors School, 1948–1950; as Maintenance Supervisor and Squadron Commander, 28th Armament Electronics Maintenance Squadron, Ellsworth AFB, South Dakota, 1951–1954; as Special Weapons Staff Officer, 21st Fighter Bomber Wing, France, 1954–1956; as Maintenance Control Officer, 100th Bomb Wing, Pease AFB, New Hampshire, 1957–1958; and as B-47 Aircraft Commander and Squadron Operations Officer, 1958–1960. Major Hurst is a 1961 graduate of the Command and Staff College.

Lieutenant Colonel Herbert Herman (B.S., University of Pittsburgh) is Assistant Chief, Communications-Electronics Doctrinal Project Office, Research Studies Institute. He was one of the first U.S. Army officers trained in the field of radar. During World War II he served with the amphibious forces in both the Atlantic and the Pacific, and he assisted in establishment of the curriculum and doctrine for employment of C-E techniques in amphibious warfare. From 1947 to 1949, as a member of the Joint U.S. Military Advisory Group, he established C-E technical schools for Nationalist China at Chengtu and at Konsan, Taiwan. Other assignments have been as Chief, Air Force C-E Division, MAD, U.S. EUCOM; as Director of C-E, Eighteenth Air Force; as Commander, 4418th Communications Group; and in various C-E engineering assignments in the Tactical Air Command and the Strategic Air Command. He has taught C-E engineering at service schools and has written numerous technical manuals, papers, and training publications in the field of communications-electronics.

Major Alph L. Westley (B.S., Moorhead College) was CED Project Officer, Research Studies Institute, from February 1958 until his recent retirement as a Reserve lieutenant colonel. In this capacity he assisted in drafting Air Force Manuals on electronic warfare and C-E command and control systems. During World War II he served as Ground Radio Officer, Hq Eighth Air Force, and commanded various Signal Corps units. Other assignments have been as Chief, Plans Division, Hq Airways and Air Communications Service, 1947—1952; as a member of the Military Aid Advisory Group to Norway, 1952-1955; and in the Directorate of Communications-Electronics, Hq USAF, 1956-1958. He is a 1956 graduate of the Command and Staff College.

Colonel John A. McCann (B.A., M.A., Miami University of Ohio) is Vice Commandant, War College, Air University. During World War II he served first with the Army Air Forces School of Applied Tactics, Orlando, Florida, and then at Headquarters CBI Theater. Subsequently he was S-2 for the 443d Troop Carrier Group, the 3d Combat Cargo Group, and the North Burma Air Task Force, and Operations Officer, 69th Composite Wing, in China. After the war he returned to civilian pursuits but retained his reserve status, serving as Air Base Group Commander and Wing Executive, 433d Troop Carrier Wing. He was recalled to active duty with this wing in 1950 at Greenville, South Carolina. Other assignments have been as student, War College, 1952; as War Plans Officer, USAFE, and Chief of Intelligence Plans, USEUCOM, in Germany and France; and as faculty member and Deputy Commandant for Extension Course, War College, from 1956 until he assumed his present duty in 1961.

Colonel Edward A. Jurkens (B.A., Knox College) is Deputy Commandant for Nonresident Programs, War College, Air University. During World War II he served as a squadron commander and group operations officer, 307th Bomb Group, South Pacific, and as Director of Flying Training, Clovis, New Mexico. After the war he was Professor of Air Science, Yale University, then attended the RAF Staff College. After a tour as Chief, Curriculum Branch, Squadron Officer School, he returned to the RAF Staff College as a member of the staff. Other assignments have been as Commander, Officer Candidate School and later the Officer Preflight School; as student, War College, 1957-58; as Commander of K-8 Korea; and as Vice Commander, 70th Reconnaissance Wing (SAC).

ATTENTION

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