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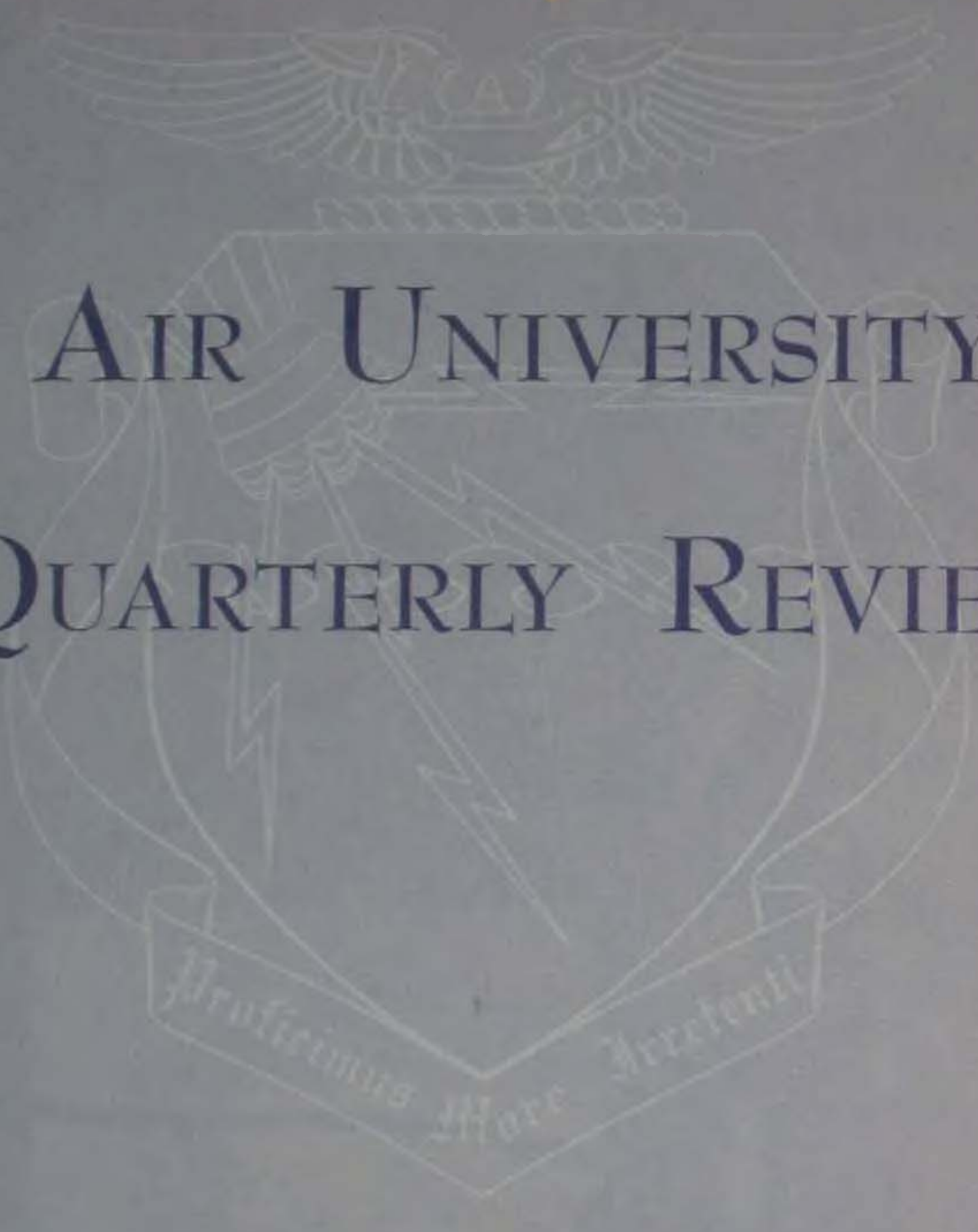

AEROSPACE FORCE IN THE SIXTIES

WINTER and SPRING 1960-61

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Aerospace Force in the Sixties

Part I: The Aerospace Force, 1960–1970

Part II: Combat and the Aerospace Force

EFFECTIVE AEROSPACE POWER

Part III: Support of Aerospace Combat Forces

Part IV: Development and the Aerospace Force

TABLE OF CONTENTS

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The Aerospace and Military Operations

General Thomas D. White

TODAY the military forces of the great nations of the world are in the midst of an explosive technological revolution. The compression of time and distance resulting from the many technical advances is having a profound impact upon the concepts, weapons, and force structures of modern land, sea, and air forces. Nowhere, however, is the influence of this rapid change being felt as drastically as in aerospace.

The term "aerospace" portrays the true nature of the medium which is the operational environment of the Air Force today. Air and space are an entity—and not identifiable as two separate and distinct areas. They comprise a single, continuous field of operations, with no barriers or boundaries to break this continuity. Physically—and in the military sense—the step from operations in the lower atmosphere into space activities is natural and evolutionary; it represents a continuous and homogeneous advance in the techniques of propulsion, ballistics and aerodynamics, servomechanics, electronics, and human survival.

The idea of complete continuity in the word aerospace is extremely important in all phases of Air Force operations. Aerospace must be recognized in its entirety when analyzing our concepts, when examining the performance capabilities of our weapons, and when determining the structure and disposition of our forces.

The basic characteristics we have associated in the past with air power—range, mobility, flexibility, speed, penetrative ability, and firepower delivery—continue to apply in aerospace power. The Air Force must exploit these characteristics to the fullest—in the design and development of new weapons, in our concepts, and in our organizational structures—as our proper contribution to national security. Since the frontiers of military weapon technology lie primarily in aerospace, the forces designed to operate in this medium will constantly reflect dynamic and substantial changes in quantity, quality, and character as we move into the future.

Because aerospace forces, by their very nature, are inherently capable of operating anywhere at any time, the entire structure of nations is exposed to the influence of their operations. The weapons which will present the most serious and immediate threat to our Nation's security during the coming years —as they do today—will be aerospace weapons as represented by aircraft, ballistic missiles, and manned and unmanned advanced aerospace vehicles. The offensive and defensive systems which will ensure our ability to maintain military predominance and to pursue our national objectives successfully will be aerospace weapons. Thus the ability of the United States to meet the growing threat must be based primarily upon the existence of strong military aerospace power.

Strong military aerospace forces are essential to provide this country with a powerful instrument for achievement of its national objectives. These forces, in concert with those of the other military services, are designed for five basic purposes: First, to deter general or small wars. Second, if general war occurs, to defeat the enemy as quickly as possible. Third, if a small war occurs, to conduct selective operations wherever required for the prompt resolution of the conflict under acceptable circumstances. Fourth, in situations when the United States and the Free World are challenged, to conduct, as directed, those operations which will further the interests of the United States and its allies. Fifth, under normal circumstances, to perform services for the benefit of people everywhere.

Today we are faced with the ironic situation in which this country's quest for peace since the end of World War II has led the United States to create the most powerful military striking force in the history of the world—not for reasons of aggression but for reasons of defense. Full appreciation of the categorical necessity of this policy is essential to any approach to the problem of national security.

Basically it comes down to a very simple statement. Defense alone cannot prevail. Even an invulnerable defense which could prevent us from being defeated would not, by itself, permit us to achieve victory. This Nation must possess powerful striking forces which present potential enemies with the probability that they might lose should they initiate attack. Thus our ability to prevail, should general war occur, serves as the deterrent. The priority requirement—until the time when all men consent to be ruled by law—is an offensive force sufficient to defeat an enemy in the event deterrence fails.

The offensive and defensive operations of the United States aerospace forces must, of course, be closely linked to achieve full over-all effectiveness. This requirement is intensified with each increase in the speed and striking power of new aerospace weapons which aggressors could bring to bear upon the United States and its allies. Our aerospace forces must be designed and employed primarily to counter the enemy aerospace threat at its source as well as en route and at the actual points of attack. In the event war should occur, the destructiveness of advanced aerospace weapons permits no alternative to the elimination of an enemy's aerospace striking power as a matter of urgent priority. This must be done as far away as possible from our own country. We cannot permit the enemy to reach his chosen targets with weapons of mass destruction.

The forces and resources provided in the total Air Force structure contribute substantially to deterring local wars or limiting their spread. For if a local aggression is undertaken and fails, the same aerospace power stands as a deterrent to deter the aggressor from extending the conflict in the hope of recovering his initial losses in a larger arena.

Should this country become involved in small wars, aerospace forces can be in action quickly and effectively. The Air Force has concentrated on improving its procedures to deploy on minimum notice selected elements of its tactical forces, wherever and whenever required. Aerospace power's capability for quick reaction anywhere in the world—measured in hours, not days—with potent firepower and flexibility—makes it particularly suited to applying the right amount of force at the right place and time with a minimum of cost and effort.

The characteristics of the Air Force as a military instrument have proved very useful in the so-called cold war. The Berlin airlift was typical of its possible uses. The deployments of our composite air strike forces in the Lebanese and Formosan situations are other examples. These instances demonstrated how quickly such forces could reach emergency areas. Evidence of this capability bolsters the morale of free nations and enhances their confidence in the strength and ability of the United States to fulfill its commitments.

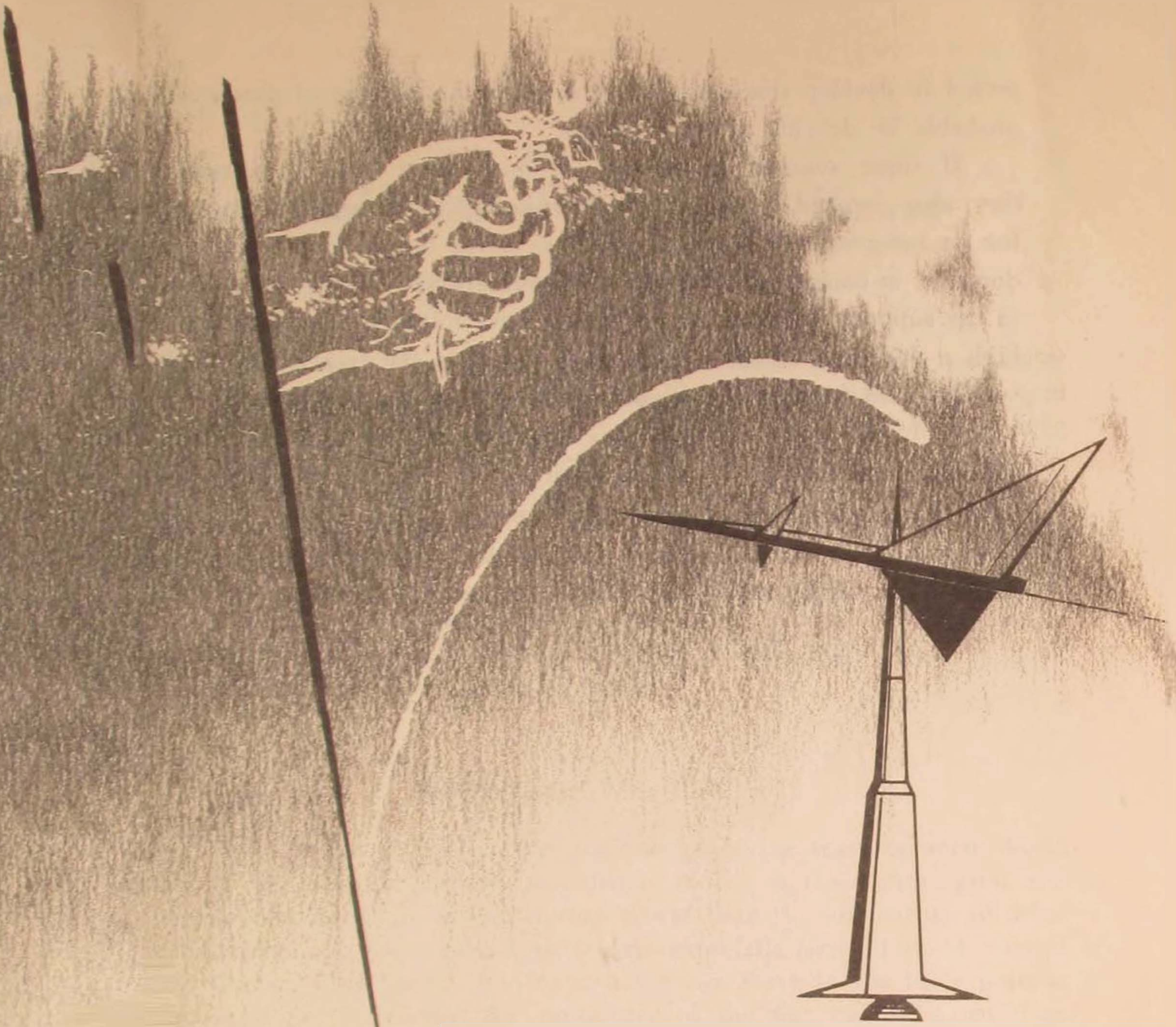
Aerospace power plays an important role as a constructive instrument for peace. Whenever aerospace power has been used to demonstrate the innate friendliness of Americans and their concern for the welfare of people of foreign nations, the impact has immediately been good. The assistance which the Air Force has been able to render in peacetime disasters offers prime examples of its influence. There have been many instances of such aid, in Pakistan, Laos, Morocco, Mexico, South America, and elsewhere. Disaster operations, mercy missions, supply flights, and storm reconnaissance are all evidence of aerospace power's readiness and strength for the good of mankind.

No one can foresee all the military or peaceful applications which will develop as we attain more advanced capabilities in our aerospace forces. The possibilities are limitless. Nevertheless I am convinced that the nation or combination of nations which achieves the dominant military position in aerospace will hold the key to future military security. In addition, our aerospace predominance will permit exploitation of this strength for peaceful purposes.

Today United States aerospace power is the Free World's primary instrument in seeking these conditions while operating in the sensible atmosphere. Operations farther out in aerospace will play a like role in the not-too-distant future. Events are moving rapidly in this area, and we must press to extend our operational capabilities in aerospace with the utmost urgency.

Historically the military have sought to "hold the high ground." In defense activities today, aerospace represents the high ground—the arena of unlimited horizons. Our job: hold the high ground by ensuring aerospace power supremacy for our Nation.

Headquarters United States Air Force



PART I

The Aerospace Force: 1960–1970

No prophet is needed to foresee in the next decade another phenomenal advance in the capabilities of aerospace power.

By any terms that have meaning for military decision, the coming decade promises manned and unmanned weapon systems with the four qualities the planner has always dreamed of: unlimited range, unlimited altitude, hypersonic speed with maneuverability, and virtually unlimited firepower. Both Free and Communist worlds may be expected to develop this enormous potential; the balance of power will probably be delicate at many points.

If these soaring capabilities promise great military potential, they also demand great military responsibility. Especially they call for an integrity of aerospace power as never before—in concept and doctrine, in command and control, in mutuality of offense and defense, in the support structure. Never before have military potentials put so high a premium on the right mix of forces at the right time, on the synchronized fruition of concept, machine, man, and employment.

In broad introduction to this challenge that is addressed to the planning and exercise of the national defense, Part I presents a perspective on aerospace power to 1960, a review of the present aerospace force and its follow-on projection out to 1965, and a prediction of the major additional systems that will come into the inventory by 1975.

Evolution of Aerospace Power

LIEUTENANT GENERAL WALTER E. TODD

USAF aerospace power is the product of the steady and often spectacular development of the Air Force since 1945. This development has been shaped by technological, strategic, and doctrinal considerations that have also profoundly influenced and acted on one another. It has been affected by still other considerations—availability of money, estimate of threats to national security, interservice differences—but these have not greatly changed the main outlines established by technology and doctrinal concepts. These main outlines have pointed purposefully toward aerospace power that will far transcend the air power of the past but will of necessity be derived from it. Knowledge of the nature of the Air Force of 1945–1960 is essential to an understanding of future aerospace power.

Heritage of World War II

The U.S. Air Force that was maintained in the years between World War II and the Korean War was deeply rooted in the technological and doctrinal environment created during World War II. Dominating all other considerations in the minds of air leaders—especially General H. H. Arnold and General Carl Spaatz, who headed the Air Force in the early postwar years—was the belief that the experience of the war had validated their confidence in strategic bombardment as the prime mission of air power. To cap their convictions, the advent of the atomic bomb at the very end of the conflict had added a magnitude of authority to strategic bombardment previously undreamed of by its prophets and practitioners. It was, therefore, foreordained that the Air Force of the future would be built primarily around the strategic air arm, to which the tactical forces were required to defer.

The Army Air Forces, in the main, had waged offensive war during 1942–1945. By 1945 the need for air defense had diminished, and it had virtually disappeared except in a few areas, principally China. The lessons of air defense therefore were not brought home to the Americans as feelingly as they were to the Germans and the Japanese. Although the AAF leaders were aware of these lessons, for doctrinal reasons they accorded air defense a lesser role in the Air Force structure they were planning for the postwar period.

AAF tactical air operations during World War II had been eminently successful in teaming with the ground forces to win the war on land. Tactical air forces in theaters of operations throughout the world had demonstrated that they could operate most successfully under centralized control of an air commander rather than in small packets parceled out to a number of ground force commanders. This principle came to be official Army doctrine and was reaffirmed after the war by the Army Chief of Staff, General Dwight D. Eisenhower. Nevertheless it was destined to become a continuing issue between the Army and the Air Force, persisting throughout the 1950's. But in 1946 the impact of the atomic bomb had caused the tactical air function to shrink drastically in the eyes of AAF leaders, and afterward, in spite of the Korean War experience and pressures from outside the Air Force, it fought for but never quite attained the eminence it had enjoyed before and during World War II.

During World War II the AAF operated in almost every area of the world, including even the Soviet Union. Linking the widely dispersed theater air forces with the United States became the function of the global Air Transport Command. Within the theaters, air transport agencies performed a like service, including such huge undertakings as the Hump airlift from India to China. Large troop-carrier organizations within the theaters served alternately for combat airborne operations and supply airlifts. The continuing oversea military commitments of the United States after the war—commitments which grew after the initial withdrawal from the battle zones—required the continuation of a global air transport agency and the maintenance of a substantial combat airlift capability. How best to delineate the roles and functions of air transport and combat airlift continued to be a periodic issue, again with strong budgetary roots, within the Air Force and between the Air Force and the Army.

The end of the war signaled the beginning of what was perhaps history's most precipitate voluntary retreat from an apogee of military might by a triumphant power. Within months the hasty and near-chaotic demobilization had reduced the combat effectiveness of American military forces to the point where commanders could no longer carry out assigned missions. AAF manpower fell from 2,253,000 on V-J Day to 485,000 at the end of April 1946 and to 303,000 at the end of May 1947. Aircrew strength dropped from 413,890 on V-J Day to 24,079 in June 1947. The decline in combat-effective units was even more meaningful—from 218 combat groups on V-J Day to 2 groups in December 1946. Although the AAF actually had 52 combat groups in being in December 1946, fully 50 of these were ineffective.

It was within this context of confusion and ferment that the AAF sought to realign its forces to achieve a measure of stability and at least a minimum effective combat force. General Spaatz, General Arnold's successor as AAF commander in February 1946, ordered, effective 21 March 1946, a reorganization of combat forces based on concepts derived from World War II experience. Three new functional commands—Strategic Air Command, Tactical Air Command, and Air Defense Command—replaced the geographic air forces under which AAF combat strength in the United States had formerly been grouped. The remainder of the AAF structure remained the same, with five supporting commands in the United States and five oversea commands, of which the United States Air Forces in Europe and the Far East Air Forces were the largest and most important.

To provide the necessary strength for its mission, the AAF projected in 1946 a program for the creation of a combat force of 70 groups and 22 specialized squadrons. In 1947 the President's Air Policy Commission, headed by Thomas K. Finletter, confirmed this program as the minimum level for national defense; but not until the Korean War completely altered the national security perspective did the Air Force receive the funds it needed to build to 70-group strength. The experience of the Air Force in the post-World War II years, then, was one of attempting to attain a high level of combat effectiveness with a minimum, and usually inadequate, allocation of resources. This stringency of resources continued, even though the primacy of air power in the national defense was formally recognized in September 1947 by the legal reconstitution of the Army Air Forces as the United States Air Force, to form with the U.S. Army and the U.S. Navy a National Military Establishment of three services.

The heaviest burden fell on the Strategic Air Command—by design as well as by necessity. Strategic air power, the Air Force held, provided the surest and most effective way for the United States to discharge its military responsibilities in the world community—responsibilities that would inevitably grow rather than decrease after the initial headlong withdrawal from oversea areas in 1945–46. In the atomic bomb the United States possessed the most powerful and decisive weapon in existence, and SAC alone had the ability to deliver the bomb against distant targets. SAC would constitute therefore a powerful striking force in being that could overwhelm and destroy any potential adversary of the United States. Further, it seemed to many USAF leaders, its existence would serve to dissuade, even deter, a potential aggressor from attacking the United States.

But in 1946 the reality of SAC power was a far cry from the concept. Nine bombardment groups, equipped chiefly with B-29's and B-17's, and two fighter groups with P-47's and P-51's, made up SAC's strength in the spring of 1946. There were only three jet planes—P-80 Shooting Stars—among the 600 aircraft in the command's inventory. On 1 May 1946 when SAC received officially the responsibility for using the atomic bomb in time of war, it had only one unit—the 509th Composite Group at Roswell Field, New Mexico—capable of delivering the bomb. The 509th, which had dropped the atomic bombs on Hiroshima and Nagasaki, was also the only group in SAC capable of sustained combat operations.

Obviously this command was not prepared to carry out its mission of conducting long-range operations in any part of the world at any time. Its planes could not attack intercontinental targets from the United States, and it had no adequate bases overseas for use in an emergency. As a deterrent to aggression in its earlier years SAC was far more symbol than reality, but the awesome drama of Hiroshima and Nagasaki lent substance to the symbol and established it firmly in the world's consciousness.

In the years before the Korean War, under the leadership first of

General George C. Kenney and then, beginning in October 1948, of Lieutenant General Curtis E. LeMay, SAC moved slowly but purposefully toward creation of an effective atomic strike force. After the Air Force became a separate military service in 1947 and could more readily follow its own inclinations, SAC could be strengthened. But even though it received top priority among the USAF combat commands, SAC still lacked bases, planes, equipment, and trained manpower, and it had to do its job with inadequate resources.

Disturbed world conditions that produced at first periodic tensions and subsequently an almost continuous tension that came to be called "cold war" served to enhance the importance of SAC as the key to the Nation's military security. By the end of 1947, SAC had 50,000 officers and men and 16 bombardment and 5 fighter groups, but few of these were fully manned or operational. In 1948 the first postwar bombers—the B-50, a much-improved B-29 design, and the very heavy B-36—joined the B-29 in the inventory.

The Berlin Airlift in 1948–49 and the explosion of an atomic device by the Russians in August 1949, at least three years earlier than anticipated by the United States, forced increased urgency in the buildup and modernization of SAC, but the resources available for the purpose still remained limited. The arrival of the B-36, especially in its later improved form, gave SAC an aircraft with near-intercontinental range and caused the B-29 and the B-50 to be classed as medium-weight and medium-range bombers. Early in 1950 SAC had 3 B-36 wings, 11 wings equipped with B-29's and B-50's, 3 strategic reconnaissance wings, and 2 fighter wings grouped under the Second, Eighth, and Fifteenth Air Forces.

The Air Force concept of strategic air power as the Nation's first line of national defense and its efforts to claim for SAC first priority within the defense establishment did not go unchallenged. The competition for funds allocated to national defense, especially after 1947, sharpened differences in strategic thinking, particularly between the Air Force and the Navy, and eventually led to a public airing of the differences in 1949. Previously in March 1948 at Key West, Florida, and again in August 1948, at Newport, Rhode Island, Secretary of Defense James V. Forrestal presided over conferences with the Joint Chiefs of Staff out of which came agreements on the delineation of service missions. The Air Force received primary responsibility for strategic air warfare, but this did not lay at rest the controversy over the merits of strategic bombardment, of which the B-36 became at once the symbol of Navy dissent. The subsequent Congressional investigation in 1949 did not uphold the Navy's indictment of strategic bombardment.

The pre-eminence of SAC within the Air Force had a profound effect on the other major combat commands. When the Air Defense Command came into existence in March 1946, its commander, Lieutenant General George E. Stratemeyer, had on hand four understrength fighter squadrons and one training unit equipped with a few World War II radar sets. In March 1948 the American military governor of Germany, General Lucius D. Clay, warned that as a result of the Communist seizure of power in Czechoslovakia war might break out suddenly at any moment. When the Air Force thereupon ordered

ADC to establish air defenses in the northeastern and northwestern sections of the United States and in Alaska, there was only one radar warning station in operation in the United States. In Alaska four radar sites were in operation a few hours each day.

The Air Force had previously approved, in 1947, a plan for a major aircraft control and warning network, and in March 1948 at the Key West Conference the Joint Chiefs of Staff had assigned to the Air Force primary responsibility for continental air defense. But resources do not necessarily accompany responsibilities, and not until 1949 did ADC receive funds to build a modified and smaller version of the warning net, to be ready in 1952. In August 1949, when the Russians broke the U.S. monopoly on atomic power, the need for effective air defense of the United States entered a new and more acute stage. By giving priority to fighter and radar squadrons, the Air Force rushed to completion by mid-1950 a temporary network of 44 radar sites in the northeastern and northwestern sections of the country. It also accelerated construction of the longer-range permanent system and dispersed ADC interceptor squadrons over more bases.

The tactical air function could not achieve the degree of unity enjoyed by the strategic and air defense functions. Because of oversea commitments, which grew with the passage of time, forces had to be divided between the Tactical Air Command and the theater air forces that were continued after World War II. The size and strength of TAC and the oversea air forces fluctuated in accordance with changes in the international situation and the allocation of funds. At the end of 1946, TAC had only six combat groups, and its aircraft were all out of date with the exception of the A-26, a tactical bomber. TAC began receiving jet aircraft in 1946 with the arrival of the P-80, followed in 1947 by the B-45 and the F-84.

The intense competition for men and money within the Air Force led to the subordination of both TAC and ADC as "operational" commands under the new Continental Air Command on 1 December 1948. All of TAC's 11 combat groups were assigned to ConAC, which could use them for either air defense or tactical air missions as necessary.

U.S. Air Forces in Europe, Far East Air Forces, and the other oversea commands suffered from the same problems and deficiencies that beset Tactical Air Command. Lack of trained men, aging aircraft and equipment, lack of capability in such important elements of air power as reconnaissance and transport, and the burden imposed by the performance of other functions, especially air defense, severely hindered the development of these commands into effective fighting forces. The Korean War threw into immediate and sharp relief these deficiencies in tactical air in the United States and the Far East.

A Jet-Atomic Air Force

THE onset of the Korean War found the Air Force far short of the 70-wing goal it had set itself as the minimum air power requirement for national security. Indeed it had been trying to support 48 wings with funds that were sufficient for only 42 combat-effective wings. The Berlin Airlift and the emergence of the Soviet Union as an atomic power yet had not convinced the U.S. Government and public of the need for an immediate and substantial expansion of American military strength. And even the Korean War provided only a minimum stimulus to large-scale expansion, until the intervention of the Chinese Communists in November 1950 completely altered the nature of the conflict.

The Air Force had felt increasingly the pressure to maintain a force in-being powerful enough to cope with any potential of attack upon the United States. Additionally there was the requirement for the defense of Western Europe, as organized under terms of the North Atlantic Treaty signed in the preceding year. The related military plan involved a major reliance upon the strategic bombing capability of the U.S. Air Force. In 1950, before the attack upon South Korea, the forces available to NATO in Europe counted only 12 divisions and 400 aircraft. Confronted by the potential of some 175 divisions in the well-equipped standing armies of the Soviet Union, which were backed up by Satellite divisions and Soviet reserve divisions that brought the total to 400, the few NATO divisions were for the most part poorly armed for combat and poorly trained and were scattered for occupation duty rather than deployed for an active defense. Supporting them in the theater was little in the way of armor, prepared positions, heavy artillery, secure lines of communications, or even adequate ammunition. Although additional troops were ultimately available from the national forces of the signatory powers, only the nuclear-armed, long-range striking force of the American Strategic Air Command counterbalanced the vast Soviet manpower and furnished the sustaining weapon of NATO to deter assault upon free Europe.

The inability to build a fully potent force in-being had thus kept the Air Force in a state of almost constant alarm, especially after the first Soviet atomic explosion occurred ahead of schedule and gave warning of an imminent counter atomic threat to the United States. But it took the Korean War—and the evidence it gave of Soviet willingness to probe Free World defenses—to awaken the Nation to the fact that the price of national security was high and was increasing rapidly. Realization that the chief threat developing to the security of the United States came from the incipient Russian atomic air power and that it could best be countered by superior U.S. air power helped to create an environment in which it became possible for the Air Force to obtain essential increases.

But as late as June 1950 the force programs had been aimed toward contraction rather than expansion of USAF strength, and in Korea, the site of actual warfare, the Air Force had to fight at first with the forces it had on hand in the Far East Air Forces. That these forces proved adequate must be ascribed more to the deficiencies of the North Korean and Chinese Communist air forces than to the readiness of the U.S. Air Force for combat. To meet the North Korean aggression, FEAF had some 33,000 officers and men organized under three air forces scattered over the Far East from Saipan to

Okinawa and the Philippines. It had 7 combat wings and a total aircraft strength of more than 1100, including 423 F-80C's. The primary mission assigned to the Far East Air Forces was the air defense of the U.S.-occupied regions in the Far East. Assigned only as subordinate missions were the maintenance of "an appropriate mobile air striking force" and the provision of "air support of operations as arranged with appropriate Army and Navy commanders." Essentially, then, FEAF was an air defense force in June 1950 —and one with declining strength that would have shrunk still more but for the beginning of hostilities.

It took time to convert FEAF's Fifth Air Force into an effective tactical air force and to reinforce it with additional combat units and higher-performance aircraft from the United States. As in World War II, all the aircraft used in Korea had been designed before the beginning of hostilities. Later-model F-84's suitable to serve as jet fighter-bombers did not arrive in numbers until the second half of 1952, and F-86 interceptor fighters were scarce to the end. Fortunately the superior skill and tactics of American fighter pilots, and better gunnery aided by the superior gun sight and armament for the mission, more than compensated for the F-86's somewhat inferior flight characteristics in comparison with the Russian Mig-15, which was supplied in overwhelming number to the Chinese Communist Air Force. The Air Force was, however, never able to provide FEAF with adequate photographic reconnaissance, night intruder aircraft, all-weather interceptors, modern jet bombers, or enough F-86 day intruder fighters for bomber escort. Much of the action was conducted with World War II survivals in the inventory, many dug from storage.

The grave shortages revealed by the Korean War in the USAF force structure, the developing capability of the Soviet Air Force for atomic attack, and the commitments for reinforcing the North Atlantic Treaty Organization inspired authorization for a large increase in Air Force strength as the primary element of the massive American rearmament begun in 1950 by the Truman Administration. Force level goals for the Air Force were raised from the pre-Korean 48 wings to 95 combat wings, to be reached by June 1952. In late 1951 a 143-wing program was approved and scheduled for completion in mid-1955, but in 1952 the President decided that the program should be "stretched out" a year longer for reasons of economy and because of the rapid changes in technology.

The requirement for oversea bases became especially imperative as the urgency to counter growing Soviet atomic air power became more pressing. Earlier, in 1948, when the Berlin Airlift served as a spur to action, the British had agreed to the construction of SAC bases in Great Britain. Additional agreements with foreign countries between 1950 and 1953 led to the construction of SAC bases at Thule, Greenland, and in Morocco and Spain. These provided the Strategic Air Command with the advance bases to give its bombers the necessary combat radius. The Korean War required the development of an impressive base structure in the Far East. In Europe the large contribution of USAF tactical air and air defense forces to NATO meant the construction or expansion of numerous bases for the Air Force in western

Europe. Extensive base construction in the United States involved mainly modernization or expansion of existing bases.

In 1953 the Eisenhower Administration reviewed national military policy within the broadest possible context, including the international situation, the U.S. economy, and technological change. There emerged from this "new look" general guidelines for the ordering of a military establishment keyed to the concept of "security with solvency." Since a strong military posture must be maintained over an indefinite term of years, of equal necessity it must be maintained at a cost that would not bankrupt the Nation. The Eisenhower Administration therefore determined to place greatest reliance on the technological primacy of the United States that permitted superior air power and exploitation of advanced weapons for economies in manpower and in conventional forces.

Substantially the new policy intended to abandon conflict with an aggressor on his own terms and in actions of his choosing. Instead it called for U.S. forces of overwhelming retaliatory power that might be applied in the manner that the United States deemed to its own best advantage in response to aggression. Particularly it was hoped to maintain this power at a magnitude that would deter attack upon the United States or its vital interests abroad, and thus avoid war on major scale. Essentially this power would rest upon the primacy of American air power.

Since the effect of the new policy was to place first emphasis on air power, the Air Force suffered less than the other two services in the post-Korean retrenchment of military strength. In December 1953 President Eisenhower approved a 137-wing goal to be reached by the end of June 1957. This resulted in significant shifts in the apportionment of funds among the military services. Prior to the Korean War there had prevailed the general principle of a "balance of forces," which called for a three-way split of money among the services so that each received roughly the same amount. This principle went by the board beginning with fiscal year 1955, when the Air Force received more than 40 per cent of the new funds granted the Department of Defense; in fiscal years 1957 and 1958 the Air Force received almost half the new funds.

While the Air Force gained much from this readjustment of resources among the services, it was still not in a position to buy all the air power that it considered desirable for the performance of its mission as the Nation's prime military force. The Administration maintained tight ceilings on the over-all defense budget that served to restrict the allotment of funds to the Air Force as well as to the other two services. Within this financial framework, the Air Force continued the first-priority development of an atomic striking force and an accompanying continental air defense system.

The Korean War revealed that the Air Force had been forced to subordinate its tactical air and air defense missions in order to concentrate on the Strategic Air Command, but it may be argued that the existence of SAC in 1950 inhibited the Chinese and their Soviet ally from spreading the war beyond Korea. SAC had been concentrating since 1947 on building an atomic bombing force, and after June 1950 it dramatically accelerated this program.

Eventually all the bomber wings acquired a capability to use atomic weapons. A degree of training and logistical effort was involved that far transcended previous experience.

Since 1944 the Air Force had pursued major programs to develop jet bombers, for the rapid improvement in jet fighter performance meant ultimate doom to SAC's conventional bombers—the B-29, B-50, and even the B-36. The first medium jet bomber—the B-47 Stratojet—arrived in SAC late in 1951, and B-29's and B-50's began going out as B-47 wings were formed. All B-29's were gone by the end of 1954 and all B-50's by mid-1955. The huge B-52 Stratofortress began replacing the B-36 in 1955, and all B-36's were gone by early 1959, leaving SAC with an all-jet bomber force. As a successor to the B-47, already showing fatigue by the end of the Fifties, the first supersonic jet bomber—the B-58—entered SAC operational units in the summer of 1960. It is planned that the B-58 will re-equip only a portion of the B-47 units.

For more than a decade after World War II, SAC persisted in maintaining a force of fighters to provide escort for the bombers. This policy was the result of World War II experience showing the importance, even indispensability, of fighter escort for bombers facing stout fighter opposition. SAC increased its fighter strength from two wings—one F-51 and one F-84—at the end of 1948 to six wings—all F-84—by 1957. But by then the handwriting on the wall was unmistakable: the growing effectiveness of air defense systems and the large margin of superiority of the jet fighter over the jet bomber spelled the end of the traditional bomber formation—and therefore the function of escort fighters. Consequently SAC relinquished its fighter wings in 1957, transferring most of them to TAC and inactivating the others.

Also by 1957 SAC had the bases, equipment, techniques, and skilled manpower to make it a truly global force. The overriding problem of developing the "long reach"—the ability to strike any target in the world from bases in the United States and elsewhere—had been solved. Oversea bases contributed much, but aerial refueling proved the major factor in giving SAC's bombers intercontinental range. Beginning in 1948 with 2 refueling squadrons, SAC built up a tanker force of 36 refueling squadrons by 1955 and an even larger one by 1960. The advent of the jet bombers created a need for a jet tanker; the KC-97 was not adequate because it lacked the speed and ceiling to refuel jets efficiently. The KC-135 provided the answer, and in 1960 SAC had more than 300 of these jet tankers, which could refuel aircraft at speeds of 500 miles per hour and at altitudes of more than 35,000 feet. Refueling became standard practice for whole bomber formations, and SAC planes averaged thousands of aerial refuelings per week.

Employment of the swifter jet bombers improved SAC's capacity for penetrating enemy defenses. The fast B-47's and B-52's flew singly or in small formations under cover of bad weather or darkness, using speed, deception, and evasive tactics to penetrate to the target. Advanced bombing techniques also improved the chances for accurate bombing and escape of the attacking bomber.

The Korean War and the fears that it periodically inspired of a larger war, coupled with the growing evidence of Soviet atomic air power, spurred development of an air defense system not only for the United States but for all North America. On 1 January 1951 the Air Force restored the Air Defense Command as an independent and major command and placed under it all USAF components with the primary duty of air defense. Since a complete air defense system involved the Army and the Navy as well as the Air Force, the Joint Chiefs of Staff agreed, after prolonged discussions, that there should be a joint command for continental air defense. On 1 September 1954, the Continental Air Defense Command, charged with the air defense of the United States, was established under the Joint Chiefs of Staff, with the Air Force as executive agent. The new joint headquarters, at Colorado Springs, Colorado, under a USAF commander, had operational control over designated forces of the three services, including Air Defense Command, and the principle of joint control was applied down to the air division level.

Effective air defense of the North American continent was not possible without the full collaboration of Canada. The two countries had been integrating their air defenses since 1951, and on 12 September 1957 they took the next logical step, establishment of an integrated headquarters, the North American Air Defense Command (NORAD), at Colorado Springs. Under an American commander and a Canadian deputy, NORAD assumed control of American and Canadian air defense operations in accordance with a single plan approved by both countries.

The threat to the United States from the atomic bombers of the Soviet Air Force grew steadily during the decade beginning with the outbreak of the Korean War. From copying old B-29's and naming them Tu-4's the Soviets progressed in the second half of the decade to sophisticated jet bombers that approached the performances of the B-47 and B-52. It seemed likely in 1957 that their long-range bomber force would eventually equal and then exceed SAC in strength, but the remarkable Soviet success in the development of ballistic missiles, stunningly dramatized by Sputniks I and II, apparently caused a major shift in policy. The bomber force grew slowly after 1957 as the Soviet Union directed its efforts towards the long-range ballistic missiles that seemed to offer a quicker and more effective means of tipping the scales of offensive power in their favor.

By 1960 a formidable North American air defense system had been fashioned against bombardment aircraft. The completion of the 75-station permanent system radar network in April 1953 was followed by construction of the Pinetree Line, of some 30 radar stations along the U.S.-Canadian border. But air defense of North America could not begin at the 49th parallel, and additional warning lines were built across Canada and extended on both sides of the continent into the Atlantic and Pacific oceans. The northernmost detection and warning network—the Distant Early Warning Line within the Arctic Circle—was begun in 1955 and became operational in 1957, and the intermediate Mid-Canada Line was constructed along the 55th parallel. These early-warning systems ultimately were flanked by additional radar nets in Alaska and the Aleutians on the west and Greenland on the east. USAF and Navy early-warning patrol aircraft, Navy picket ships, offshore Texas Towers, and the Ground Observer Corps completed this vast network designed to give the earliest possible warning of attack.

To cope with aircraft attacks, Air Defense Command relied on a large interceptor force equipped with modern planes armed with missiles and rockets. The basic need was for an all-weather interceptor that could fly under any condition, day or night. By the end of 1954, ADC's 55 squadrons of interceptors were equipped with all-weather F-94C, F-89D, and F-86D aircraft. In their turn these interceptors gave way to the "century series" aircraft—first the F-102A and then the F-104, F-101B, and F-106. The last two carried MB-1 Genie nuclear air-to-air rockets for bomber intercept, and most of the others carried a varied assortment of armament, including the Falcon and the Sidewinder guided aircraft rockets. After reaching a peak equivalent to 32 interceptor wings in 1957, strength declined to 25 wings in 1960 as the ballistic missile threat increased.

The role of the Army in air defense derived from its control of antiaircraft artillery. In the 1950's guns began to give way to missiles, and the Army placed great emphasis on the development and maximum deployment of the Nike family of interceptor missiles. Although its Nike units were under the operational control of CONAD, competition developed between the Army and the Air Force for ultimate control of ground-to-air missiles of the air defense system. The fundamental difference between the two services centered about the Army's point-defense concept versus the Air Force's area-defense concept. The Army stationed its guns and missiles in the vicinities of the targets they were to defend, whereas the Air Force believed in meeting attacking bombers with interceptors and missiles as far from the target as possible. The Army placed its faith in high reliability of its weapons, while the Air Force believed in gaining warning time for a maximum effort to prevent attackers from even approaching the target. Today's air defense system represents the meld, under CONAD operational control, of the most effective features of both concepts. The near future, however, promises a serious need for defense against air-launched missiles carried by bombers and launched from several hundred miles out from target. This trend should lead to more emphasis on the Air Force concept of area defense.

With the advent of missiles on a large scale it appeared that the role of interceptors would decline. The Air Force developed and brought into operation in 1960 the IM-99 Bomarc interceptor missile—a mach-3 pilotless aircraft launched from the ground that could seek out and destroy enemy aircraft at distances of several hundred miles. For control of Bomarc missiles as well as piloted interceptors, the Air Force had SAGE, developed since 1953, a semiautomatic ground environment system built around giant automatic computers. Once again these developments were in danger of being overtaken by strategic and technological events almost as soon as they came into operation. In 1960 the Air Force had to look ahead to creation of an effective defense against ballistic missiles.

The Korean War and the need for substantial forces to meet the U.S. commitment to NATO lent impetus to the revitalization and modernization of the Tactical Air Command and the oversea combat commands. The Air Force restored TAC to major command status on 1 December 1950 and returned to it from ConAC full control of its own units, including 520 aircraft of mixed vintage. In 1951 the command had grown to 25 tactical wings and more than 60,000 officers and men. But much of its strength had to go to build up the Far East Air Forces and the United States Air Forces in Europe. In 1952 TAC sent the 49th Air Division, with two wings, to England where it had the primary mission of conducting atomic operations in support of NATO against air aggression. By June 1953 TAC had sent to USAFE, for support of NATO, 8 combat wings and some 15 specialized units.

During the period of the Korean War the Air Force directed the development of tactics and techniques for the use of atomic weapons by the aircraft and missiles of tactical air forces. Particularly important in creating this capacity was the development by 1953 of a low-altitude bombing system that enabled fighter-bombers to deliver atomic bombs accurately and escape the effects of the ensuing blast. The tremendous speed of the fighter-bombers and their versatility shortened the lives of the light bombers—B-57's and B-66's—almost all of which were gone from the inventory by 1960. The F-84 and the F-86 gave way to the supersonic century-series aircraft—the F-100, F-101, F-104, and F-105, the last being the most advanced in performance. The first USAF surface-to-surface tactical missile—the TM-61 Matador—came into operational use overseas in 1954. A more advanced version—the TM-76 Mace—began entering the inventory in 1960. These missiles, capable of being equipped with nuclear warheads, augmented actual and potential USAF strength in oversea areas where they must be deployed because of their limited range—up to 600 miles.

The major problem facing TAC in the Fifties was to find techniques for deploying its strength to oversea areas instantaneously in time of emergency or war. The possibility, and even likelihood, of little wars and incidents, logically to be anticipated after Korea, required great flexibility from American air power. To meet this requirement, TAC developed highly mobile composite air strike forces (CASF) that could react within hours to emergency calls. These forces could be adjusted in size, composition, and firepower to meet any given war or emergency situation. With the help of aerial refueling, a whole CASF could fly nonstop across the oceans en route to Europe, the Middle East, the Far East—indeed to any trouble spot in the world. The Lebanon and Taiwan incidents in 1958 provided excellent tests of the ability of TAC's composite air strike forces to respond to trouble far from home. The deployments, on the whole, were successful, but they also revealed deficiencies that would have to be remedied. Better tankers and more and better-equipped bases were needed to speed up the movement of these forces.

The global airlift mission of the Air Force has been met by the Military Air Transport Service, a major USAF command and also a Department of Defense agency, organized in 1948 by merger of the USAF Air Transport Command and the Naval Air Transport Service. The prime mission assigned to MATS was to meet the wartime requirements of the Department of Defense. This involved strategic support of the SAC striking force by airlifting men and materiel, support of other USAF commands, and strategic airlift of ground forces as required by the Joint Chiefs of Staff. Specifically excluded from the MATS mission was responsibility for tactical air transport of airborne troops and for the initial supply and resupply of units in forward combat areas. This function remained with the troop carriers assigned to Air Force combat commands.

MATS demonstrated its value during the Berlin Airlift of 1948–49 and the Pacific airlift of the Korean War period. During the Lebanon and Taiwan crises of 1958 it participated in or operated airlifts to the affected areas. Much of the success of these and other MATS airlifts depended on the activities of four MATS technical agencies: Air Rescue Service, Air Weather Service, Air Photographic and Charting Service, and Airways and Air Communications Service. The greatest problem facing MATS during its entire history has been the maintenance of a force of modern aircraft. Development of transport aircraft consistently lagged behind combat aircraft, and indeed MATS lagged behind the best civil airlines in its equipment. In 1960 Congress authorized limited funds for beginning an interim modernization of the MATS force of almost 500 four-engine aircraft.

Towards the Missile Era

THE missile era was foreshadowed by the German V-weapons of World War II, but the technological breakthroughs that made it possible came much more rapidly than expected. It is likely that these breakthroughs might have come even more quickly had the U.S. Government allocated more resources for the purpose in the decade after World War II and had the Air Force used more of its resources for development of ballistic missiles. But between 1945 and 1950 the Air Force had to make the hard choice between present and future, and the limited funds available gave little opportunity for the kind of compromise between the two it would have preferred. Sheer necessity demanded that first priority go to a minimum force in-being—and even this was not attainable during those years.

The increased funds that became available during the Korean War made possible the expansion of the missile program. In September 1951 the Air Force selected the ballistic missile approach for long-range rocket development and focused on what became the SM-65, the Atlas. In 1952–53 the thermonuclear breakthrough heralded the advent of lightweight warheads of high yield that would make the development of long-range ballistic missiles economically and militarily feasible. As a result of recommendations from competent technical advisers in 1954, the Air Force accorded to the development of the Atlas the highest priority and initiated work on the SM-68 Titan in May 1955 as a backup to Atlas. In addition the Air Force, with assistance from technical and Congressional sources, pressed for the assignment of the highest national priority to Atlas.

The potentiality of the intercontinental ballistic missile was obviously so great that if the Soviet Union developed the ICBM first the outcome could be disastrous for the United States. Impressed by the need for swift action, President Eisenhower accorded the "highest priority above all others" to Atlas development. Three months later, in December 1955, the President gave the same priority to the development of intermediate-range ballistic missiles: the Army Jupiter and the Air Force SM-75 Thor, already under development by the two services as interim missiles. In November 1956 operational employment of all missiles with range over 200 miles, including the Jupiter IRBM as well as Thor, was assigned to the Air Force.

The Air Force now pressed for development of the earliest possible initial operational capability for the ballistic missiles—prior to 1960 if at all possible. But the size of the projected IRBM and ICBM forces and their operational dates were subject to frequent changes after 1955 as a result of stretchouts of the programs caused by financial, technical, and operational considerations. Potentially outweighing all these influences was the rate of Soviet progress in developing ballistic missiles.

As early as July 1956 the Air Force was aware that it might face a "missile gap" about 1960 if well-evidenced Soviet progress should exceed American progress. The spectacular success of Sputnik I on 4 October 1957 provided unquestionable confirmation of the advanced state of Russian technology, especially in rocket propulsion. It was the opening overt shot of the missile race and the race for prestige in the conquest of space. The United States had no choice but to accept the challenge. The alternative could mean catastrophe.

The immediate result of Sputnik was the expansion of the IRBM and ICBM force programs, but as is normal with all such programs they continued to fluctuate during the next three years. The limited range of the IRBM's and the rapid progress of the Atlas after 1957 resulted in gradual cutbacks in the IRBM program, which called for the delivery of Thor missiles to the United Kingdom and Jupiter missiles to Italy. The Air Force trained British and Italian personnel in the United States to man the squadrons. The first Thor squadron became operational in the United Kingdom in 1959 and was followed by three more in 1959–60.

The first operational Atlas missile was launched by a SAC crew from Vandenberg AFB, California, in September 1959, and additional launches followed. In 1960 the missile base at Francis E. Warren AFB, Wyoming, became operational. Since the ICBM is a strategic missile, the Air Force assigned control to the Strategic Air Command in late 1957, thereby ensuring unified command and use of USAF strategic air weapons. Progress on the SM-68 Titan, particularly the Titan II, gave promise of a liquid-propellant missile with considerable advantages over the Atlas.

The abbreviated warning time—on the order of 15 to 30 minutes—that could be expected before an ICBM attack made it imperative that the Air Force harden its ICBM force to reduce its vulnerability to surprise attack. This took the form of generous use of concrete in aboveground sites and use of silo underground sites. To attain an early operational capability the

Air Force undertook its first four sites without hardening, but subsequent sites are being built with progressive degrees of hardening.

Seeking the advantages of quicker reaction time and decreased vulnerability, the Air Force secured approval in 1958 for accelerated development of the SM-80 Minuteman, a solid-fuel missile with intercontinental range that could be fired instantly. The Minuteman will be launched from underground hardened silos. Also the Strategic Air Command has made tests of the use of Minuteman on railroad cars, to move the missile about from place to place and make it impossible for an enemy to plot its precise location.

There were, to be sure, other missiles, but the influence of the ballistic missiles, and especially the ICBM's, on the Air Force was quite clear in 1960, by which time they had already decidedly altered every major facet of Air Force activities: training, research and development, procurement, construction, logistics, and operations. In fiscal year 1960 the Air Force allocated 38 per cent of its procurement money for aircraft, but 24 per cent for missiles. Research and development expenditures for missiles exceeded those for aircraft as early as fiscal year 1958. Emphasis has shifted also in construction of base facilities. Most of the new construction under way consists of facilities for missiles, while the number of aircraft bases is declining gradually.

Between 30 June 1957 and 30 June 1960 the Air Force reduced the number of its combat wings by 41—from 137 to 96. Of the 96 wings on hand in 1960, 3 were missile wings. Meanwhile the Air Force has sought to improve the effectiveness of its bombers, especially the B-52, by adding air-to-ground nuclear missiles to their armament. The effect of this shift is in the direction of what has been called a "mixed" force of aircraft and missiles in SAC. These two elements of the force complement each other for optimum combat power, each being capable of attacking targets for which it is individually best suited, and the combination greatly complicating the enemy's defensive problem.

The ballistic missile threat has required bold measures by SAC to safeguard its bomber force and to reduce to a minimum the time required to react to an attack. Hardening of bases, dispersal of units over a larger number of bases, maintenance of a large portion of the force on ground alert with a capability for constant airborne alert, and development of techniques for launching aircraft much more quickly than previously thought possible—all have added to the effectiveness of the force. To meet the critical problem of providing early warning of ballistic missile attack to SAC, NORAD, and the Nation, the Air Force began construction of the Ballistic Missile Early Warning System (BMEWS). It is anticipated that, by the time a full-scale ICBM attack can be mounted against the United States, BMEWS will be able to provide enough warning after the enemy launch to permit the launching of SAC's bombers and missiles and the taking of other appropriate measures.

Sputnik I signalized the extension of the ballistic missile race beyond the atmosphere and into space. Within a few short years revolutionary advances in propulsion have made it obligatory to extend the bounds of military thought to dimensions of space and power previously staggering the imagination. Although such dimensions may still be staggering, it has been necessary to contemplate them soberly and to formulate concepts and doctrines that will permit the fashioning of the most effective military forces for the future. And since these operations will almost certainly be extended into space, the Air Force has adopted the concept of *aerospace,* which holds that the earth's sensible atmosphere and the space beyond are operationally indivisible.

History has demonstrated repeatedly the towering effect of technological change upon military forces and upon ideas and concepts of warfare as well. But ideas and concepts themselves also can direct and modify change by providing a logical and realistic basis for transition from the past to the future. In a brief span of 15 years the Air Force has progressed to the threshold of space. And in a future that promises even more revolutionary change, it must draw on its rich experience of the past to help it forge new concepts and shape the aerospace forces of tomorrow.

Headquarters Air University

The Present Pattern

General Curtis E. LeMay

THE FIRST five years of the Sixties will find the United States Air Force in a dynamic period of new dimensions, with fresh concepts and greater capability as the intercontinental ballistic missile force becomes a growing factor in the complementary mix.

But this is only a transition. Another era crowds the horizon. As aerospace power moves from predominant reliance on the manned aircraft to the mix of manned and unmanned aerospacecraft, missiles, and satellites, the leveling out is only momentary before we push ahead to the next plateau.

The Air Force in the Sixties will have an ever increasing role as an instrument of national policy to maintain peace. It will continue to be a principal part of the over-all strategy composed of political, economic, psychological, and military factors. A homogeneous blend of strength, philosophy, and concepts will continue to give the Free World tangible promise of lasting peace.

The basic tasks of the Department of Defense in meeting the threats are:

- maintenance of forces capable of military victory in event of general war
- maintenance of an effective defense of the North American continent
- maintenance of forces, strategically placed, to demonstrate the intent, capability, and readiness to support our allies and possessing an effective limited-war capability.

The greatest threat to survival will remain that of general war. Increasing Soviet ICBM capability makes the threat even more serious because of the continuing compression of time. The Air Force contribution to national defense, therefore, will be to provide a decisive counterforce capability.

Since aerospace extends from here to infinity, the power applications inherent in operations within this medium present a wide range of possibilities and problems. Flexibility will continue to be a key factor, with the emergence of new systems that will accent our present problems and require increased emphasis in certain areas—specifically, in intelligence, warning, and control.

Organizational changes will be inevitable during this period of transition, to streamline existing structures to match technological advances. An example of streamlining will be the consolidation of tanker forces. A single-managership of tanker forces is now planned, as the KC-135 Stratotanker becomes predominant in the inventory. The tanker force will refuel both SAC bombers and TAC fighters. This standardization and centralization will profit the defense structure.

Personnel changes forecast during the next five years will not be drastic but will be marked by an increased emphasis on attracting and retaining personnel with technical and scientific backgrounds. This trend will result from the activation of missile units and aerospace control and support systems. Simultaneously our development program will strive for simplicity of operation of weapon systems. Cross training and diversion of present personnel to allied fields will enable us to utilize most of the skills presently available. Requirements for flying personnel will not be as large as in the past, but the manned system is vital to a flexible aerospace force and significant numbers of aircrewmen will be required. Skills required today will be required in the middle Sixties. Dedication to the mission, professionalism in every job, and effective management of men and materials will remain the ingredients of leadership at all levels.

The most noticeable changes will come from technological upheaval. Unanticipated technological breakthroughs and the constant need to surpass the changing Communist threat require continuous improvement in weapons performance. The mating of the Hound Dog and Skybolt air-launched missiles to the B-52 bomber typifies this requirement and the solution. The complexity of weapons has accented not only the long lead time required for the weapons themselves but also the lead time for their elaborate and increasingly expensive support structures and associated supporting systems. These structures are not always suited for the succeeding generation of weapons, as evidenced today in the case of air bases being converted to missile bases. Technological progress will continue to raise the costs of developing, buying, operating, and maintaining weapon systems. Today the cost per hour flown by a B-52 is more than twice that of the B-47. The cost of a new bomber, even when produced in sizable numbers, has increased twofold over its predecessor. In research and development, funding in the missile field has reached the multibillion mark.

Because of the threat, the mid-Sixties will be marked by more and more funds devoted to means and methods for devising and developing an ability to discourage and repel attack. Command and control structures are being hardened. The strategic forces are stressing dispersal and hardening, mobile missile train systems, and airborne and ground alert. Increased emphasis on electronics communications will continue because should an attack come we must have swift, reliable, and survivable communications for the control of our forces.

counterforce

An assessment of deterrent military power must be based on the power we can reasonably expect to have left after a surprise attack. Superior aerospace power, in teamwork with ground and sea power, remains the key to victory.

Victory in the future, as in the past, will come through an optimum balance of offensive and defensive actions. Victory is achieved by the interrelated efforts of offensive and defensive forces employed to destroy the aggressor's aerospace force. Forces that can prevail under any circumstances—even after suffering a surprise attack—are war-winning forces. To satisfy the requirement, an ensured counterforce potential continues as the essence of the Air Force formula for national security.

There will be both fixed and mobile missile systems in our forces to confront an enemy with diversified power which will be extremely difficult if not impossible to destroy. But the numbers of missiles in each type of delivery system will be carefully evaluated with respect to the advantages and disadvantages of each system.

There will not be overemphasis on the unmanned systems. Undue reliance on ballistic missiles could create an intolerable strategic position where no flexibility exists in choice or degree of response. With manned aerospacecraft in our forces, reactions can vary with the situations. Forces can be launched on less-than-certain information and recalled if the situation changes. The man in control can use his judgment when faced with different situations. He can observe, think, discriminate, and make unrehearsed decisions.

In summary, aerospace forces must be sufficient, prepared, and able to destroy any aggressor's military power to the extent that he no longer has the will or ability to wage war. Peace will depend on our ability to maintain a poised and ever-ready war-fighting and war-winning force—a credible counterforce. In the Sixties this force will continue to be the nucleus of deterrence.

strategic aerospace forces

The Strategic Air Command will continue to make a major contribution to the national military posture in the Sixties. Yet more than any other single command it will be changing dynamically with the evolution of air power into aerospace power.

Relatively early in the decade SAC will have made the transition to a true mixed force. For all practical purposes the strategic counterforce will in numbers be an equal blend of manned bombers and missiles—air-to-surface missiles (ASM's) and intercontinental ballistic missiles (ICBM's). This long-range strike force will retain the mission of deterring war, or, if deterrence fails, of destroying the military power of the aggressor. SAC's capability will continue to be the cornerstone of deterrence of war.

The critical problems facing SAC will be warning, intelligence, and control. Positive efforts are being made to solve these problems and enhance the qualities of readiness, survivability, and capability to penetrate.

Since our national policy is deterrence, the requirement for survivability assumes great importance. When manned bombers were the only threat to national survival, we could expect several hours of tactical warning. With the introduction of ICBM's and their reduced time of flight over intercontinental ranges, useful warning time is drastically reduced. The Ballistic Missile Early Warning System (BMEWS) and the missile defense alarm satellite (Midas) will provide 15 to 30 minutes' warning of missile attack. Confronted with this compression of time, SAC will rely for security of its forces on professional people, improved command and control, dispersal, ground and airborne alert, mobility, and hardening, in addition to strategic and tactical warning.

Tactical warning will come from air defense systems, while strategic warning will accrue from intelligence and other sources.

Of constant importance is the problem of control. Improved communications will strengthen SAC's control of the forces and interlock the operation of the ground and airborne alert forces.

SAC will continue to place heavy reliance on the manned system, because there is no reliable substitute for the human brain and further because a satisfactory answer may be found to the problem of defense against ballistic missiles.

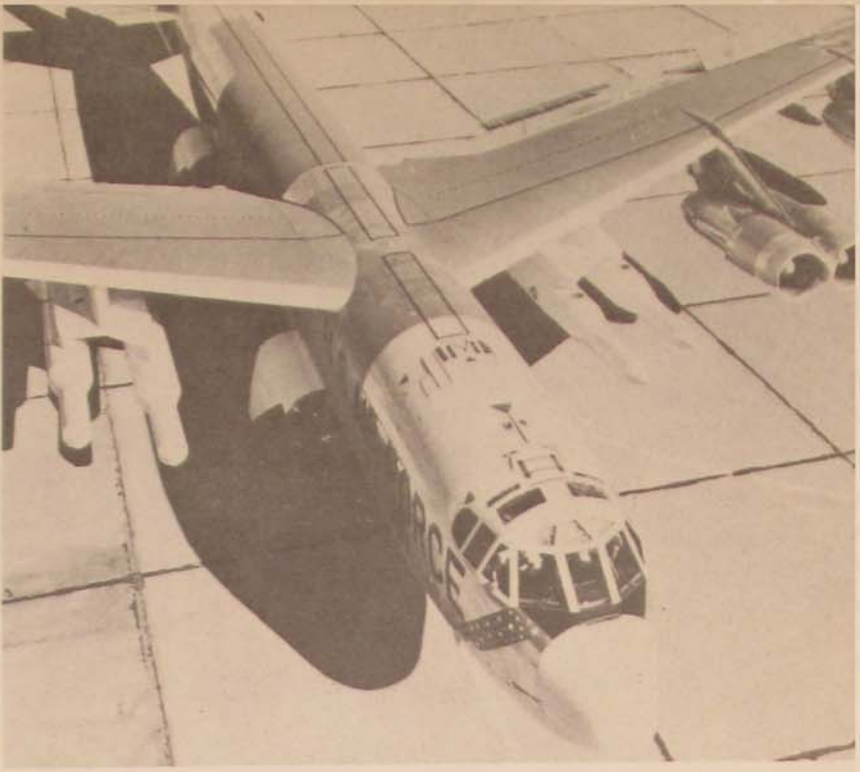
By basing strategic forces in the United States, SAC will retain security, control, and economy of force. The all-jet bomber and tanker force of the Sixties will be launched under positive control and will have the capability of being recalled. In addition the bomber-tanker force will have the capability of continued air operations and armed reconnaissance in a mop-up role. This essential restrike capability is inherent in the manned systems and provides sustaining power.

By the middle of this decade, much of SAC's striking power will be entrusted to the unmanned systems—ICBM's and ASM's. But until missiles reach the required state of reliability, the manned bomber will represent the major U.S. military instrument to ensure peace.

During this period the B-47 Stratojet force will phase down. There will be no consequent lessening of SAC's capability, however, because of the introduction of the air-to-surface missiles Hound Dog and Skybolt. Simultaneously the B-52 bomber force will continue to expand until it reaches its programed level. Advanced models of the B-52 will have increased range and survival capabilities. The ASM's will complement the B-52 force and more than compensate for the loss in numbers of the medium jets that face obsolescence in the early 1960's.

Hound Dog, the air-breathing more-than-500-mile-range missile, pays its own way in that its jet engine not only gives the B-52 added thrust for take-off but also is usable as boost in flight. The hypersonic Skybolt, a solid-propellant air-launched ballistic missile, follow-on to the Hound Dog, will have a 1000-mile range. Air-to-surface missiles thus give new uses to the old, updating the B-52 as a versatile, mobile vehicle responsive to the demands of counterforce operations.

Already capable of penetrating known defenses, the B-52 augmented by the long reach of the ASM will further be able to survive through the most heavily defended areas and with great selectivity destroy assigned targets with its internal bomb load. A high-altitude and low-altitude penetration



B-52H with full complement of four GAM-87 Skybolt air-launched ballistic missiles.

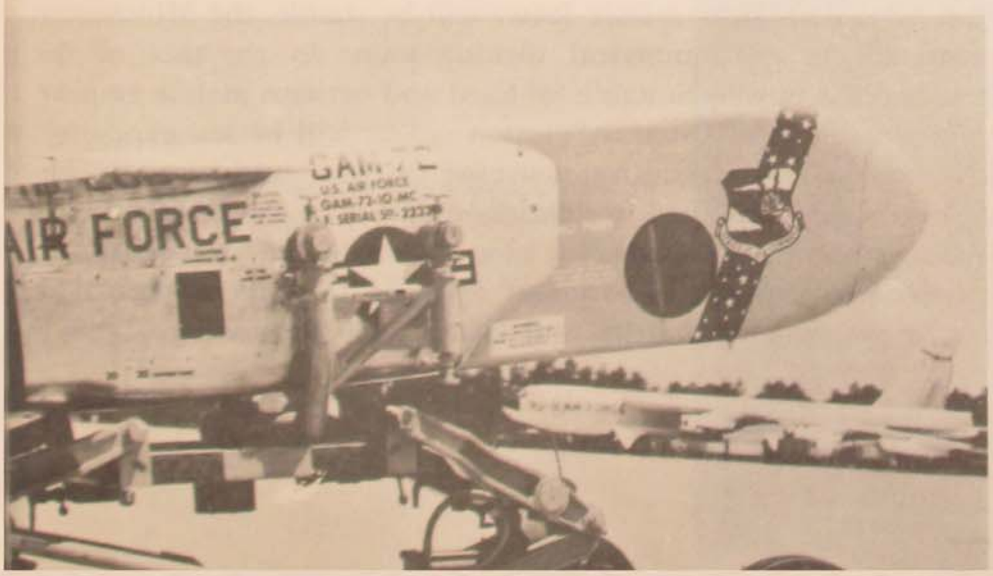
capability and use of the Quan decoy missile will further complicate the defensive problems of an enemy.

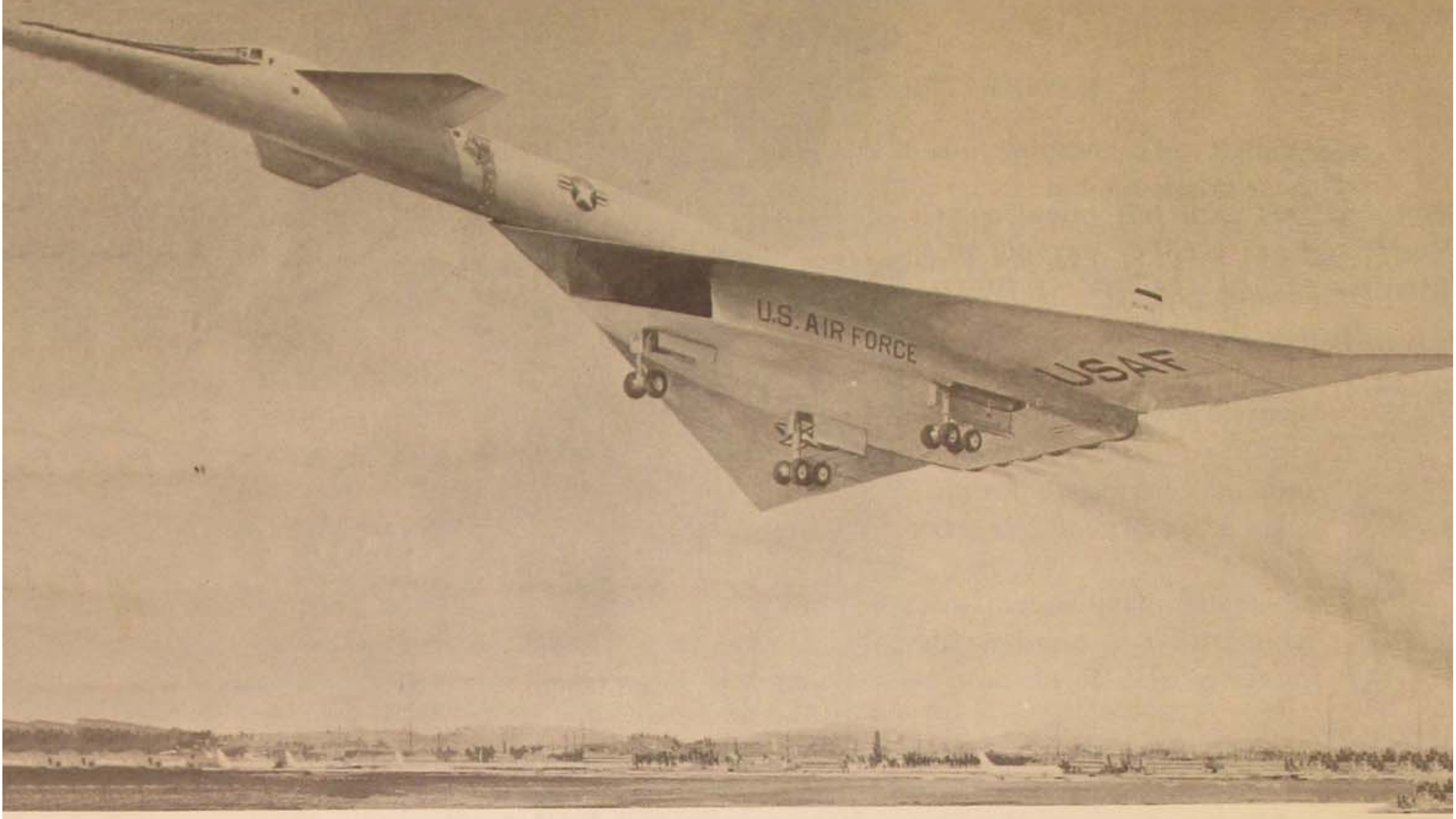
The KC-135 Stratotanker will be operational in full strength by the mid-Sixties. Like the strategic bomber forces, it will be based in the United States and thus be able to meet threats from all directions. The KC-97 tanker, like its teammate the B-47, will phase down.

Entering the SAC inventory in 1960, the mach-2 B-58 Hustler is able to fill a variety of roles and has increased survivability. The programed force of B-58's will be operational by the mid-Sixties. Development will continue on the mach-3 B-70 bomber.

While the bulk of SAC's power will be carried in the bomb bays and under the wings of manned bombers during the next five years, the age of the intercontinental missile is at hand. Survivability of the force, manned and unmanned, remains critical.

Quail decoy missile, used with the B-52G



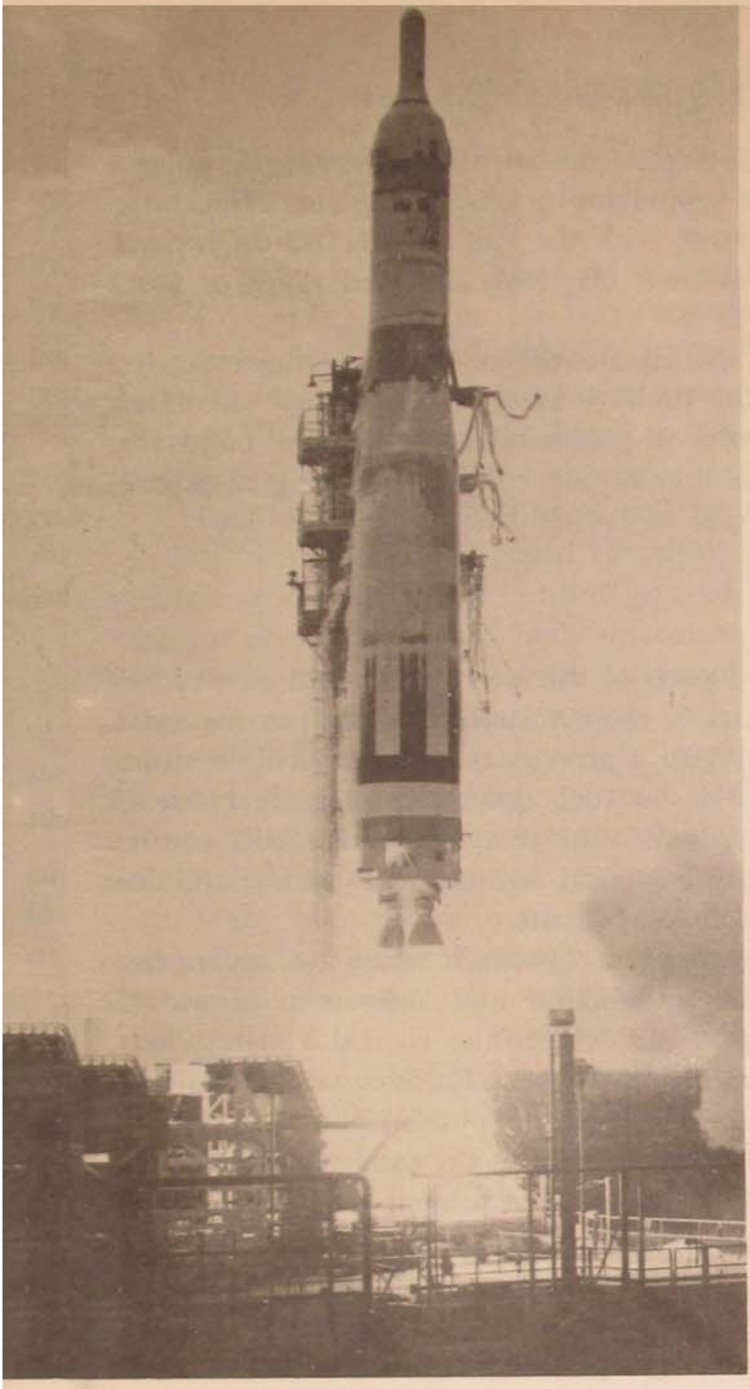


Artist's sketch of the B-70 intercontinental bomber

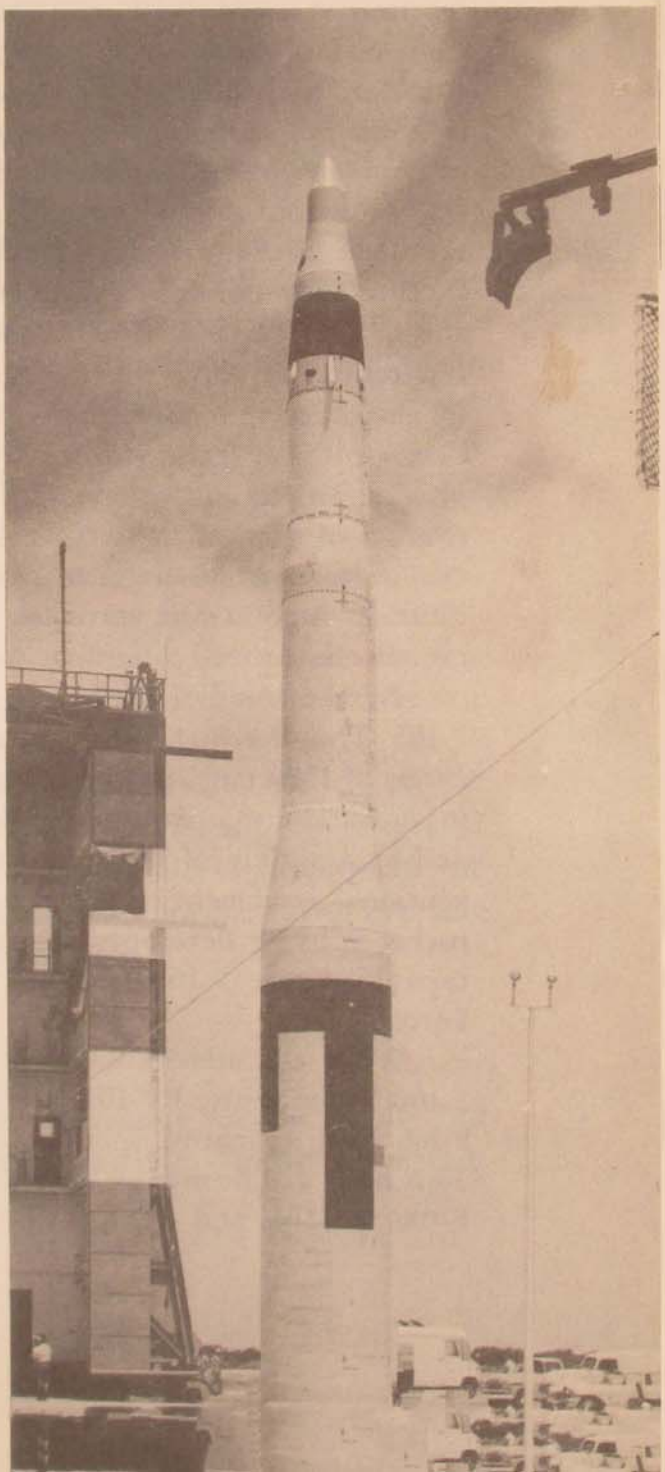
A counterforce capability which includes intercontinental ballistic missiles will require that the U.S. missile force be large in numbers and that the force be deployed and configured so that each missile presents a single target. Concurrently, instant reaction and control must be achieved. Basing missiles in the United States under positive command and control is the Air Force formula.

Already operational is the liquid-fueled Atlas, the "Adam" of the ICBM program. The tremendous growth potential of the Atlas is exemplified by its transition from radio-controlled guidance to inertial guidance and from soft to hardened installations. By the end of this period the full Atlas force will be operational. Alongside it in the inventory will be the two-stage liquid-fueled Titan ICBM, another advance in the state of the art. The programed Titan force is also expected to be fully on guard, including the much-improved Titan II, which will use storable, noncryogenic fuels and be launched from underground silos.

While the Atlas and Titan missile forces will be sizable, the Minuteman weapon system will be the numerical turning point in the mix of the manned system and the missile. Suitable for fixed and perhaps mobile employment, the solid-propellant Minuteman weapon system will be less expensive, more reliable, capable of almost instantaneous reaction, and virtually impregnable. Minuteman, if obtained in sufficient quantity by the middle Sixties and deployed in hardened and dispersed silos and on mobile missile trains, will present a near insolvable missile target equation for any attacker. The Minuteman will not make the Atlas and Titan missiles obsolete. Liquid-



Titan A intercontinental ballistic missile



Minuteman intercontinental ballistic missile fueled rocket engines at the present stage of the art have greater thrust potential, i.e., specific impulse, than solid-propellant rockets. Atlases and Titans will be the workhorses of the missile force, with the ability to launch high-yield nuclear warheads well in excess of their originally designed range of 6000 miles.

The middle Sixties will see the ascendancy of the unmanned missile systems, but SAC, fully realizing the limitations of these systems, will exert every effort to retain its hard core of professional people and build for the next era when man will continue his key role in operating aerospace forces for the maintenance of peace.

tactical aerospace forces

Tactical forces in the first five years of this new decade will be wedded even more closely to other elements of the aerospace force to provide swift reaction to a variety of situations. With a primary role of delivering destruction against predesignated targets or on such other targets as the tactical situation may dictate, highly mobile tactical weapon systems will consist primarily of subsonic and supersonic tactical fighters and tactical missiles augmented by swift and rugged airlift components.

TAC's job will be virtually unchanged: to attain aerospace superiority over the battle areas; to perform interdiction and support missions; to execute reconnaissance—photographic and electronic, tactical and weather; and to provide tactical airlift. Recognizing the need for adequate limited-war capability, the Air Force will continue to place emphasis upon the necessity for maintaining mobile, hard-hitting strike forces in the zone of interior. The Composite Air Strike Force (CASF) fills this requirement. Developed to provide an efficient, economical means of combating limited wars, the CASF consists of tactical fighters, reconnaissance, tankers, and tactical airlift and can be tailored to fit most situations. Designed to take advantage of the inherent mobility of aerospace power, improvements in air-refueling techniques enable CASF forces to dash to trouble spots in a matter of hours.

By the middle Sixties the backbone of tactical air forces will be the F-105 Thunderchief. This versatile tactical fighter is capable of speeds in excess of 1300 miles per hour, yet has an improved loiter capability. Designed to attain and maintain aerospace supremacy over battle areas, the F-105 can deliver a variety of munitions on selected targets. Equally able to use conventional armament, it has a nuclear-bomb capability, and a nuclear-armed rocket is being developed for it. With its in-flight refueling and all-weather capability, the F-105 will be the mainstay of the Composite Air Strike Force.

While the mid-Sixties force will still rely to a decreasing extent on the F-100 Super Sabre, RF-101 Voodoo, and the KB-50 tanker, conversion to the F-105 with its mach-2 speed has accented the need for a companion tanker. This need will be met by the KC-135 Stratotanker. The team of the F/RF-105, F-100, RF-101, and KC-135 will further decrease the time required to speed to trouble spots and will add to reliability. The present inventory of B-57 and B-66 bombers will be phased out during the next few years, yet the fighter aircraft of TAC will continue to provide a force that can fight in a matter of hours at any place in the world.

In keeping with the Air Force concept of a mixture of weapon systems to provide flexibility and mobility, world-wide tactical aerospace forces will be a blend of manned and unmanned systems. The tactical fighters of the Air Force will capitalize on the latest rocket systems, such as the Bullpup and Sidewinder, but be equally competent in using other conventional munitions.

Retiring during this period will be the Matador air-breathing tactical missile, which has stood guard effectively in Germany and Formosa. By the middle of the Sixties the much-improved Mace will be predominant in the tactical missile inventory, both in mobile and hardened configuration. The Mace will capitalize on a virtually jamproof guidance system to make treetop penetrations and attack targets with great accuracy.

While the number of aircraft in the tactical airlift force will remain constant during this period, the total airlift capacity will increase as a result of the C-130 Hercules transport replacing the C-123 Provider. The Hercules will greatly increase the ability of TAC to support the Army requirements.

Many refinements in techniques can be expected during the five-year period ahead. Tactical aerospace forces will continue to stress survivability, taking full advantage of mobility and quick reaction time. Plans for increasing the tactical fighter's survivability include hardening, dispersal, and use of unimproved airfields, highways, and other strips suitable for operations in an emergency. The years ahead will see more stress on this ability to operate from nonfixed bases. Training and experience gained in actual emergencies such as Taiwan and Lebanon and in routine peacetime rotational deployments overseas will sharpen techniques necessary in times of tension.

With a sizable strength positioned overseas, tactical aerospace forces contribute significantly to the strength of the Air Force in event of general war. Combining range, speed, and ability to penetrate and using low-altitude bombing techniques, the tactical fighter will complement the counteroffensive effort of the Strategic Air Command in general war and supplement the Air Defense Command in its role of aerospace control.

During this time period follow-on aircraft and missiles needed by TAC are: (1) an advanced multipurpose tactical fighter aircraft with short take-off and landing characteristics; and (2) a mid-range missile to supplement the Mace, giving TAC a high-altitude and low-altitude missile capability like the high-low capability possessed by its fighter force.

aerospace defense

Air defense forces, although faced with an increasing ballistic missile and space threat, will also continue to improve their capability to defend against the air-breathing threat.

Offensive and defensive operations will be interrelated tomorrow as they are today. The prime defensive role will be to provide warning of enemy attack, to prevent unacceptable destruction by enemy air attack, and to control aerospace for employment of our strategic forces.

One of the most complex problems confronting air defense forces during the early and middle Sixties will be warning of ballistic missile attack. The BMEWS and Midas systems will increase our military capability and ability to protect the counterforce, as will other survival actions such as the SAC airborne alert, dispersal and hardening of our strategic bases, hardening of key air defense centers, and survival and recovery planning for essential military and civilian elements.

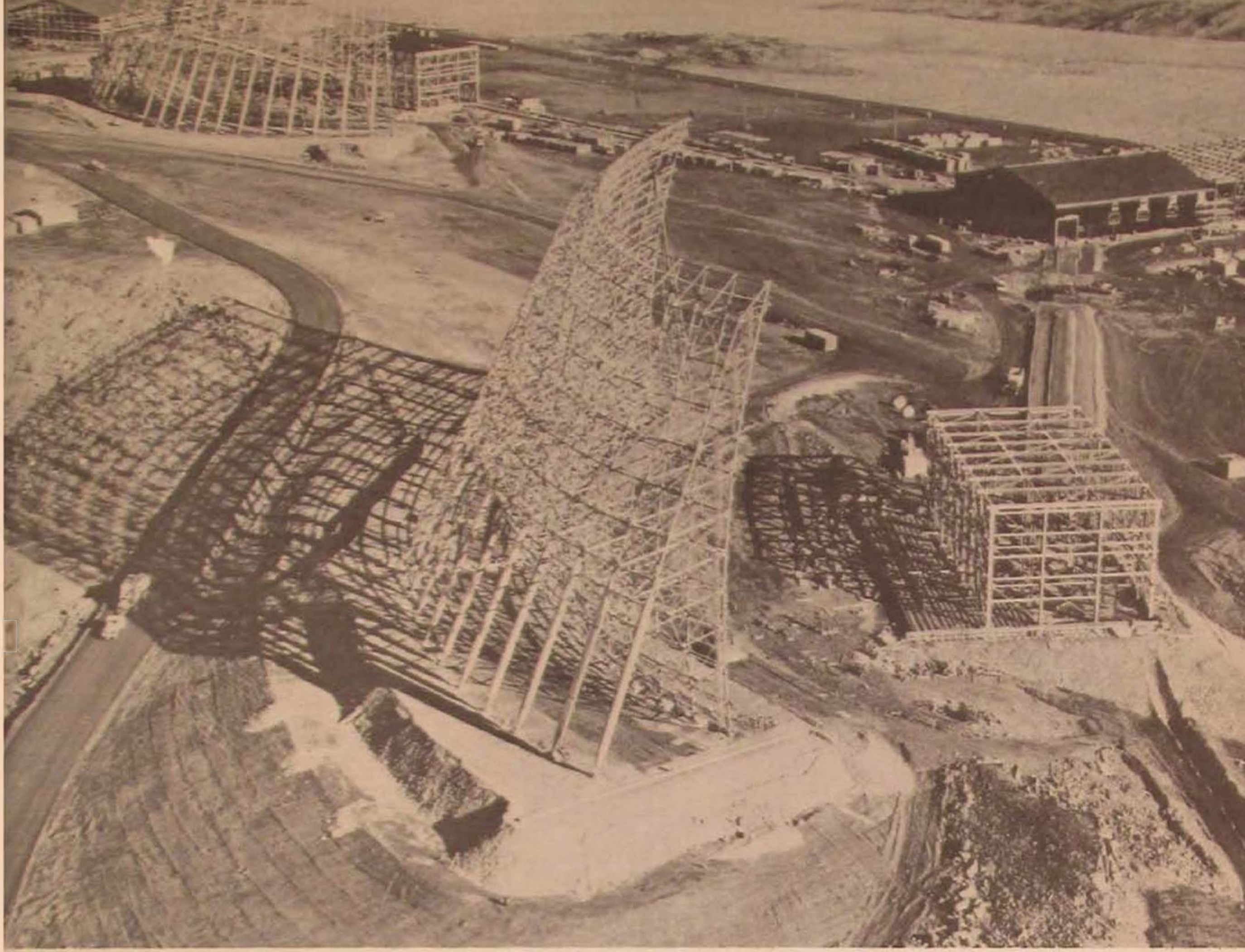
The first key link in the missile warning system is BMEWS, the Ballistic Missile Early Warning System, which will consist of three gigantic electronic installations in Alaska, Greenland, and the United Kingdom. The Greenland site is already operational. In 1961 the station in Alaska will be operational and, along with the Greenland installation, will give warning of ICBM attack from over the North Polar regions. When the site in the United Kingdom is operational in 1963, air defense forces will be able to warn of attack from the critical approaches flanking the polar route. This far-searching radar fence, scanning the reaches of aerospace, should provide about 15 minutes' warning. Restricted to line-of-sight detection, the BMEWS is the first element of a complementary system.

To obtain maximum warning, the Midas satellite warning system will be operational by the mid-point in the decade. Air defense forces will then be able to increase significantly the response time available to mount the offensive forces. The two systems, Midas and BMEWS, are designed to provide the earliest and most reliable warning possible against ICBM's, regardless of the wide variety of tactics available to the enemy.

The capabilities of either system do not reduce the requirement for the other. The two systems complement each other in attaining a time-phased capability.

During this period the threat of the air-to-surface missile will increase. In addition to the blast effect, problems associated with nuclear detonations require destruction of hostile enemy bombers as far away as possible. The introduction of ASM's in the Soviet inventory will aggravate the problem, just as our Hound Dog and Skybolt missiles greatly compound the Soviet defense problems. Without long-range manned and unmanned interceptors, the enemy would have the initiative and operational latitude to concentrate even more on this tactic of standoff attack.

Under present plans, total interceptor strength will be gradually reduced. Air Defense Command will have as its primary manned interceptor the supersonic F-106 Delta Dart. The present strength in F-102 Delta Daggers will show a gradual decline, while the number of F-101B Voodoos will remain fairly stable. Modernization programs already begun, and those that will follow as a result of technological breakthroughs, will upgrade the capability of the defense forces. Supersonic all-weather jet interceptors, armed with great kill arsenals in the Falcon, Sidewinder, and Genie air-to-air



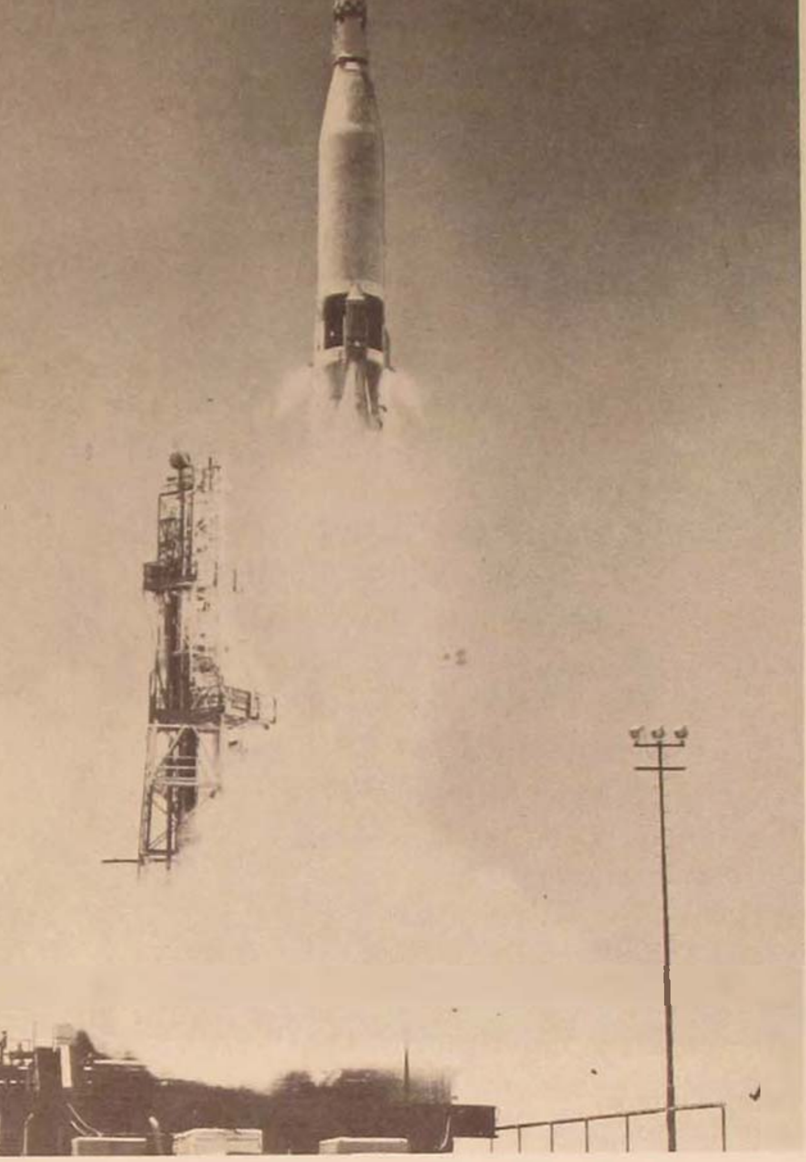
BMEWS (Ballistic Missile Early Warning System)

rockets, will remain the backbone of area defense. The development of a long-range mach-3 interceptor—LRI-X—may become mandatory during this period to meet the ASM threat as well as the threat of Soviet high-performance bombers.

Like the other commands, ADC will have a mixture of manned and unmanned systems. Bomarc missiles, our unmanned interceptors, will significantly strengthen the manned force. Tests during the spring and summer of 1960 confirm that Bomarc offers a potent answer to the manned-bomber threat in the years to come. The A model, with a 200-mile range, will be supplemented by the newer B model that can streak more than 400 miles to destroy its quarry at speeds of mach 3.

Since man will not be replaced, because only he can perform the vital function of positive identification and assessment, the manned interceptor will remain in the inventory for the foreseeable future. The Bomarc is an extension of this manned capability, but it is faced with the limitations of other missiles—once it is fired there is no recall.

Early in the period, capacity, accuracy, and speed of our weapon control systems will be improved further through the use of electronic data-handling techniques to plot and record aircraft positions. Replacing the old manual



Midas (Missile Defense Alarm Satellite)

systems, this advancement will be incorporated in the SAGE control system. The SAGE system provides centralized control of air defense operations, adequate control in the assignment and direction of high-speed air defense weapons against hostile aerial vehicles, and defense in depth along approaches to vital and critical target areas within the United States.

Manned interceptors, along with various air defense missile systems, satellites, and the radar complexes, satisfy the requirements for adequate air defense—detection, guidance to target, interception of attackers, and the destruction of attackers before they are able to destroy their target.

Through the middle Sixties the air defense forces of the Air Force will be built and operated on these concepts:

- Air offense and air defense are interrelated, and both are essential to deterrence and to victory.
- A primary air defense mission is tactical warning.
- Air defense must adhere to the concept of area defense in depth, with the goal of remoting the combat.
- Air defense requires a mixture of complementary weapons. The increasing threat of ICBM's does not eliminate the requirement for manned

and unmanned interceptors to counter the air-breathing and ASM threats.

- Centralized control is required for effective use of air defense weapons and for protection of air offensive forces. Automation is essential in air defense.

airlift

Military Air Transport Service will continue to have the basic task and mission of providing the essential wartime airlift as approved by the Joint Chiefs of Staff. Long-overdue modernization programs will begin to strengthen the transport fleet, with the acquisition of new and more modern aircraft by the middle Sixties.

Modernization will permit a reduction in the total number of aircraft, provided current airlift requirements are not increased. By maintaining a state of instant readiness, MATS will be able to accomplish its primary task of quick response and direct support of the strategic and tactical offensive strike forces. Already MATS is airlifting intercontinental and intermediate-range missiles.

During this period MATS will still rely on the C-124, C-121, C-118, and newer C-133 aircraft. Augmenting MATS in an emergency will be the Civil Reserve Air Fleet (CRAF) and Air Reserve units. The airlift potential can be further increased by use of tactical air troop-carrier airlift, if it is not otherwise committed. On the horizon is a new transport aircraft designed to meet MATS specifications and enable the command to more effectively perform its mission in the rapidly approaching missile age. To fill the breach, turboprop and possibly some jet transports will enter the inventory to replace a portion of the aging C-124's.

Other MATS units will provide the same basic services in the Sixties. The Air Rescue Service may be reduced in size because of improved aircraft and changing mission requirements. The units will be equipped with C-118 or C-121 aircraft resulting from the expected modernization. We expect to be able to retire the five air weather reconnaissance units. While the requirement for this service will continue to exist, advanced Tiros satellites and other units will perform the task. Through conversion to C-130 aircraft, the MATS photomapping units can be reduced from three squadrons to two.

With nearly 90 per cent of its aircraft considered obsolete, the next five years for MATS will be ones requiring innovation and resourcefulness in order to maintain an adequate, effective airlift for supporting our worldwide forces.

By 1965 another era will be approaching. In the inevitable race between offensive and defensive forces for superiority, the performance characteristics of weapon systems already have increased to the point where it is now possible to achieve extreme altitudes and speeds and almost infinite duration. Aerospace systems designed to take advantage of these technological breakthroughs will be incorporated to provide the most effective means for performing specific military missions.

Photograph taken from a Tiros weather satellite four hundred miles above the earth. The earth's curved horizon shows on the left. The light area in the center is a cloud formation over Spain; the lower grey area is North Africa; the dark area to the right center is the Mediterranean Sea.

For interim modernization of the MATS transport force, the Air Force has chosen the C-130E (shown in model above), an extended-fuselage, improved version of the well-tried C-130B. In the later Sixties the transport force will be bolstered by more than 100 of the C-141 turbofan transports (artist's sketch shown below).

The Air Force's experience and delegated mission are such that a separate doctrine or concept will not be required for the employment of weapon systems which exceed some arbitrary velocity and altitude or which operate in some artificially segregated medium. Such artificial segregation of orbital or space systems from other Air Force systems is impractical and would result in an unacceptable division of responsibilities, in confusion, and in waste. The Air Force concept for the development and operation of space systems is a logical and economical approach for providing for the defense of the Nation.

Headquarters United States Air Force

Tomorrow in Aerospace Power

Lieutenant General Roscoe C. Wilson

IN DISCUSSING aerospace forces of the period beyond 1970, I believe it more profitable to examine military technology in relation to policy and strategy than to treat it in isolation from its applications. As Douhet once stated, the form of warfare depends on the technical means available. Historically we have pressed technology to give us weapons of increased performance. As we have acquired them, we have found that these advances made new strategies possible and, at times, essential. This may well be the course of the future, although the rate of change probably will accelerate as the present technological revolution continues.

This phenomenon is well illustrated by our experience since the end of World War II. In 1945 Dr. Theodore von Karman submitted a report to General Arnold entitled, "Toward New Horizons." This was a forecast by the Scientific Advisory Group of the technical possibilities of the future. If we were to write a similar report today, we might properly call it "Beyond Horizons," for we visualize that man shortly will make his first attempts to operate outside his earth environment. In so doing he will leave the world in which the word "horizon" has meaning and find himself in a new environment which is essentially unlimited.

As we stand on the threshold of this great advance, we are very optimistic that technology can provide whatever is required to make it a reality. In fact at times the very richness of our technology makes it difficult to choose the specific systems to develop in order to attain this capability. While it is true that we are lacking in adequate knowledge in many basic areas, such as propulsion, materials, and solid-state physics, we feel that such knowledge will be forthcoming in time to meet our requirements.

Because of this aspect of the coming decades, it is more meaningful and profitable to examine the most likely ways in which we will develop future capabilities. Thus my point of departure is not technology per se but technology in relation to strategy and policy.

Policy Considerations: Deterrence

IN the midst of the dynamic change resulting from technology we can anticipate a constant that will be of prime importance to aerospace operations and strategy. This constant is our policy of ensuring peace by deterring war through superior strength in-being. The strategic positions of the U.S. and U.S.S.R. are and must be asymmetrical because of vast difference in policy and objectives. This will be an enduring condition unless there is a basic change by one side or the other. The central facets of the U.S. position are our determination to preserve peace and our belief that peace is essential to our progress.

We have constructed an elaborate conceptual and practical position to deter the Communists from using aggression as an instrument of policy. My interest centers on the technology necessary to make a strategy of deterrence possible. While the basic concept is static, the execution of concept is extremely dynamic because of the revolution in military capabilities resulting from an exploding technology. The new capabilities have increased the possibility of surprise and of attaining a military decision in a very short span of time.

image of future total war

Prior to the advent of the ballistic missile there was general acceptance of the idea that total war would involve the use of nuclear weapons and would be of short duration. There were dissenting opinions by proponents of various strategies and policies, but they were essentially in the minority.

Today we find a different popular image of total war, which is visualized as "two-shot" nuclear exchange. The enemy launches an all-out attack, attempting to achieve surprise, and we retaliate. Then we try to learn who won. This great oversimplification comes from a failure to understand the intricacies of tactics and logistics, which by their nature dictate a course of events that will be quite different from the popular idea. Problems of fueling, of controlling and guiding large numbers of missiles simultaneously, of scheduling launches so that minimum warning is given of the various phases of the attack—these and many other considerations preclude a "one-shot" attack. Furthermore the enemy must plan for contingencies. He must assume that his knowledge is imperfect, that he has not visualized the exact course of the future, and that we will try to deceive him. To meet these problems he must allocate a significant part of his military power to the conduct of follow-on operations.

A future total war may be of short duration in comparison to previous wars. But it will have several phases, and the first blows will not be the end of hostilities. Even though the enemy will have expended part of his military power in the initial attack, significant forces will remain. We must attack and destroy this part of his power. The outcome of the war will depend on the action and reaction in the clashes of forces, not on an exchange of cities.

We can assume that the enemy will calculate and recalculate the results of these possible clashes, taking into account variations in tactics and in weapon characteristics. We must do the same and devise our forces so that the results of his calculations will always lead him to a certainty—the decision not to attack. As long as we succeed in motivating that decision, a policy of deterrence will be possible.

Fundamental to a consideration of strategies are the relative military strengths of the opponents. When these strengths are equal or nearly equal, the strategic situation is delicately poised. International stability is ensured only when one side has overwhelming force and is dedicated to the maintenance of the status quo. The present situation between the Free and Communist worlds is the most unstable in modern history.

Returning to Douhet's observation, we must recognize today that the technical means available have altered radically the nature of military operations. Once hostilities begin we must attack those military forces in-being that are capable of destroying us as a nation in a very short period of time. We must have the advanced technical means to disarm the aggressor of those weapons which are a direct threat to our survival. Therefore our military strength must be superior to that of the Communists, regardless of the strategic and tactical circumstances which may arise. Only in this way can we ensure stability and peace.

Strategic Considerations

Within this general outline of policy considerations we visualize military forces with certain characteristics enabling them to implement various strategies of our policy of deterrence. These strategies are:

- second strike
- a credible option
- meeting contingencies.

Before examining these strategies in detail, we must note a condition that will apply to all military operations in the future. Aerospace systems will have the ability to provide information on a complex environment. Our many projects in electronic environments and in the use of early satellite systems will lead to a gigantic extension of the world of the senses. Commanders will have instantaneous information of a wide variety. Within the next 15 years they will be in close touch with events in the terrestrial, cislunar, and lunar regions.

Illustrations of this can be seen through the early satellite systems now in advanced state of development. The Midas will keep us informed of missile and satellite launchings in selected areas of the globe. The Tiros system will offer us global data on weather, greatly enhancing our capability of forecasting surface weather phenomena. A wide variety of communications satellites will permit commanders to communicate instantly with earthborne, airborne, and spaceborne forces. Data on events will be transmitted and will be displayed in meaningful form for decision makers while such events are occurring.

The ramifications of these capabilities can be seen in broad outline, but the details must wait until the systems are closer to an operational status. To gain some measure of the magnitude of change, we may find a clue in a historical comparison. Napoleon had to climb towers or ride for miles to get a perspective of the battlefield and an insight into enemy dispositions. The operational environment of the future will be as radically different from today's as ours is from Napoleon's.

second-strike capability

With these general remarks, let us turn to the forces operating in this complex environment. Second-strike forces must possess these characteristics:

- ability to survive surprise attack
- ability to penetrate enemy defenses
- ability to destroy selected military targets.

Survivability. Survivability can be achieved through a variety of measures. Warning of attack is of course essential to protection of our offensive striking power. It can contribute to the active defense of this part of our strategic forces. But as we study the active defense systems needed to meet future threats, question arises as to whether the defense may be able to destroy a significant part of the enemy attacking force.

Nevertheless an active defense, even though it may not approach the perfection we seek, is essential to a war-winning capability because of tactical considerations. Any defense measures that degrade the efficiency of the enemy's striking force can give us an advantage. An active defense against ballistic missiles in the terminal phase of their trajectory may in the long run be less effective than a satellite-based defense. Yet this technical approach has growth potential and can force the enemy to adopt countermeasures. And if we can make him increase his forces or expend energy to vary trajectories and thus increase the time of flight, we make him expend more of his treasure or give us more warning time. Any increase in warning time increases the possibility of acquiring more information, of deciding the correct measures to take, and of acting to meet the threat. Any or all of these eventualities can make us more effective in attacking the uncommitted elements of his military power. This complicates the calculation of what the Soviets call "the balance of forces." The net result is that we reduce his certainty and increase our deterrent power.

We recognize that this conclusion on the superiority of the offense is a tentative one based on our present point of view. New information and developments promise vastly more effective defensive systems. But until we actually have them in being we must rely on counteroffensive operations, with our extremely advanced systems as the key to our strategy. Even when we succeed in attaining a truly effective active defense, we will continue to capitalize on defensive measures which are largely passive in nature. They will be extensions of our present approach to survivability—that is, our forces must be dispersed, hardened, mobile, and concealed. We have undertaken to disperse our manned bomber and missile forces. By hardening our missile sites we can magnify the delivery problems of the aggressor to the point that he finds it economically infeasible to deliver an attack sufficiently powerful to destroy our missiles. Thus hardening ensures that a significant number of offensive systems will survive for a counterstroke.

Mobile forces create uncertainty in the mind of the aggressor and may persuade him to allocate a significant part of his military force to attack these targets. Rail mobility alone probably will not suffice to create this uncertainty over many years.

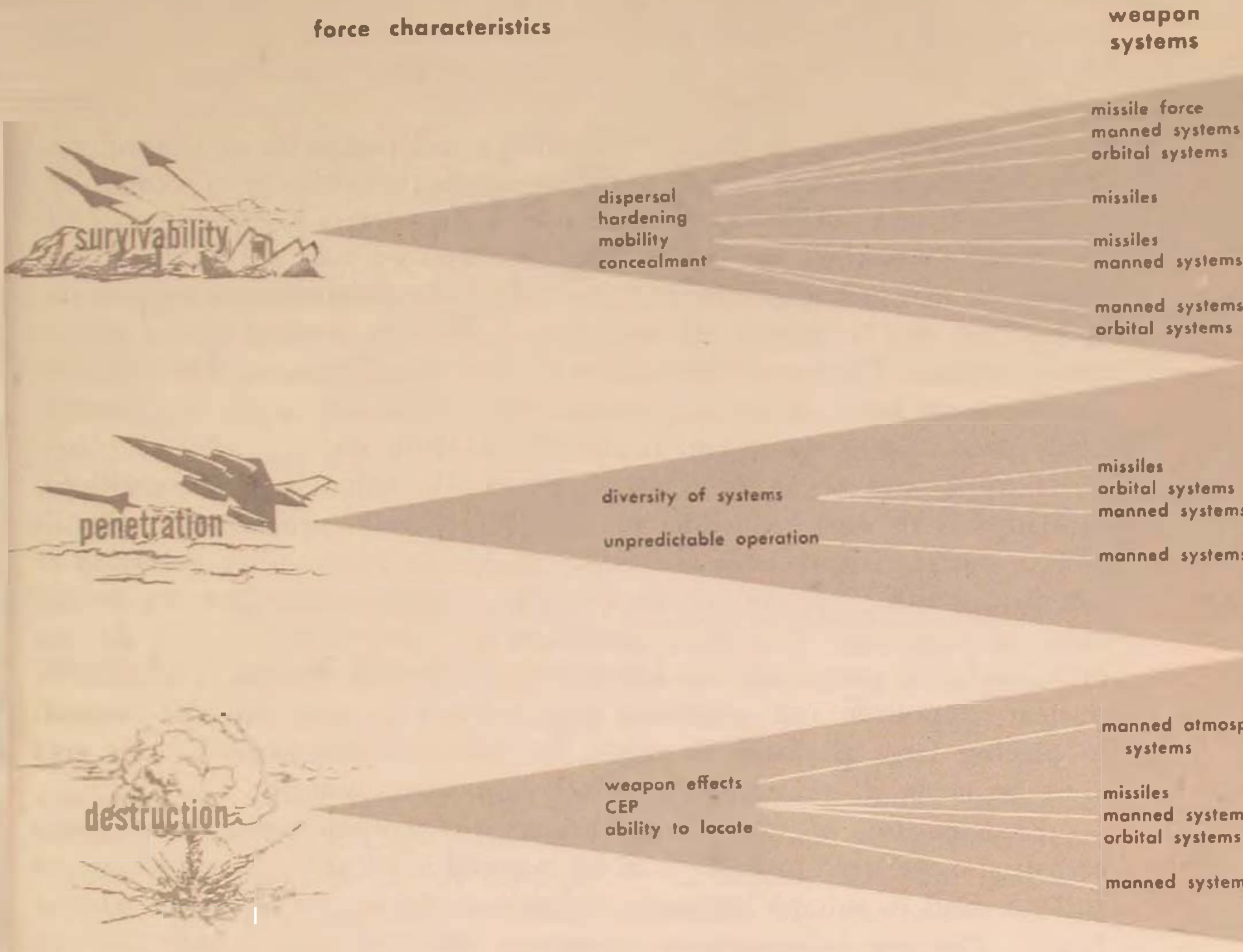
Finally concealment, if effective, creates uncertainty in the mind of the aggressor that he has the ability to destroy enough of our forces to escape our delivery of a decisive counterblow.

Penetration. The ascendancy of the offensive over the defensive stems particularly from the ability of advanced weapon systems to penetrate enemy defenses. The combination of great speed and great altitude, taken together with numbers during a mass launch, ensures that selected targets will be reached. Improvements clearly possible through the use of decoys, multiple warheads, electronic countermeasures, varying trajectories, maneuverability, feinting, and omnidirectional attack will further increase the ability to penetrate defenses.

Destruction of targets. All these measures and capabilities have as their goal the destruction of selected enemy targets. Success will depend upon circular probable error (CEP), weapon effects (including nuclear yield), and knowledge of location. If our forces are inadequate in any of these three aspects, they will make unrealistic our strategy and thus our ability to deter aggression. We can postulate that the enemy may be hardened well beyond our present general assumption. If he increases hardening by one order of magnitude, we may be forced to modify the present "brute force" approach to firepower and employ new types of selective destruction.

Retaliation, a military strategy. An important aspect of retaliation—that is, a second strike which retaliates to a surprise attack—which we must keep clearly in mind is that we are not talking of operations of a punitive nature. Our forces must not be designed for purposes of revenge. A sound military strategy or national policy cannot be directed to goals of this nature. Rather a retaliatory force must be of a size sufficient to ensure delivery of a decisive blow to the aggressor's military power and ability to resist.

Ensuring our second-strike capability. The weapon systems now entering the inventory and under active development for the coming decade will in large measure give our second-strike forces the characteristics they will need. The dispersal of our manned bomber force and of our missile systems will be a reality in this time period. Atlas, Titan, and Minuteman sites will have been constructed to hardness criteria that will enhance their survival. The mobility of our Minuteman and Polaris forces will be an integral part of military operations.



Nevertheless we can still do much to increase survivability through mobility and concealment. Both features will be found in manned and unmanned systems operating at random throughout the vast reaches of the aerospace. Unmanned orbital systems which can be concealed in deep space and called down on targets appear to be possibilities which might take their place in the future operational inventory. Enemy difficulties in inspecting our offensive orbital systems concealed in space would make such systems attractive, particularly if an opponent should perfect an effective orbital-based system to counter our earth-based offensive capabilities.

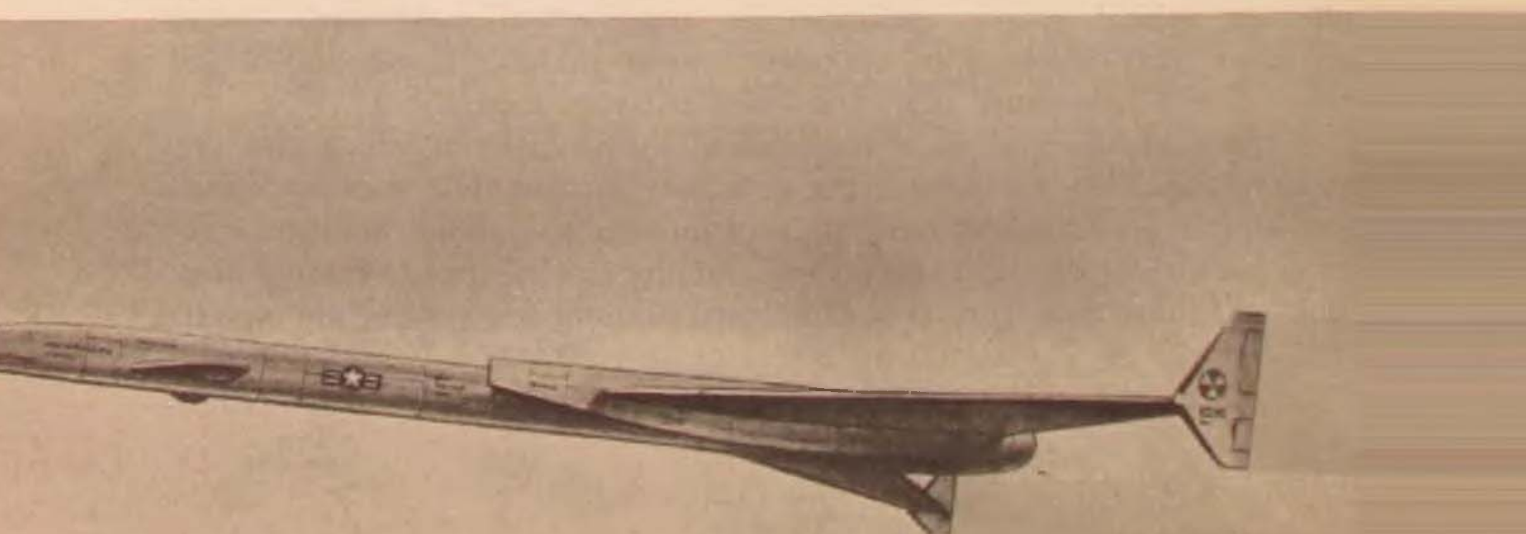
We must also give more emphasis to weapon systems which give us a manned capability throughout the aerospace. Atmospheric manned systems can find increased concealment through random operations. Manned spacecraft can employ dispersal and maneuverability as a means of avoiding detection and inspection. Furthermore manned atmospheric systems are essential because of their ability to place graduated, nuclear, multiple firepower on selected targets. This capability is the result of the combination of air-launched missiles and gravity bombs. The Hound Dog and Skybolt missiles, together with their follow-on versions, will do much to ensure an effective second-strike capability. In addition to the essential tactical flexibility they give us, we need manned aircraft to seek out hard or soft, unknown, and mobile targets.

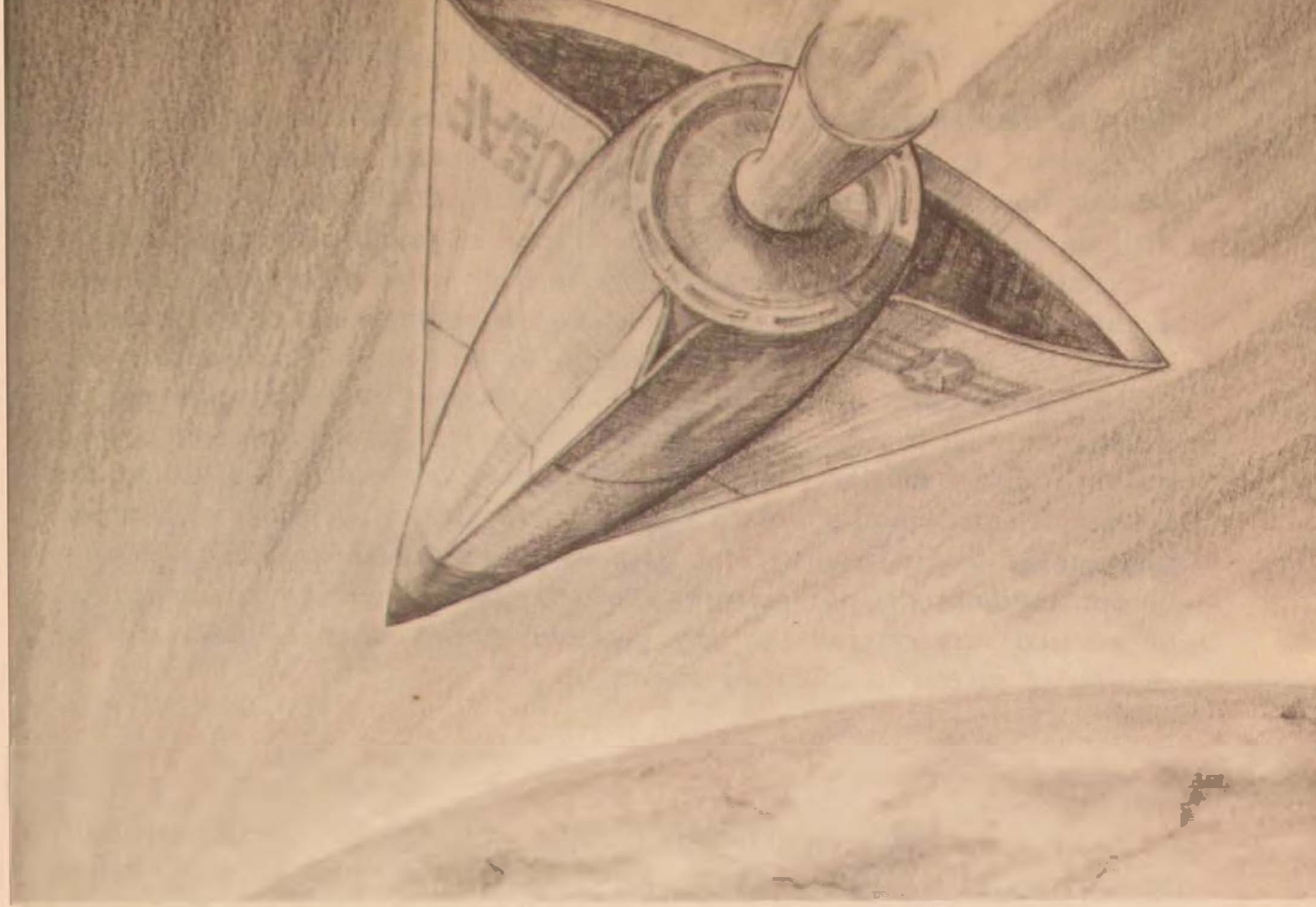
The relationship of force characteristics and categories of weapon systems to ensure execution of a second-strike strategy is exhibited in accompanying illustration. Examination of these relationships makes it apparent that for the ultimate versatility and capability of our forces we must call on technology to give us manned aerospacecraft that can operate within and beyond the atmosphere and be capable of returning to selected landing points on the earth's surface. This need underscores the vital importance of the Dyna-Soar project as the essential first step which will enable man to operate in near-earth space, in the cislunar region, and beyond the moon.

Further advances in the trend started in Minuteman must be continued. Miniaturization and reduction in cost will permit proliferation of this part of our retaliatory force and thus enhance its survivability. Advances of this nature will be possible if we are able to reduce costs. The key to this effort is propulsion. We are approaching the theoretical limit in the use of chemicals as propellants for our advanced offensive systems. Undoubtedly nuclear propulsion and other new concepts will be attractive and essential to placing large payloads in orbit. Technical developments in this area must be made if we are to have follow-on space systems.

Examination of the force-characteristics–weapon-system relationship reveals also the need to modernize the manned atmospheric systems that can strike second in suitable tactical formation to deliver firepower on selected targets. This capability dictates continuous airborne alert, a need that can be met through development of long-endurance aircraft able to carry heavy-yield bomb loads and missiles. Presently there are two avenues which we can follow to develop such long-endurance aircraft: by way of the nuclear-powered

Supersonic nuclear-powered aircraft





Maneuverable manned spacecraft

aircraft or the Dromedary aircraft. The Dromedary is a concept which, as presently considered, would be powered by jet engines and would incorporate boundary-layer control in the design of its airframe as the necessary aerodynamic feature for long endurance. Naturally the great promise of the nuclear-powered aircraft is in the virtually unlimited endurance of its propulsion system.

Of these two approaches the Dromedary promises to be more easily attained technically. However this approach represents only an incremental advance in aircraft development, whereas nuclear propulsion will open up a whole new technical area. It is highly probable that by the time period of the 1970's we will have a feasible nuclear-propulsion system in the day-to-day operations of our aerospace forces. Armed with air-launched ballistic missiles and operating on random patrol within the lower levels of the atmosphere, the nuclear-powered aircraft will, through its inherent mobility, be ideally suited to survive and constantly ready for second-strike action.

credible option

It should be clear that up to this point I have been discussing deterrence of a general war resulting from direct attack or threats against the United States. To ensure peace, we must also deter aggression against our allies. The most effective strategy to attain this goal has been termed the "credible option." In examining the ways in which general war may be initiated, we can postulate circumstances wherein the Soviets would attack an ally without involving the U.S. directly. Deterrence of this possibility is based on the credibility of our proclamation that we will act to defend our ally even at the risk of involving our own homeland, its population, and its resources. This is the most difficult form of strategy to comprehend and to plan for.

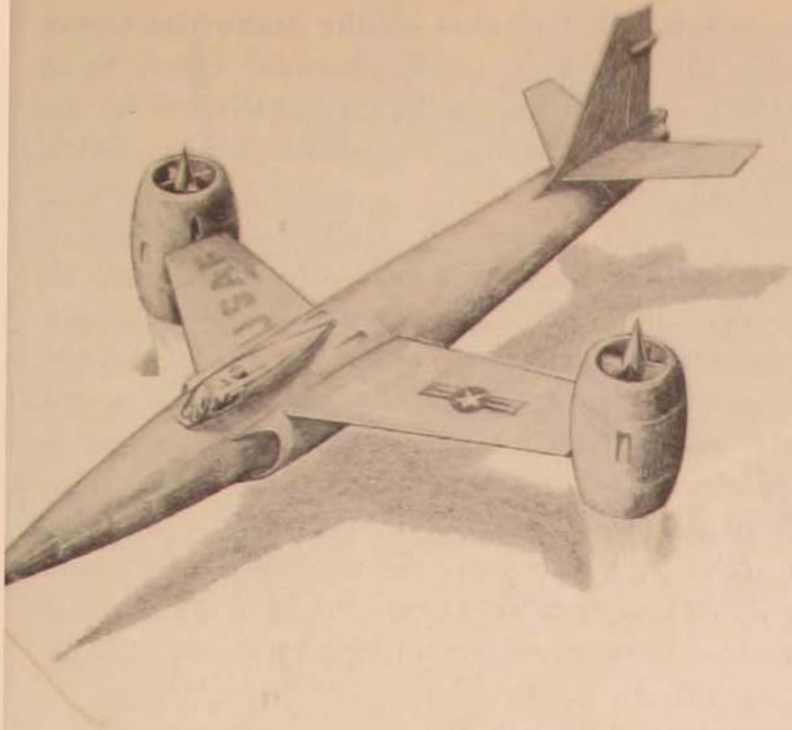
From the point of view of technology, we must devise weapon systems necessary to that strategy. To make the strategy credible, we must look beyond strictly military measures and incorporate into our national planning the defense of our civilian populace. Civil defense, with the objective of minimizing damage to our country and its people, is and will be a vital element of our national defense posture. Practical passive defense measures must be assessed very carefully by any potential enemy when he calculates his chances of success in initiating aggression.

meeting contingencies

The final aspect of strategy which we must consider is the capability to meet the wide variety of threats short of total war which we will continue to face. A part of our aerospace power must have characteristics that permit decisive military action to control selected terrain and to defeat forces seeking limited surface advances. But inherent in such limited conflicts is also the danger that they will lead to total war. Operations around the globe do not and will not occur in isolation. They must always be viewed in the context of their impact on the total balance of military forces. Against this very general image of conflict we can foresee a need for operation of combined arms and for the use of atmospheric systems as an essential part of the combination. The detailed knowledge of events gained through aerospace systems will enhance the effectiveness of such atmospheric systems.

At this point we must ask ourselves whether the air vehicles used in such small-war situations will differ markedly from those we know today. At the present time we see that conflicting military requirements are making it difficult to develop atmospheric systems with the features needed for anticipated operations. On the one hand we search for increased performance in terms of speed, range, and altitude. This is dictated by the need to survive in the face of constantly increasing performance of enemy defensive systems. To attain these goals, we develop systems of ever increasing complexity and higher cost, with consequent smaller numbers in the inventory. On the other hand we search for an easily produced and cheaper vehicle that can operate under austere conditions and capitalize on the principle of mass.

The evolution of U.S. Air Force aircraft has been dictated by the hard military reasoning of the first of these courses of action. And the need for flexibility to operate in the face of a wide spectrum of threats continues to dictate that our aircraft be able to cope with the most difficult situation they may face. An opportunity to meet these varied requirements can be



Vertical take-off and landing (VTOL) aircraft

found in nuclear-powered atmospheric systems. It is obvious that they can have great range. They can be designed to fly at high speeds and high altitudes. Their large carrying capacity can make them usable for limited-war situations. We are also certain to have a vertical take-off and landing aircraft capable of operating under austere conditions around the globe. This will be a multipurpose weapon system, able to carry bombs and air-launched missiles and to conduct reconnaissance. This aircraft may complement the nuclear-powered systems.

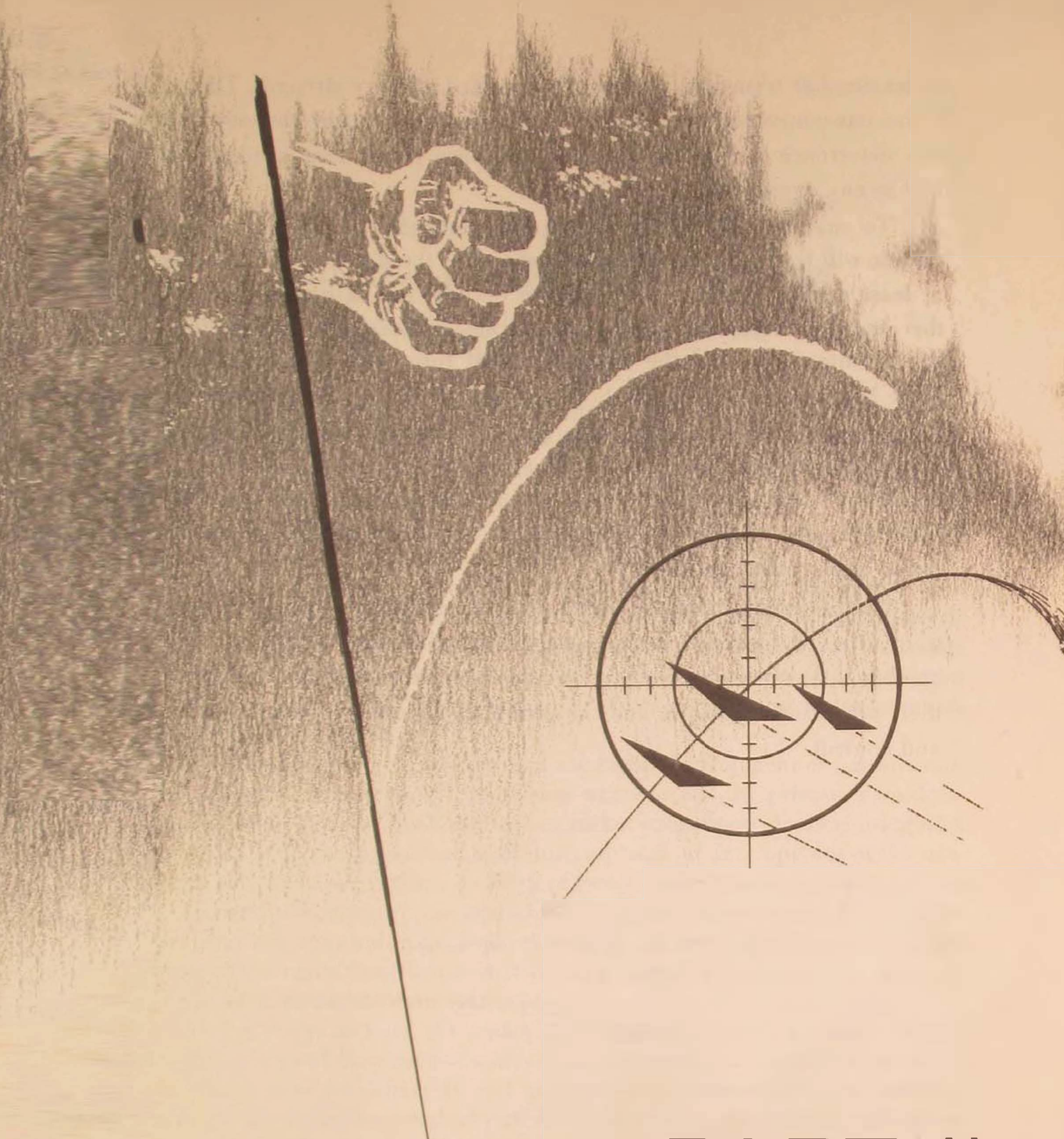
The need for increased firepower will be met by our advancing technology. We can anticipate that the nuclear weapons of today will be replaced by vastly improved munitions which will capitalize on the destructive power of nuclear reaction but which will not have certain harmful effects as at present, notably fallout. Significant advances in yield can greatly reduce the requirement for the wide variety of munitions now employed by tactical forces.

The foregoing summary of major weapon systems postulates major advances in many areas of science and technology, including materials, propulsion, and electronics. These advances will come about if our management processes are designed to ensure reliability of the weapon systems and if significant breakthroughs are made in reducing costs. But if we are to optimize these advances, our doctrinal concepts for conducting war must be as dynamic as our technology. Aerospace operations in the period of 1970 and later will be characterized by an intimate awareness of dynamic changes in a complex environment. Aerospace forces will be a combination of many offensive and defensive systems of widely varying characteristics and capabilities to operate throughout the continuum of the aerospace.

The technical areas most important for the future are nuclear propulsion and weapon effects. Nuclear propulsion is essential for the manned systems of the coming decades. It is imperative if we are to be able to orbit large satellites. Significant achievements here are possible.

Nuclear energy will thus be a key to aerospace power. Harnessing the atom for destructive effect brought air power to its culmination and has helped to preserve the peace. Harnessing the atom for propulsion of manned aircraft and space systems can well give us aerospace power and make continued deterrence a reality.

Headquarters United States Air Force



PART II

Combat and the Aerospace Force

For some years it has been apparent to thinking men the world over that modern warfare has become one of mankind's most urgent problems and one of his most serious threats. Yet so fundamental and unbridgeable has been the gulf between Free World and Communist positions that the only sane posture from which to debate the essential easement of tension has seemed to be one of undoubted military strength. The Air Force has consistently held that for the foreseeable future the only positive deterrence is derived from an aerospace power that promises defeat to any aggressor.

To maintaining this deterrent, the aerospace forces of the next decade will be dedicated. In terms of missions these forces will resemble, at least during the first years of the decade, the aerospace forces of the past. However, the roles of the strategic force, the tactical force, the defense force, and the strategic airlift force will progressively become less separate and distinct. By the end of the decade, their missions probably will be, at the minimum, global in range, cislunar in altitude, hypersonic in speed. Already in the areas of concept, of command and control, of over-all military tasks and missions, there have been foreshadowings of overlap and merging of the lines of demarcation between these responsibilities.

Part II offers informed views upon the context of aerospace operations, the philosophy, equipment, and deployment of the principal combat components of aerospace power, their conceptual framework, their operational posture, and the probable evolution of their command and control.

Aerospace Forces and the Range of Situations

LIEUTENANT GENERAL DEAN C. STROTHER

AT MID-CENTURY the Air Force aircraft inventory consisted largely of piston-engine types. Early jet models were just becoming operational. As arms for these air vehicles, operations planners had available a few types of nuclear bombs and a range of high-explosive, incendiary, and antipersonnel bombs of the types that had proved most effective in the Second World War. Air-to-air and air-to-ground rockets were new weapons.

This was a time of flux and of change. The operations planners had to achieve an ever growing combat capability while phasing in advanced aircraft and new weapons, all this within rigid limits imposed by manpower ceilings and available funds. At the same time the military potential of new weapon systems then under development had to be taken into account as the planners looked toward the future.

Rocket propulsion gave promise of successful development of ballistic missiles. The military potential of these new weapons was the primary consideration, of course, but the Air Force saw in rocket propulsion the beginning of a new epoch. We recognized that, with due emphasis on development of the new systems and their integration into existing forces, American air superiority could be extended to the entire circumambient medium of aerospace. We foresaw that, from this continuous medium extending upward and outward from the surface of the earth, American power could be brought to bear at any point on our planet more swiftly than ever before.

Today, ten years later, the anticipated aerospace force is a reality. It is an integrated force of manned and unmanned air and space systems which, taken as a whole, provides a flexible and potent instrument of American national policy to serve our national objectives. It provides for tailoring aerospace strength to fit precisely any given situation that might require its application. It is appropriate, then, to appraise the range of situations that could arise and to examine the force applications they would require.

All humanity is confronted by two possible situations representing the extremes of its hopes and its fears. One of these extremes is true, lasting peace. The other extreme is global nuclear war. Between the white of true peace and the black of global nuclear war there lies a gradient of situations—a gray scale, so to speak, whose tones merge more or less imperceptibly. With the exception of the still improbable condition of true peace or complete international harmony, all these situations are characterized by conflict between the interests and objectives of the nations of the earth. Conflict is a continuous state of affairs at this stage of history, varying only in degree of intensity.

Not all conflicts between nations lead to military action. If the conflict is in the world market place, it is fought with the weapons of economic resources and diplomatic negotiation. Its strategy seeks to establish advantageous economic positions. Any given national resource can become an instrument of national will. In modern social organization these instruments are so interdependent that all, including the military resource, are brought to bear to greater or lesser degree, whatever the conflicting area of interest. Therefore it is the nature of the conflict and its degree of intensity which determine two aspects of national action: (a) which, or what combination of, instruments of national strength shall be used; and (b) what proportion of total national effort is to be exerted.

No matter what the exact shade of gray may be, at any given point along the gradient of situations, our national aerospace forces have definite and decisive applications. At the two extremes and between them, circumstances combine to create an almost infinite range of situations. Only four will be discussed here: peace, cold war, limited war, and global nuclear war.

peace

The first of these situations is true peace—a blessed condition which mankind has never known. Because it has never been experienced, the essential characteristics of true peace are generally misunderstood. The usual definition is a negative one: peace is simply defined as an absence of war. Traditionally the termination of hostilities has been hailed as the beginning of a new era of peace. Imprisoned by a mental dichotomy of war or peace, men have generally failed to grasp the positive aspects of true peace, which represents the summation of human hopes and aspirations.

If peace ever is to be achieved, its very definition must become a positive one, for peace, to be real and enduring, must go far beyond the mere cessation of wars. Before it can be achieved, all human and international conflicts must have ready, workable means of resolution, with the objective of eventual elimination of conflict itself. True peace must be a condition of complete international concord, in which the efforts of all humanity are channeled toward humanitarian objectives.

In a world climate of true peace, a military aerospace force would be an anachronism. Weapons, in a world at peace, would be deposited in museums as mementos of the barbaric days of early civilization. Still, a civil scientific aerospace force, deriving from what was originally a military technology, would be an essential element of the situation of true peace.

In time of disaster—famine, fire, flood, or typhoon—the airlift capacity of the civil scientific aerospace force would speed relief to the afflicted areas. The speed of international travel and of commerce, served by this aerospace force, would further more profound understanding and firmer cooperation between all peoples. The exploration of space itself, and its exploitation for peaceful purposes, would be served by a civil scientific aerospace force for the benefit of all mankind.

cold war

In the clash of national wills, the work of the aerospace operations planner is simplified today. He need not make numerous assumptions as to the will, capabilities, and intentions of many nations. He need recognize only the cleavage between the Free World and the Soviet Union with its proxies and satellite states. The areas of conflict between these two blocs have been exhaustively studied, are clearly understood, and need not be reviewed here. With such a clear understanding we can establish the present situation and anticipate the developments that could occur along the whole gradient of situations.

The present environment, of course, is a phase of conflict sometimes called "cold war," which is waged largely with nonmilitary resources. The diplomatic, social, psychological, and economic resources of the Free World are the strategic weapons in this phase of the conflict.

In this respect the conflict is between the forces of Communism and self-determination. In this conflict the strategies differ. On the one hand the Communists seek to establish their system in a position of prestige, so as to secure the commitment of more nations to their system and thereby to expand their sphere of influence. By contrast, the strategy of the Free World is to provide assistance in the form of public and private capital, supported by professional and technical knowledge and assistance. The objective is not the spread of any specific doctrine or social order. It is rather to help the peoples of many nations—including many new ones—to freely decide their own destiny.

All these nonmilitary forces are being employed against a background of Free World strength and determination. In this sense the existence of clearly superior aerospace power, coupled with a firm national will to use it if need be, has confined international conflict to the social and economic arenas. The effect of the existence of the aerospace force has been to deny the enemy freedom to resort to armed aggression in furtherance of his aims. In short, the effect has been one of deterrence to aggression—an effect which the aerospace forces of the United States must continue to create until it is no longer needed.

Armed conflicts have occurred since the end of the Second World War, but this fact in no way contravenes the principle of deterrence. In no case have the armed forces of the major world powers been pitted against each other. Such actions as have occurred have been limited in nature and have given us clues as to what circumstances might lead to the next level in the gradient of situations.

limited war

Knowing the areas of conflict in national interest, we can assess their effects in terms of geographical contiguity. In this context the limited situation could develop, signaling the end of the cold-war situation. On almost any pretext a point of friction could occur between a proxy nation of the Soviet Union and either an uncommitted nation or a member nation of some Free World alliance. No other potential international tension appears likely to reach this extreme. If such tensions develop, they would pose no threat to the security of the Free World. The conflict therefore would be limited, in terms of its origin, to Communist action.

Assuming that the initial friction, such as a clash of border patrols or the acts of *agents provocateurs,* should develop into armed conflict between the two initial belligerents, several courses of action could follow. The nation attacked could, if an uncommitted nation, request intervention by a friendly power or by forces of the United Nations. If it were a member of a Free World alliance, it would be strengthened by the forces of its alliance.

Whatever the subsequent course of events, the situation would constitute a test of the principle of deterrence. In its primary and fluid stage, the swift deployment of small but adequate segments of the aerospace force could stabilize the situation or bring the conflict to an end. Such deployment would, among other effects, serve notice that the total aerospace force was ready to act.

With tactical warning provided by the beginning of friction, the total aerospace force would be on full alert status. Preparations would be complete to the most minute detail, even while the tribunals of the diplomats would be bringing all pressures to bear to end the conflict and seek solutions of the frictions that caused it.

In such a world environment, the Soviet Union would face momentous decisions. Two courses of action would be open, the consequences of either being unfavorable to Soviet national interest. One alternative would be for the Soviet Union to disavow the aggressive action of its proxy nation, in an attempt to deny Communist responsibility for initial aggression and thereby absolve the Kremlin from guilt by association. This would sacrifice the proxy nation to immediate surrender or to ultimate defeat. Such a sacrifice of a proxy nation would have an inevitable effect upon other proxies and satellites of the Soviet Union. It could signal the beginning of disintegration of the satellite empire—a process which would inevitably create equally dangerous situations in other geographic regions. The second alternative of the Soviet Union would be to commit its own military forces in support of the proxy. It could do so in either or both of two ways: force commitments could be minimal at the scene of battle, or they could be all-out, in an effort to neutralize Free World strength. Events could follow in that order, or both commitments could be made simultaneously.

Such would be the test of the principle of deterrence. If the Soviet Union should commit its forces, deterrence would have failed, and full retaliation by the Free World aerospace forces would follow. The resultant global nuclear war, then, would be the extreme or maximum military situation along our gradient.

global nuclear war

The maximum situation could begin without the interposition of limited conflict. Our clearly stated national policy of nonaggression grants to a would-be attacker the advantage of surprise. Conceivably the Soviet Union might seek to exploit this advantage if its estimate of the situation indicated that the odds were highly in favor of success. No such conclusion could be reached at this time on rational grounds. Nor could it be reached in the future, given the continued logical development of aerospace deterrent capability. But the operations planner can never discount the possibility of an enemy decision arising from irrational conclusions or as a result of desperation. Such deliberate nuclear self-immolation is almost impossible to imagine, but impossible also to discount.

No matter how the maximum situation might develop, it is axiomatic that the military effort would be total. Action would certainly not be confined to the area of any original localized conflict but would speedily become global in scope. The conflict at this point would be between the aerospace forces of the principal belligerents, each seeking to destroy the warmaking potential of the other.

Considering the nature of existing forces, it is evident that the decisive phase would be the initial aerospace battle. Once this decision was gained, exploitation of the clear-cut advantage would then proceed toward the conclusion of all hostilities. The residual aerospace forces would make clear to the enemy the utter futility of prolonged resistance.

deterrence

Across the gradient of situations we have considered only four: peace, cold war, limited war, and all-out war. In connection with three of these gradients of conflict the question of deterrence has been raised. It should be understood that neither the aerospace force structure nor the span of time is static, as related to the gradient of situations.

A true deterrent force must have a total power clearly capable of winning a swift and favorable decision. The existence of the force must be clearly supported by national will and by the determination to use it in support of national policies and objectives if the need should arise. Since deterrence is an effect upon an enemy, the enemy must know of the existence and capabilities of the force and fully understand the national character and determination to employ it.

Obviously both the nature of the aerospace force and the level of national determination are variable. The deterrent force of 1950 was only a fraction of the deterrent force of 1960, which in turn will be only a component of the deterrent force of 1970. What deters a potential aggressor this year, he may discount a year from now. Deterrent power, therefore, must always be held at such a level as to be able to deal successfully with the maximum situation—global nuclear war under conditions of surprise attack. Within the scope of such a force, its various elements provide the flexibility needed to deal with any situation less than maximum in scope and to do so without diluting the total capability.

Under the conditions of true peace, there would be no potential aggressor and hence no need for a deterrent force. As we have not yet reached that state of perfect civilization, but instead exist under conditions of cold war, aerospace force in-being now deters potential aggressors and gives other instruments of national policy their essential freedom of action.

Limited actions, since they contain the seeds of global conflict, require swift application of the precise amount of force needed to contain them and to control them, coupled with a clearly expressed national intention to commit the full strength of the total force in the event of intervention of a hostile major power.

If at this point on the gradient of conflict deterrence should fail, the aerospace forces would then carry out their assigned counterattack missions, destroying the enemy's aerospace forces, depriving him of the means of fighting, and ending his will for war.

AEROSPACE forces have roles to play across the entire gradient of international situations from true peace to global nuclear war. At the one extreme, as a civil scientific instrument of human progress, aerospace power represents dedication to the nobler purposes of humankind. At the other extreme, American aerospace forces would ensure swift and favorable decision in global nuclear war. Such a war would be history's most violent, as well as its shortest.

Headquarters United States Air Force

The Deterrent Offensive Force

Major General Hewitt T. Wheless

THE FUNDAMENTAL measure of this Nation's deterrent effectiveness is the operational capability in-being of its strategic offensive forces. These forces must be designed for decisive capabilities, with due consideration of the variable conditions under which a general war may start and the manner in which forces will be employed. Inherent in these forces must be the ability to preserve world peace on terms favorable to the United States and the Free World, through recognition by a would-be aggressor that he cannot possibly emerge the victor in event military hostilities are initiated. As of today, this capability is in being, represented by forces of the Strategic Air Command. These forces, present and future, are the subject of this discussion.

From a national standpoint, attainment of a decisive capability must be based on certain essential elements:

(1) The national will, intent, and determination to maintain, and employ when required, forces capable of military decision in battle.

(2) Adequate intelligence that will provide the required information for the President to make appropriate and timely decisions, and for the military commander to determine the current enemy order of battle as the basis for effective war plans.

(3) Effective command and control procedures and systems whereby decisions can be passed immediately and continuously to the operational forces.

(4) Strategic offensive forces, quantitatively and qualitatively capable of inflicting maximum destruction on the nuclear and conventional threat to the U.S. and its allies, at the source.

(5) Defensive forces, to destroy the enemy nuclear and conventional delivery systems and weapons after they have been launched and prior to impact on target.

(6) Sustaining power, both military and civil, to provide the follow-on forces and the recuperative strength essential for favorable strategic decision in war.

These elements of decisiveness are the variables in the deterrent equation. From a national standpoint they are infinitely complex. Political, economic, and military factors are totally enmeshed, and they vitally affect each other. Economic limitations dictate allocation of resources, on a priority basis, to those military capabilities that can best achieve national objectives. Militarily there are numerous critical elements, such as the tactics of offense and defense, scientific breakthroughs, weapon developments, and passive defense measures. These complex and dynamic variables interplay in a dynamic environment, highlighting the requirement to reduce to fundamentals the essential national task in war.

Simply stated, this task is to destroy the capability of the enemy to wage war. The task is great, but not insurmountable. Thus the overriding priority for U.S. strategic forces, on a time basis, is to have in being the capability to effectively destroy the enemy nuclear offensive forces, together with the supporting elements that employ and sustain the enemy warmaking effort.

The derivative of strategic capability is an effective, recognized deterrent offensive force that provides the basis for exercising compelling initiative in the conduct of international affairs. It provides credibility both in the eyes of our allies and in the eyes of an enemy as to our national will and determination; it imposes an effective reduction in the enemy's political, economic, and military options; and, most significantly, it provides the tangible measure and true meaning of the national policy of deterrence.

force criteria

The criteria for the deterrent offensive force are established in the perspective of the nature of general war. General war is unpredictable, from the standpoint of when and how it may start, the first strike objectives, the tactics, and the duration of operations. For example, general war could start under conditions of relative surprise from an aggravated overt act or as an expansion of limited-war actions. The initial-strike objective could be to destroy only the nuclear offensive capability and to maintain a residual threat against the industrial potential; or it could reach for a much higher level of destruction—the simultaneous targeting of both the offensive threat and the urban-industrial potential. The first-strike objectives will be determined by the broader, long-term consideration of what is achievable through the general-war course of action, as well as the expediency and requirements to meet the current situation. The duration of general war will be determined by the over-all national capability to sustain operations, and specifically by the timeliness and decisiveness of the offensive in destroying the enemy nuclear forces.

The vast scope of operations in general war determines the basic criteria of the deterrent offensive force. Each weapon and support system must contribute through the complete spectrum of operations. Force application and effectiveness are measured by weapon system reliability, penetration capability, minimum time to target, and target destructiveness, as represented by accuracy and warhead yield. From a sustaining standpoint the force and its supporting elements must be postured for maximum survival by means of dispersal, hardening, mobility, and quick reaction.

No one weapon system can meet all these criteria. It therefore becomes necessary to select, on a contributory basis, those systems that will be most effective and efficient. It is through the selection and exploitation of the unique capabilities of the proper blend of manned and unmanned systems, employing optimized targeting techniques and sophisticated tactics, that the decisive deterrent offensive force is maintained.

the force trend

The 1960–1970 decade will be a period of dynamic transition in the composition and character of the deterrent offensive force. The manned bomber force will continue to be modernized; missiles in quantity will be included in the operational inventory. At the same time newly developed space systems will be making positive contributions to force effectiveness.

The primary offensive capability today resides in the manned bomber force. The improved B-52 models and the new B-58 supersonic bombers are entering the operational inventory to programed levels. During this same period the B-47 bomber, which is entering obsolescence, will be phased out of the force. Improved penetration capability and targeting flexibility will be achieved by incorporating the air-to-surface missile Hound Dog on the B-52, to be followed by the longer-range air-launched ballistic missile Skybolt. The all-jet tanker KC-135 continues to enter the operational inventory, extending the range of the bomber force to global target coverage. The general trend in this manned force during the Sixties will be downward in numbers, allowing for the buildup of ICBM's. However, significant improvements in strike capabilities with this all-jet force will be realized during this time period.

Atlas and Titan intercontinental ballistic missiles are being integrated into the deterrent offensive force, to be followed next year by the solid-propellant Minuteman. With Minuteman, designed specifically for simplicity, low cost, and high reliability, missiles in the quantity required can feasibly be obtained. These missiles make a positive contribution to total force effectiveness from the standpoints of time period of availability and payload flexibility. By the mid-Sixties a true mixed-force capability in missiles and bombers will be achieved.

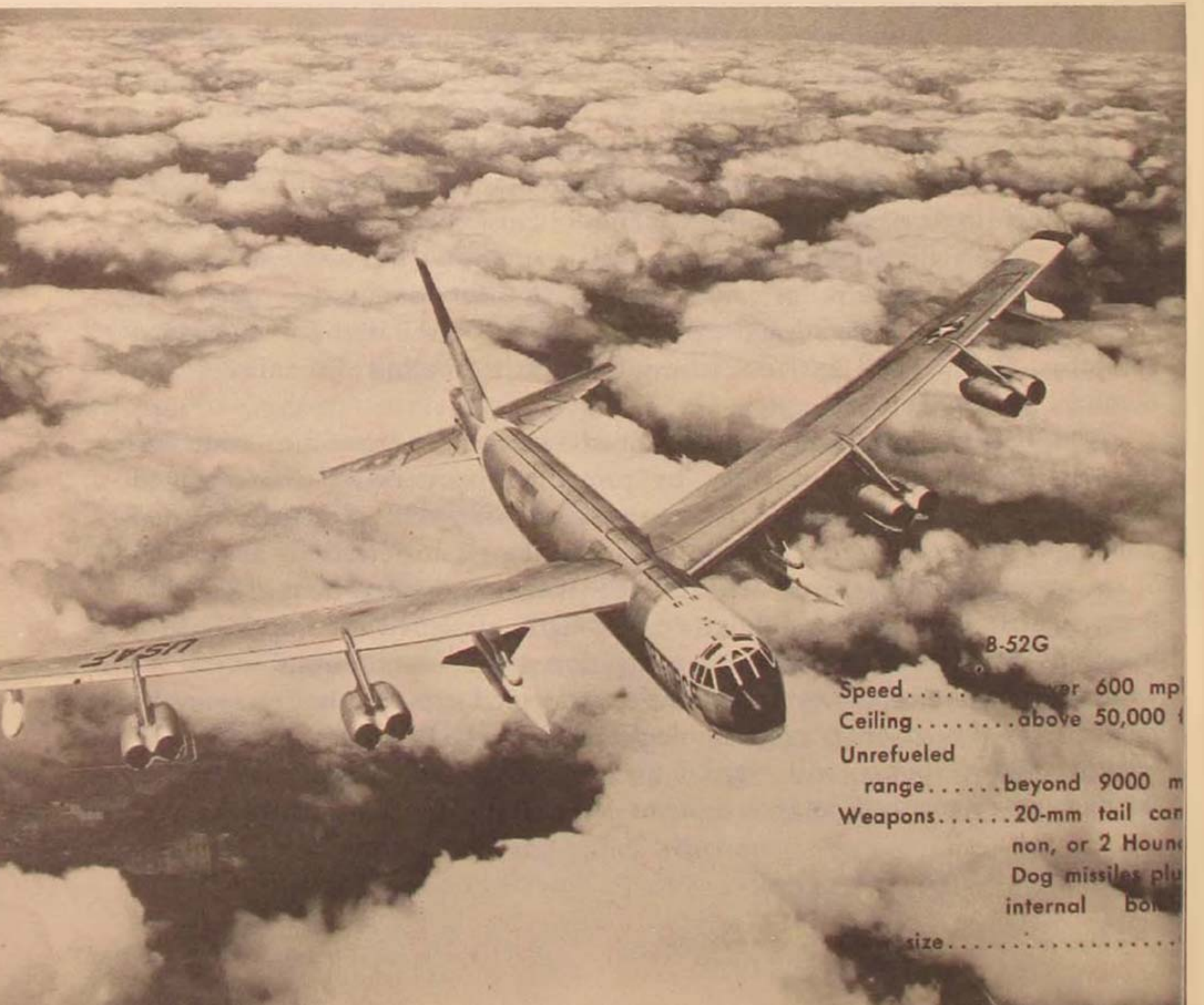
The ballistic missile program has made an equally significant contribution to the national space effort by providing boosters for instrumented satellites. Midas, the missile defense alarm satellite, will provide increased warning of impending attack, complementing the radar detection capabilities of the ground-based Ballistic Missile Early Warning System (BMEWS). Other instrumented satellites are under development, designed to improve such functions as weather forecasting, navigation, and communications—all of which will make positive contributions to strategic force effectiveness. For the longer term the advances of technology, particularly in propulsion, the life sciences, and weaponry, will expand the operational environment and allow for the use of manned weapon systems at orbital altitudes and speeds.

Today's Strategic Aerospace Force

Fundamental to the armed defense of the United States is the strategic offensive force, a blend of intercontinental bombers and intercontinental missiles in constant combat readiness.

As this force faces the decade of the Sixties, its backbone is still the manned jet bomber: the B-47, the B-52, and the B-58. All are capable of carrying nuclear weapons and with in-flight refueling can reach any military target in the world.

The B-52 Stratofortress heavy bomber is the principal component of today's force. Over 550 of these 8-jet giants have been built and put into operation since 1955, the growth potential of the B-52 as a weapon system having been equal to the challenges of improved enemy air defense radar and interceptor weapons. Succeeding models have flown higher, faster, and farther, meanwhile taking on additional equipment. The latest operational model, the B-52G, not only has greater target altitude, 25 per cent more range, and increased climb performance but carries, in addition to its interior bomb load, two Hound Dog missiles — also capable of carrying nuclear war-



B-52G

Speed........over 600 mp
Ceiling........above 50,000
Unrefueled
range......beyond 9000 m
Weapons......20-mm tail can
non, or 2 Houn
Dog missiles plu
internal bo
[illegible] size..................

heads — air-launched missiles that can be released from outside the enemy perimeter defenses. The B-52H will have even greater capability, including Skybolt as an improved air-launched ballistic missile in place of Hound Dog.

Numerically the greatest part of the strategic bomber force is the aged B-47 Stratojet. When the 6-jet B-47A first flew in 1950, it was the first operational jet strategic bomber in the world, and over 1400 were built before the program ended in 1956. By that time most of the force had been either built with or refitted to the capabilities of the B-47E. First supplemented by the heavier B-52 and now being partially replaced by the B-58, the B-47 is gradually being phased out, but it has yet a very real value in the over-all force, including ability to come in at altitudes of 2000 feet or less and deliver nuclear weapons with the low-level bombing techniques normally reserved for fighter-bombers.

The newest component of the manned bomber force is the supersonic B-58 Hustler. A radical design departure from its predecessors, the B-58 represents the greatest one-generation speed increase in bombers in the 50 years of aircraft design and manufacture. Once described as all engine and gas tank, the B-58 in many ways is more like a big fighter-bomber than its companion strategic bombers. There is no internal bomb bay, for example, but an external pod slung under the fuselage. First flown in 1956 and with one squadron now operational, the B-58 will replace a part of the B-47 medium-range force.

B-47

Speed	over 600 mph
Ceiling	above 40,000 ft
Unrefueled range	beyond 3000 mi
Weapons	2 20-mm tail cannons; nuclear capability
Crew size	3

B-58

Speed	over 1300 mph
Ceiling	above 60,000 ft
Unrefueled range	undisclosed
Weapons	20-mm tail cannon; capable of carrying nuclear weapons in disposable pod
Crew size	3

Other systems aid the manned bomber force in its air alert and, if need be, in penetrating to its target. A fleet of tanker aircraft rendezvous with the bombers throughout a great arc across the Northern Hemisphere, enabling the bombers to maintain their patrol and ensuring that at all times a certain portion of the force is ready to move on to strike at the farthest targets. The sleek KC-135 is the prime tanker. A 6-jet transport-type aircraft, it is a fit companion to the bombers, for it can refuel them along their flight paths and at their speeds and altitudes. It is rapidly taking over the job from the slower KC-97, which has given faithful service for more than a decade but which hampered the efficiency of the jet bombers by forcing them to drop to lower altitudes and slower speeds during refueling.

To help the B-52 overcome the improved air defense, to reduce losses in the attacking strategic force, and to add flexibility to the attack, the aerospace force is equipping the B-52G with the Hound Dog missile. This supersonic, turbojet-propelled missile that can carry a nuclear warhead will be slung under the wing of the bomber and carried to the desired release area, which may be outside or inside the perimeter defenses of the enemy. Upon release Hound Dog can speed ahead another 600 miles to its target. Its self-contained inertial guidance system can direct it to the target or it can be diverted to another target in flight. With two of these

KC-135

Speed . . . . over 600 mph
Ceiling . . . . above 50,000 ft
Unrefueled
range . . . . beyond 4500 mi
Cargo capacity . . . . 80 troops
or 50,000 lb
Crew size 4

KC-97

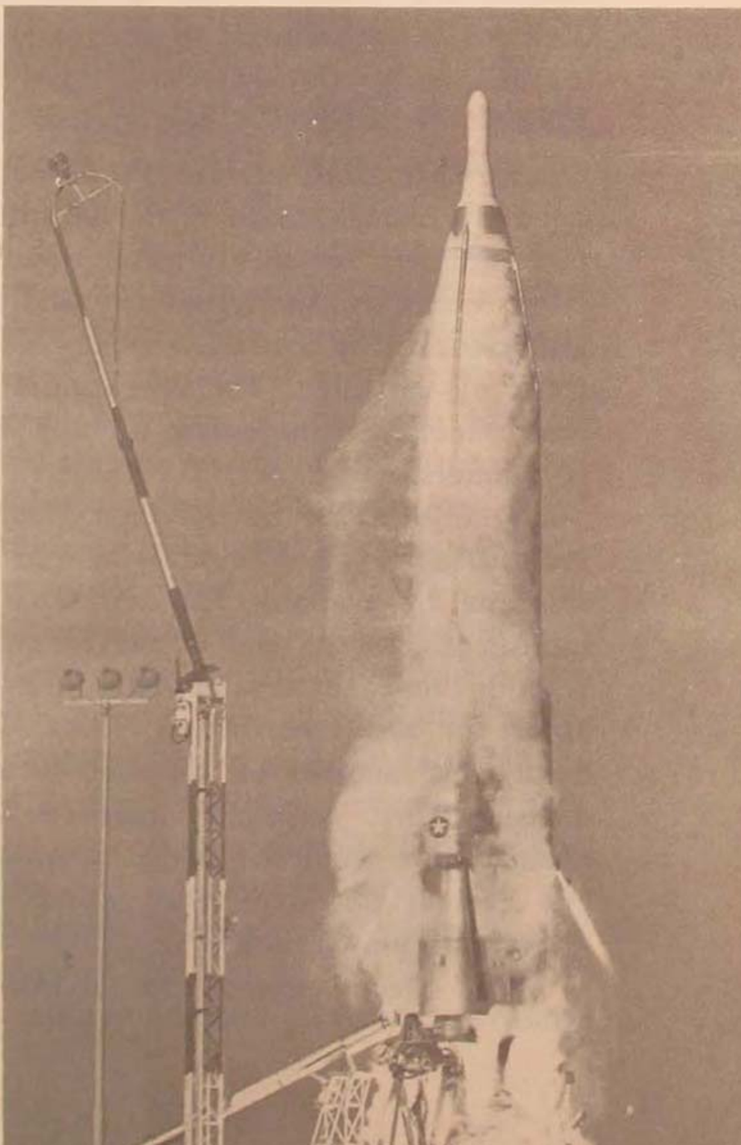
Speed . . . . 375 mph
Ceiling . . . . above 35,000 ft
Unrefueled
range . . . . beyond 4000 mi
Cargo capacity . . . . . . 96 troops
or
64,000 lb
Crew size 5

missiles slung under its wings in addition to its internal bomb load, the B-52 on one mission can destroy several targets great distances apart, can use the missiles to blast a path through enemy defenses in advance of the bomber, or can send the missile in at supersonic speed to attack heavily defended targets.

While the manned bomber continues to offer advantages in accuracy, flexibility, and the extension of human judgment to the battlefield, the formidable intercontinental ballistic missile offers an attack weapon of tremendous speed and is at present a weapon against which there is no defense. Atlas, the ICBM now operational, has two booster engines and a sustainer engine that lift the big rocket off the ground and arc it into its ballistic trajectory at approximately 18,000 miles per hour, at which point the nose cone containing the nuclear warhead separates from the main rocket and continues passage through the predetermined trajectory to targets of intercontinental range. Since its first operational firing from Vandenberg Air Force Base in September 1959, the liquid-fueled Atlas has been speedily integrated into the strategic operational force. To be joined in 1961 by the liquid-fueled Titan and in 1962 by the solid-fueled Minuteman, the Atlas is the first weapon system in the strategic missile force that is planned as a principal striking component of the strategic offensive force during the coming years.

Atlas (SM-65)

Speed	approx. 18,000 mph
Ceiling	about 500 mi
Range	5500 to 9000 mi
Dimensions	length: 75 to 82 ft depending upon nose cone diameter: 10 ft
Thrust	approx. 360,000 lb



Hound Dog (GAM-77)

Speed	supersonic
Range	approx. 600 mi
Dimensions	length: 42 ft 6 in diameter: 28 in span: 12 ft 2 in
Thrust	7500 lb at sea level

The continued integration of manned and unmanned systems is essential in maintaining the operational effectiveness of the deterrent offensive force. Each type of system makes a contribution in terms of weapon delivery as well as in the essential support functions of intelligence and command-control and in providing effective sustaining power. For example, manned delivery systems provide a visible deterrent that can be exercised to show national intent and purpose. The security of this force can be realized, with or without warning, by ground-alert or air-alert posture. It is a force that makes use of man's judgment, which provides flexibility and reliability advantages not otherwise attainable. Perhaps most important, the manned aircraft delivery systems provide the hard core of residual fighting force that can be recovered and recycled throughout the duration and successful ending of hostilities.

Missile delivery systems have their own inherent military advantages, such as the dramatic reduction in time from launch to warhead on target and their relative invulnerability to the enemy defenses. The ballistic missile compounds the enemy's targeting problem, since our force will be dispersed, hardened, quick-reacting, and mobile. Finally, current missile delivery vehicles have high growth potential, from the standpoints of increasing payload capabilities and flexibility to incorporate decoys, multiple warheads, and maneuverable re-entry vehicles for penetration purposes. With continued improvement of the programed missile systems, they can be expected to maintain their effectiveness through the foreseeable future.

the concept of operations

A basic consideration in developing the operational concept for the deterrent offensive force in the ballistic missile era is the dramatic compression of time. Here the ability to employ the forces effectively is determined to a large extent by the availability and relationship of warning, both strategic and tactical, the timeliness of decision, and the posture and reaction capability of the force. The operational concept and the posture of the force must therefore compensate for any deficiencies that may exist within these parameters.

One third of the strategic bomber force is presently maintained on ground alert. These aircraft are in full combat configuration with crews standing by available for immediate take-off. An alert area has been established near the end of the launch runway on each base to reduce this reaction time to a minimum. The alert area is composed of a parking apron for both bomber and tanker aircraft, complete with maintenance and flying-crew facilities for the alert personnel on duty. It is surrounded by a security fence, constantly guarded by trained security personnel. During periods of tension the entire manned force can be generated to full combat configuration in a short period of time, ready to respond as the specific situation may dictate.

The effectiveness of ground alert is further enhanced on a day-to-day basis through "positive control" procedures and "reflex" operations. Positive control procedure provides the capability to launch the manned force on receipt of warning that an enemy attack is imminent. Reflex methods provide combat-configured aircraft on alert in overseas areas. Under reflex, designated medium-bomber and tanker units maintain aircraft on alert status in the forward areas, both on the North American continent and at overseas bases. Crews and aircraft are rotated at periodic intervals and remain at the forward bases for a temporary period. On arrival the aircraft are immediately placed in combat configuration, allowing for the return of a like number of crews and aircraft to their permanent bases. The aircraft deploy and redeploy between their temporary and home stations nonstop, refueling air-to-air as required. Additional training requirements are accomplished during these flights to ensure that the crews remain at peak proficiency in all phases of operations. Most of this training closely resembles actual combat responsibilities.

The reflex operation contributes to the deterrent offensive capability by providing further dispersal of the force and quick reaction time to attack high-priority targets without the need for tanker refueling support. In addition these forces do much to solidify the Nation's various commitments around the globe. The price of this operation is not high, since only a small operations and maintenance task force is required at the forward bases to maintain the reflex forces on alert. All major maintenance and periodic inspections are accomplished at the permanent home station.

The positive control concept was developed in recognition of the fact that a national decision to launch a strategic attack will always require an unknown but finite amount of time and that tactical warning of impending attack may not be absolute, particularly in the near future. It must be remembered that only the President of the United States can authorize expenditure of nuclear weapons; therefore he is the only person that can execute the force. To ensure survivability of the manned force, the positive control concept authorizes the commander of the deterrent offensive force to launch manned aircraft whenever in his judgment survivability of the force on the ground is questionable, or whenever the current situation so dictates. Typical examples of indications that could lead to launch of the force under positive control include large numbers of unidentified objects on early-warning radar screens, or a sudden rash of incidents that could indicate widespread sabotage against military installations.

When launched, the positive control aircraft proceed on course toward assigned targets. These aircraft do not fly beyond the positive control line unless the execution order, through the Joint Chiefs of Staff, has been received and verified. The positive control line is located far outside the radar early-warning line of the enemy. If the execution order—the "Go-Code"—is not received prior to arrival at the positive control line, the aircraft return to their home bases; in other words, they "fail-safe." The use of this procedure eliminates any possibility of inadvertently executing the force prior to national decision.

On launch of the alert force under positive control, each base prepares the remaining aircraft for strike. In case the initially launched aircraft should begin to fail-safe, follow-on ground-alert aircraft are in combat configuration, ready to launch, so that the total size of the alert force is never degraded. These follow-on aircraft preclude the possibility of the enemy feinting the alert force out of position.

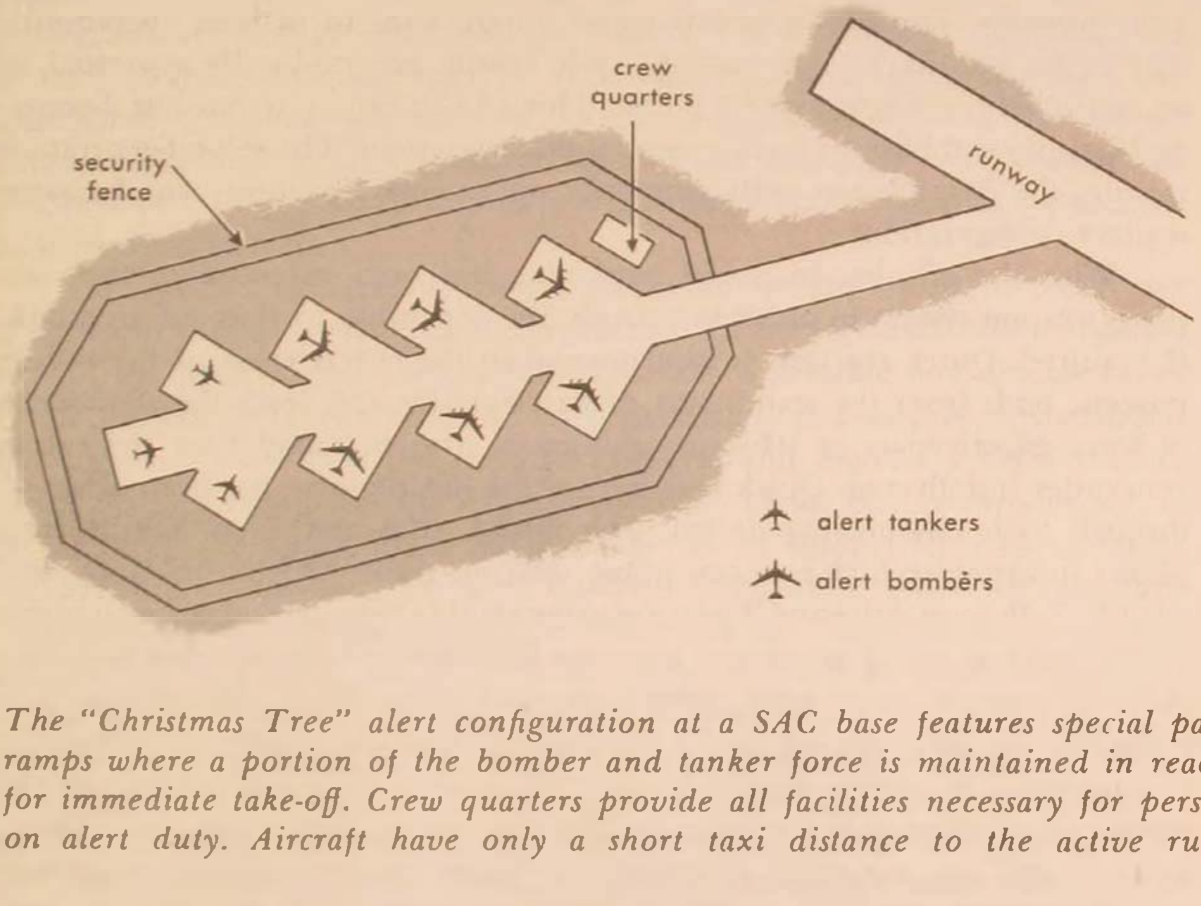
The effectiveness of the ground-alert posture and the positive control procedure is a direct function of the timeliness and reliability of warning. Without tactical warning the manned bomber force is vulnerable on the ground. Today warning against a manned bomber attack can be anticipated to be somewhere between 15 minutes and 3 hours. This warning is received through a number of contiguous radar establishments, such as the Dew Line, the Mid-Canada Line, the Pinetree Line, picket ships off both coasts, and airborne early-warning aircraft. The warning systems against manned bomber attack are considered highly effective; they will provide the necessary time for the ground-alert forces to react.

With the buildup in enemy ballistic missile capabilities, warning against the new mode of attack becomes essential, directly influencing the effectiveness of the present ground-alert concept. Two ballistic missile warning systems are currently programed. The first, already partially operational, is the Ballistic Missile Early Warning System (BMEWS). This system will consist of missile-detection radars located in Greenland, Alaska, and the United Kingdom. These radars look northward to the area from which a missile attack would be anticipated and will give approximately 15 minutes' warning as enemy missiles pass through their radar beams. As it employs radar, the system will be subject to atmospheric interference, jamming, and deception and by itself cannot be completely relied upon for warning. The second warning system, which will complement BMEWS, is the missile defense alarm satellite (Midas). Until the BMEWS and Midas warning networks are completed and while the missile threat exists, it may become necessary to convert to an air-alert posture, to ensure maximum survivability for a portion of the force.

The air-alert concept provides a force of combat-configured aircraft airborne at all times, capable of destroying selected enemy targets 24 hours a day, 365 days of the year. These aircraft will be effective in the deterrent offensive regardless of surprise attack or any other action that the enemy might take. The air-alert concept is the essence of simplicity.

Feasibility of the airborne-alert operation has been proved by experience of thousands of sorties. Air alert can be maintained with up to 25 per cent of the force continuously airborne, depending upon the logistics base established. These flying rates are achieved through a firm maintenance schedule, through operating the aircraft in a standard configuration, and through the consolidation of personnel to provide both mass launch and mass recovery of aircraft. The current manning authorizations for the ground-alert posture provide a capability to keep one eighth of the B-52 force on airborne alert. At this level, flying hours are increased by a factor of 3. The achievement of a higher airborne-alert level is dependent on additional logistic support and some increase in combat crews and maintenance personnel. The airborne-alert operation is not meant to be a permanent way of life but is designed for maximum security of the bomber force until we possess systems for timely and reliable warning against a missile attack. During this period of the "warning gap" the airborne-alert operation will make a vital contribution to the deterrent posture of the offensive strike force.

Passive measures to secure the manned bomber force have also been undertaken. One measure is the dispersal program, the basic criterion of which is to provide the capability to launch the alert force within a 15-minute warning period. A secondary consideration is to expand the enemy's target system. Today dispersal of the manned force is virtually complete. The B-52 heavy bombers have been deployed at the ratio of one squadron per base, aligned with supporting KC-135 tankers. Random dispersal of the B-47 medium bombers to other military and civilian bases throughout the North American continent has been tested and can be employed, as required, to increase further their survivability.



The "Christmas Tree" alert configuration at a SAC base features special parking ramps where a portion of the bomber and tanker force is maintained in readiness for immediate take-off. Crew quarters provide all facilities necessary for personnel on alert duty. Aircraft have only a short taxi distance to the active runway.

The Atlas ICBM, which became operational in September 1959, marks a milestone in the development of advanced strategic capabilities. As follow-on squadrons are activated and equipped, improved versions of the Atlas missile will be produced. To the strategic force this means greater survivability and capabilities in the form of dispersal, hardening, reliability, reaction time, range, and accuracy. The later equipping of Titan and Minuteman squadrons will augment these early ICBM capabilities and mark the transition from manned to unmanned systems as the backbone of the deterrent offensive force.

The basic difference in posturing the missile force is one of emphasis and degree, the prime consideration being that all missiles on launchers are on constant alert with fast reaction times but that they cannot be launched on warning alone, as the manned bombers can. Lack of a positive control capability in missile systems means that national decision for execution is required prior to launch. Since the ICBM force therefore will in all probability have to ride out the initial attack, dispersal and hardening become the key elements to survivability. Mobility is a further advantage of specialized elements of the missile force on land, at sea, and in the air.

The basic objective in dispersing the missile force is to make each missile launch site a separate aiming point as far as the enemy is concerned, compounding his targeting problem. The early missiles being phased into the force, Atlas and Titan, are in a basic "3 x 3" configuration, i.e., three missiles on launchers form a complex and there are three complexes per squadron. The follow-on Atlas and Titan, soon to become operational, will be in a unitary configuration, each missile geographically separated so as to provide a single aiming point. This configuration is possible because each missile will have its own integral guidance system. The second-generation missile, the Minuteman, will enter the operational inventory in the same unitary configuration.

With the missiles, increased hardening has been extended to the complete weapon system in order to provide the capability to ride out an attack, if required. Quick reaction is fundamental to the effectiveness of the missile systems, both from the standpoint of survivability and from the standpoint of force effectiveness in achieving minimum time to target once the execution order is delivered. Quick reaction for the missile force has been achieved through basic engineering design. The initial Atlas and Titan missile complexes incorporate high-pressure pump systems, radio inertial guidance, and silo lift. Follow-on Atlas and Titan squadrons will incorporate advanced designs, significantly reducing silo-launch reaction time and permitting salvo launches. The Minuteman, using solid propellants with in-silo firing, can achieve near instantaneous salvo launch, and it has other operational features and flexibility not obtained in earlier missile designs. To ensure maximum survival of the missile force when under attack, sophisticated firing tactics have been developed, based on statistical probabilities. These optional tactics, employed as the situation may dictate, will minimize exposure of the missiles to enemy attack during the launch phase.

The emphasis of the ICBM force configuration on survivability will be further enhanced through mobility. A portion of the Minuteman force will be used in the mobile configuration. Force security will be achieved for this portion of the force through random, deceptive movements over the rail nets of the nation. In addition missile mobility is being achieved with the Hound Dog air-to-surface missile and the Skybolt air-launched ballistic missile, carried by the manned bomber force. Complementing this mobile portion of the strategic force will be the Fleet Ballistic Missile, Polaris.

force employment

The concepts of operation which have been developed to ensure survivability of the manned and unmanned force are fundamental and vital. The real payoff, however, is in the successful employment of these weapon systems against an enemy's targets and target systems, thereby destroying his warmaking capability. Here the priority objective is the destruction of the enemy's nuclear delivery capability that poses a direct threat against this Nation and its allies. The complementary task is to destroy his war-sustaining capability. The capability to accomplish these tasks, with the highest possible assurance of success and in the minimum time after hostilities start, is the true measure of deterrent effectiveness.

Penetration tactics are developed after careful analysis of the enemy defensive environment to ensure minimum attrition of our forces and maximum bombs or warheads on target. Enemy defensive capabilities today are primarily antiaircraft guns, barrage rockets, day and night all-weather fighter aircraft, and guided intercept rockets. For the future, improvements in each of these categories can be anticipated, as well as the potential for incorporating atomic warheads in follow-on defensive systems. It can be anticipated that during this decade operational anti-ICBM systems also will be developed, calling for further improvements in the penetration capabilities of unmanned systems.

The specific penetration tactics employed at any point in time are designed to exploit weaknesses in the enemy defensive posture. Here application of the principle of mass is fundamental, to saturate any defenses that cannot otherwise be countered through deception and surprise. Penetration altitudes may vary from the extreme low-level and high-level flight profiles of the manned bomber to the ballistic trajectory of the missile through space. In addition, the air-launched missiles also attack through this spectrum of altitude, from low level through ballistic trajectories. Area defenses are further degraded through the use of electronic countermeasures—chaff and decoys—and high-speed penetration, all integrated and mutually supporting in the penetration plan. Also the manned bombers can employ their own defensive armament, including weapons and infrared countermeasures. Finally, and most important, direct attack on selected elements of the defensive systems themselves will always be an essential requirement of the attack.

Today the deterrent offensive task is accomplished primarily by the manned bomber. As the missile force increases there will be a continual transition in over-all tactics and targeting. Missiles will be employed primarily against targets where timeliness of attack is essential, while the manned aircraft, exploiting operational flexibility, will be employed against targets that are ill defined, of uncertain location, superhard, or mobile. When missiles have entered the force in quantity, the wartime capability for armed reconnaissance by manned aircraft will become increasingly important in seeking out the targets of unknown location and in attacking the targets not destroyed by missiles. The damage-assessment capability of manned reconnaissance will also play a vital role in determining the employment of residual and recoverable forces for their follow-on strikes.

maintaining effectiveness of the deterrent offensive

The operational war plans and the specific tactics to be employed in the execution of these plans are constantly being evaluated, modified, and validated. The unique capabilities of each weapon system are exploited, with the objective of improving total force effectiveness.

The manned bomber force has achieved high in-commission rates, navigation and bombing accuracy, and refueling proficiency through years of continuous training. Reliability of the bomber alert force is near 100 per cent; radar navigation techniques eliminate errors in position; bombing accuracy is measured in feet. These are proven capabilities. As improvements are made in enemy defenses, the manned bomber force is also being improved to ensure offensive effectiveness for the future. Air-to-surface missiles, supersonic speeds, and other tools for the offense are programed. The B-70 bomber, which will fly at three times the speed of sound and at altitudes in excess of 70,000 feet, could very well be followed by a manned spacecraft with orbital range. The potential of these future systems is being investigated through active research and development of such programs as the X-15, Mercury, and Dyna-Soar.

The ballistic missile, a new weapon system using a unique medium of attack, has undeniable penetration capability today. It may be safely assumed that the enemy will make a defensive effort against it, thereby creating the requirement for improving missile penetration tactics. This program is under way and is directed towards the development and employment of devices and tactics that will render defenses against the ballistic missile ineffective. The means could include saturation and deception of detection and tracking radars, by use of decoys as part of the missile payload.

Since the ICBM is projected to constitute the major weapon system for the deterrent offensive force, it becomes essential that its capabilities give the same high degree of confidence now placed in the manned bomber force. This means that survivability, reliability, and offensive effectiveness must be stressed and realized in the development of the ICBM force. Most important is the realization of close accuracies and adequate warhead yields, in view of the priority task of destroying the enemy nuclear delivery capability. The design and development trend of our early production missiles gives every reason to believe that these capabilities will become an integral part of the operational missile force in the near future.

Essential to the effectiveness of the deterrent offensive force are the supporting elements of intelligence, warning, and command-control systems. These systems are in effect today, but they must be improved for the future. Again, programs are being pursued to ensure that these capabilities keep pace with the increasing threat and that they are integrated, on a timely basis, with the advanced weapon-delivery systems.

For the long term, the decisiveness of the deterrent offensive force will be maintained through the exploitation, integration, and coordination of the total strategic capabilities of U.S. forces in-being. The rapidly advancing rate of U.S. technology will provide the new weapon systems and capabilities needed for the future. The operational concept for the employment of these weapons will continue to be directed to the essential national task of maintaining the ability to destroy the nuclear threat that faces the Nation. This capability for decisiveness in battle, in-being and recognized, will remain the yardstick of effectiveness in measuring the national policy of deterrence.

Headquarters Strategic Air Command

Tactical Aerospace Forces

MAJOR GENERAL STANLEY J. DONOVAN

BECAUSE of their usefulness in general war, in lesser conflicts, and in the present cold-war environment, tactical air forces will continue to play an important part in our military planning. Our purpose here is to examine the capabilities of these forces in the three major mission areas and to forecast some of the major advancements in tactical air weapon systems we can expect during the next ten years.

The term "tactical air forces" often proves confusing even in military circles. Whereas strategic aerospace forces destroy deep military targets and the enemy's warmaking and industrial capacity, tactical air forces are primarily designed to operate at shorter range against deployed military forces. More specifically, their objective is to defend geographical areas essential to U.S. policy. Strategic and tactical forces are complementary.

The tactical aircraft of World War II, in contrast to their strategic counterparts, were short-ranged, limited in firepower, and highly maneuverable. In the years since, the range of tactical aircraft has increased tenfold with aerial refueling, and their firepower a thousandfold with small nuclear weapons. Now, in addition to their functions in the air-land battle, they can also conduct nuclear strikes against all types of targets.

At present U.S. tactical air forces are organized in three commands—the U.S.-based Tactical Air Command and two overseas commands, United States Air Forces in Europe (USAFE) and Pacific Air Forces (PACAF). Each bears major responsibilities in both general and limited war.

general-war functions

The strategic aerospace forces have become this Nation's primary general-war force. It is imperative that these and other general-war forces be conditioned to survive surprise attack, with enough strength remaining to destroy the enemy's military force. The capability to survive, counterstrike, and prevail will in turn guarantee us the most credible deterrence we can purchase; in fact, one literally depends on the other.

The trend today is toward missiles to perform those well-defined general-war tasks which can be preplanned in detail. Missiles inherently are designed to live through surprise attack and penetrate to the target in spite of an enemy's defensive measures. Hence they lend reliability to our counterstrike effort. On the other hand there are many tasks which missiles cannot accomplish. They would be less effective against poorly identified fixed targets, fixed targets requiring a high degree of accuracy, or any moving target. Invariably the aircraft with an experienced pilot is the better solution when on-the-spot judgment is required.

An inventory of United States nuclear forces which can be immediately brought to bear in a general war would include not only strategic missiles and bombers but also Air Force tactical bombers, tactical fighters, and cruise missiles based in the European and Pacific theaters. These overseas air forces are also a vital element in our over-all deterrent posture. The primary general-war mission assigned them is a counterforce counterattack upon known fixed installations. They would be expected to destroy those aerospace forces which menace their respective theaters. Their targets would be sites, airfields, military control centers, and other objectives of immediate concern to Allied land forces within the combat radius of the tactical aircraft.

A percentage of the overseas combat crews are kept on alert, fully briefed and their aircraft armed in anticipation of even a few minutes' warning of enemy attack. As a safeguard, they could be launched on tentative evidence of imminent attack and held in the air under positive control until the order to strike is received. Depending on their mission profile, most tactical strike aircraft can hold for 15 to 20 minutes over their home base and still have enough fuel to accomplish their mission. Several squadrons of Mace cruise missiles are also maintained overseas. Designed to strike heavily defended targets in bad weather or darkness, the Mace can penetrate at a low enough altitude to avoid most of the enemy's air defenses. Some think it would be the first vehicle to strike enemy soil in an all-out war.

With a few hours' advance warning, theater air forces can be dispersed to preselected and prestocked secondary bases for additional protection. Dispersed operating bases are normally far enough apart to require the enemy to commit at least one nuclear sortie against each of them. This in turn increases significantly the effort he must expend to destroy all theater strike forces before they can become airborne.

The location of theater air forces around the periphery of the Sino-Soviet land mass thus further complicates any plans the Communists might have for launching a surprise attack. Admittedly dispersal in itself does not make the Soviets' problem insoluble. What it does, however, is demand more comprehensive preparations on their part, which may afford us some strategic warning. Certainly any indication of impending attack would be of the utmost value in alerting our own forces. Theater-based tactical air forces also give assurance to our allies that we are ready to assist them with every means at our disposal. While most of our allies fully appreciate the value of strategic forces based in the United States, a portion of our military strength stationed in their own geographical area announces very clearly that the U.S. considers those areas fundamental to its national security. To this extent they prevent or at least discourage piecemeal seizure. One can surmise that the Communist forces might not have attacked Korea if U.S. tactical fighters and troops had been physically located in that country.

There is every reason to believe that the requirement for theater air forces will prevail throughout the 1960's. But as the Soviet missile threat increases, a portion of these forces should be re-equipped with a lightweight tactical ballistic missile, which, through mobility or hardening, can be conditioned to survive in a general war. Some of the characteristics of this missile will be enumerated later. Theater air forces are also charged with counterair, interdiction, close support of ground forces, and reconnaissance in both general war and low-intensity conflicts. Since most of these operations are not now within the province of a missile, they must be accomplished by manned aircraft. Theater air forces therefore should retain both aircraft and missiles to provide combat effectiveness in a variety of situations.

The remainder of U.S. tactical air forces are held in the United States as reinforcements for the theaters. To prepare for that mission, U.S.-based tactical units are periodically deployed overseas on practice exercises. While in the overseas theater, crews are placed on alert and are required to fly several combat sorties simulating their wartime tasks.

To be of real value in a general war with no advance warning, these forces must first escape the consequences of the enemy's initial attack, deploy to the theater, and on arrival operate from partially damaged air bases or from secondary airfields. If adequate facilities, fuel, and ordnance are available, these reinforcement aircraft can have a significant effect on the outcome by helping to destroy what is left of the enemy's nuclear strike forces. In a general war other U.S.-based fighter units would also supplement the continental aerospace defense forces, and tactical reconnaissance and troop-carrier units would perform important jobs, such as bomb damage assessment and airlift missions in support of Western Hemisphere defense.

Operationally ready reserve forces in the United States are also heavily committed in general-war planning. The numerous Air Reserve and Air National Guard tactical fighter, reconnaissance, and troop-carrier units represent a ready reserve of air power which would figure prominently in the follow-on phases of a general war or in a protracted small war. These reserve components are well trained, adequately equipped, and maintained at a high state of operational readiness.

limited-war functions

Limited war is usually defined as active military conflict in which one or both sides commit less than their total military capability and in which national survival is not immediately at stake. To an even greater extent than in general war, political considerations and restraints dominate the conditions under which it is fought.

The value of military forces in conflicts less than general war depends largely on their flexibility and versatility, for they must be constantly ready to meet an almost infinite number of contingencies at unpredictable and widely scattered points around the world. These military tasks can range from friendly show-of-the-flag deployments, through determined displays of force, to actual combat with either high explosives or nuclear weapons. The usefulness of the forces can be measured to a great extent by their adaptability to strange environments and to the political restraints which may be applicable to any given action.

After World War II, with the U.S. having a virtual monopoly on the A-bomb as well as the means to deliver it at intercontinental range, our strategic aerospace forces were considered an effective deterrent not only to a major war but to lesser conflicts as well. The requirement for the tactical fighter with its high-explosive ordnance had rapidly diminished.

Then, in 1950, the Korean War erupted, and except for certain restrictions it was fought under conditions not unlike the air-land battles of World War II, except that enemy aircraft were virtually nonexistent in the land battle area. Air superiority fighters, tactical fighters, and tactical bombers were once again very much in demand.

By the close of the Korean War it was apparent that conflicts less than general war were quite possible and that forces which could respond effectively to such wars were necessary. We could not afford to give additional ground to the Communists by enduring a series of small thrusts slowly chipping away at the perimeter of Free World defense.

To help counter the threat of piecemeal aggression, the United States became a partner in a series of mutual-defense pacts throughout the world. At present we are committed to provide military assistance to some 40 different Free World nations if they become a target of military aggression. Most of these allies maintain relatively large ground forces. Because they cannot produce or support their own air power, their air forces are small and usually confined to an air defense mission. Hence the most valuable contribution we can make to their security is an air force, trained and equipped for the full spectrum of tactical air operations.

Yet we cannot afford to station tactical air units all over the world to meet small-war commitments. Nor can we rely completely on general-war forces stationed in Europe or in the Far East. It would be unwise to weaken our general-war deterrence during a limited-war emergency. The best solution is to retain in the United States sufficient tactical air forces for contingencies less than general war. With the aid of aerial refueling a small, self-supporting force of tactical aircraft can be deployed in a matter of hours from this country to almost any place in the world where adequate runways, fuel, and ordnance are available. A relatively small but effective army force, on the order of a battle group, can be air-transported with it.

Such a highly mobile air force exists today. Called the Composite Air Strike Force (CASF), it is made up of certain predesignated combat and support squadrons which are kept in constant readiness for small-war combat. While the basic CASF organization mounts roughly 140 aircraft, its strength can be altered to fit the occasion. Included are not only tactical fighters but also reconnaissance, transport, and tanker elements.

Except for fuel, ordnance, and other expendables prepositioned or moved in by the appropriate theater transportation, the Composite Air Strike Force carries with it enough supplies and equipment to operate for 30 days under normal combat conditions. All these support items are kept in mobility kits so that they can be quickly loaded aboard transport aircraft. Each U.S.-based fighter squadron detailed for CASF duty maintains its own kits with the utmost care.

Today's Tactical Aerospace Force

The primary mission of the tactical aerospace forces is the defeat of enemy action by decisive application of the versatile firepower and large radius of action that is characteristic of aerospace forces. For this mission, customarily established in cooperation with friendly ground forces, the specialized tasks of the tactical aerospace force are to control the air vital to the battle area and to exploit control by interdiction of communications and movement and by destruction of enemy forces and their support. The tactical forces also augment the strategic defense of the North American continent and of the areas abroad into which their elements are deployed. In general war they will join in the strategic offensive, operating from their forward stations around the globe to take out assigned portions of the enemy's warmaking capability. In limited war their elements already deployed in overseas theaters may hold their positions, on guard against spreading war, while specially composed, combat-ready air task forces deploy from the United States to the zone of conflict in a matter of hours.

With many diverse mission assignments, tactical aerospace forces must have versatile capabilities. They must be capable in both conventional and nuclear ordnance delivery. They must be capable of both treetop attack and extremely high-altitude intercept. A prime requirement is capability for all-weather tactical reconnaissance (which is separately reviewed in the chapter by General Ford). There must be tactical airlift to support the far-flung deployment and the associated ground forces. There must be tankers to refuel the combat elements in their extended transits between theaters.

The fighter aircraft form the heart of the tactical forces. All four types in the current force are supersonic and are equipped to handle both air defense and fighter-bomber assignments. These four tactical fighters are the

F-100

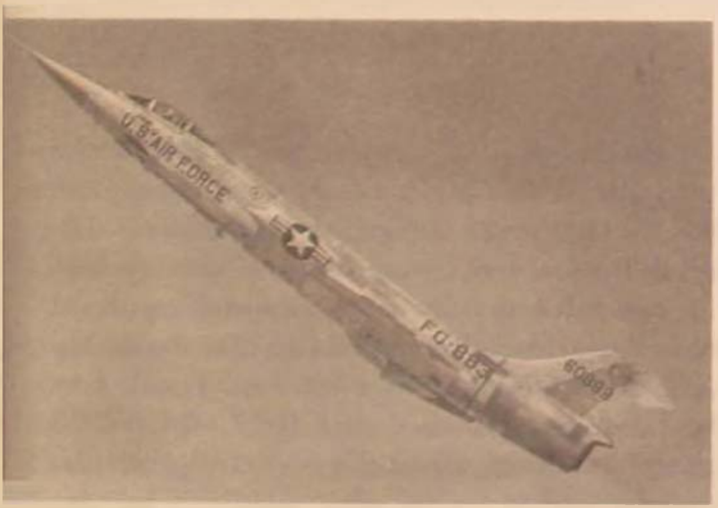
Speed	over 800 mph
Ceiling	above 50,000 ft
Unrefueled range	beyond 1000 mi
Weapons	4 20-mm cannon and Sidewinders; conventional or nuclear bomb capability
Crew size	1

F-105

Speed..........over 1000 mph
Ceiling........above 55,000 ft
Unrefueled
range......beyond 1500 mi
Weapons......Vulcan cannon, rockets, air-to-air missiles; conventional or nuclear bomb capability
Crew size 1

F-101

Speed..........over 1200 mph
Ceiling........above 50,000 ft
Unrefueled
range.......beyond 1000 mi
Weapons.......combinations of 4 20-mm cannon, Genie, Falcon, and Sidewinder rockets; conventional and nuclear bomb capability
Crew size 1



F-104

Speed ....over 1400 mph
Ceiling........above 90,000 ft
Unrefueled
range.......beyond 1000 mi
Weapons.......Vulcan cannon and Sidewinders; conventional and nuclear bomb capability
Crew size 1

F-100, the F-101, the F-104, and the F-105, called the "century series" fighters because of their numerical designations.

The F-100 Super Sabre fighter, which began coming into use in 1954, is the oldest in the current force. As the first U.S. fighter aircraft capable of supersonic speeds in level flight, the F-100 was originally intended as a day fighter with a fighter-bomber capability. Later models—the D and F—are primarily fighter-bombers, with secondary capability as interceptors.

Now replacing some of the F-100's is the newest of the tactical fighters, the F-105 Thunderchief. In keeping with the growing determination to reduce

Matador (TM-61C)

Speed...........over 650 mph
Ceiling........above 35,000 ft
Range...........about 600 mi
Dimensions....length: 39 ft 7 in
height: 9 ft 8 in
span: 27 ft 10 in
Thrust..10,000 lb from engine plus
100,000 lb from booster

Mace (TM-76B)

Speed..........over 650 mph
Ceiling........above 40,000 ft
Range..........about 750 mi
Dimensions....length: 44 ft 2 in
height: 10 ft
span: 22 ft 10 in
Thrust..10,000 lb from engine plus
100,000 lb from booster

the number of different aircraft in the tactical inventory, the F-105 is the first fighter specifically designed with the versatility necessary to accomplish the all-round tactical mission. It can do this more effectively than any existing aircraft. Equipped with a special fire-control system, the Thunderchief can perform pinpoint bombing at any altitude from extremely low level to 50,000 feet. The later D model has an all-weather capability for bombing by night or day and through clouds. In addition to an internal bomb bay longer than that of the World War II heavy bomber, the B-17, the F-105 can sling under its wings a full complement of air-to-ground Bullpup missiles. For its interceptor role it is armed with Sidewinder missiles and the Vulcan cannon.

The F-101 Voodoo was originally designed as a high-speed, long-range, all-weather interceptor, still its primary function in the tactical forces, which have deployed it overseas for that purpose. The later C model, strengthened structurally for additional duties as a fighter-bomber, has been in squadron service with tactical forces since 1957. It has a longer range and increased navigation capability over the F-100.

The fourth member of the tactical fighter family is the sleek, stubby-

B-57

Speed	over 600 mph
Ceiling	over 45,000 ft
Unrefueled range	beyond 2000 mi
Weapons	4 20-mm cannon, 8 5-in HVAR rockets, and 5000-lb bomb load
Crew size	2

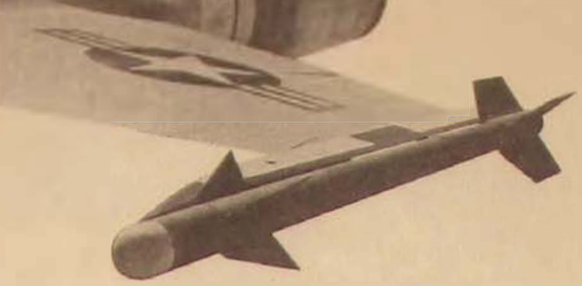
B-66

Speed	700 mph
Ceiling	above 45,000 ft
Unrefueled range	beyond 1500 mi
Weapons	2 20-mm tail cannon and 15,000-lb bomb load including nuclear bombs
Crew size	3

winged F-104 Starfighter. With an airframe weighing only about half that of other century-series fighters, the F-104 was designed for maximum speed and climb as a first-line interceptor. The day-fighter role is still primary, although the aircraft now has also an atomic-weapon delivery capability.

Complementing the rounded family of tactical fighter aircraft are the tactical surface-to-surface guided missiles and the light bombers. The two surface-to-surface guided missiles, the TM-61 Matador and the TM-76 Mace, may both be armed with nuclear warheads, both have ground mobility, and both can be launched from mobile translaunchers. The Matador has been deployed overseas since 1954. A subsonic, air-breathing missile, it is dependent on ground stations for guidance, but in an improved model the guidance is highly resistant to electronic countermeasures. The Mace, which is now replacing the Matador, is a much-improved version with longer range and self-contained guidance. Mace's earlier model had a map-matching electronic guidance system. The current production model features inertial guidance.

The light bombers, although soon to be phased out of the tactical force, have filled an important role in the years that the fighters were being developed to all-round performance. The B-66 Destroyer, operational since



Sidewinder (GAR-8)

Speed	supersonic
Ceiling	above 50,000 ft
Dimensions	length: 9 ft 4 in diameter: 5 in span: 2 ft
Thrust	over 6000 lb

Bullpup (GAM-83A)

Speed	supersonic
Range	over 15,000 ft
Dimensions	length: 11 ft diameter: 1 ft span: 3 ft 1 in

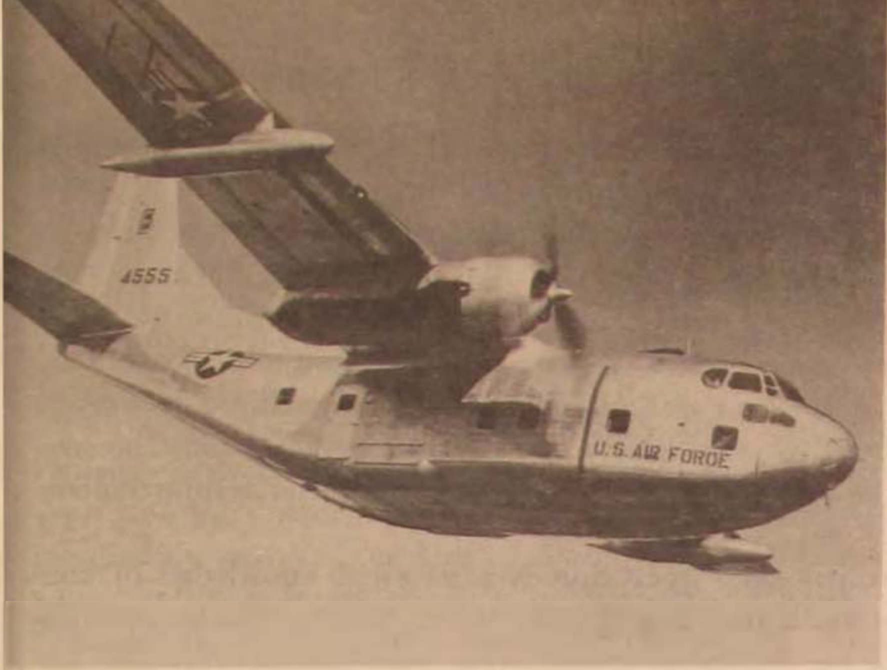
1956, is the newer of the two light bombers. In the 600–700-mph class the B-66 can carry a large selection of weapons, including nuclear ordnance. It has filled well a variety of roles for the tactical forces. The older B-57 Canberra, now being phased out, has been in the tactical forces since 1954. In both night intruder and bomber roles, it features a unique rotating bomb bay that can release bombs without exposing any protrusions to slow down the aircraft.

Completing the tactical offensive arsenal are the air-to-air missiles and air-to-ground missiles fired by the various aircraft. The principal reliance for air-to-air combat is the GAR-8 Sidewinder. A supersonic guided missile, the Sidewinder is the cheapest, smallest, and lightest of air-to-air missiles. Its passive infrared "heat seeking" guidance system causes it to home in on the hot tailpipe of the target aircraft but also limits its usefulness to clear-weather intercepts. For the air-to-ground role there is the GAM-83 Bullpup. Powered by a solid-propellant rocket motor and guided by radio-command signals from the launching aircraft, Bullpup delivers conventional firepower against ground targets and in close support of ground troops.

Backing up the combat elements of the tactical aerospace force are

KB-50J

Speed	over 400 mph
Ceiling	approx. 35,000 ft
Range	beyond 2000 mi
Cargo capacity	over 20,000 lb
Crew size	6



C-123

Speed	240 mph max.
Ceiling	above 25,000 ft
Unrefueled range	beyond 3000 mi
Cargo capacity	60 troops or 24,000 lb
Crew size	2 to 4

C-130

Speed	370 mph max. cruise
Ceiling	above 30,000 ft
Unrefueled range	beyond 2000 mi
Cargo capacity	92 troops or 36,700 lb
Crew size	4

the tankers and the tactical airlift. The principal tanker for the tactical force is the KB-50J, although KC-135's of the strategic force are also occasionally employed. Primarily used in the long overseas flights to deploy tactical units to trouble spots around the world, the KB-50J is the oldest first-line tactical aircraft still in service. A converted bomber of the early post-war strategic force, the KB-50J now has two additional jet engines slung under the wings to supplement its four piston engines and give it the altitude and speed needed for refueling high-performance fighters.

The tactical airlift force is comprised of C-123's and C-130's. The C-130 is already the principal reliance of the tactical airlift force and continues to replace the C-123. A medium assault transport, the C-130 Hercules can take off from a shorter runway than can any other aircraft of its size. With a cargo capacity of up to 20 tons, the C-130 also has a self-contained auxiliary power system that enables it to operate from forward or remote areas, independent of ground electrical power. The C-123 Provider has operated with the tactical forces since 1955. Also designed for forward-area operations and short take-off, the C-123's cargo compartment can take 60 troops or a 155-mm howitzer and a truck.

One of the most important considerations in limited-war operations is reaction time. A small force swiftly deployed by air is often more effective than a larger seaborne force moved too late to prevent armed hostilities in an area of tension. In the case of an internal crisis, as in Lebanon, the prompt arrival of our military forces, integrated with appropriate political actions, should be enough in itself to restore order. In countering overt aggression, as in Korea, our forces undoubtedly would be required to engage in active combat. Under this contingency the advance elements must be supplemented as rapidly as possible with airborne and seaborne reinforcements and logistical support.

Another factor in any such operation is a detailed knowledge of conditions in the geographical area where it is to be fought. Consequently a continuing effort must be expended in planning and studies of routes, airfields, possible targets, and the availability of logistical support throughout the world. Separate plans have been prepared and are periodically updated for each of the areas of the globe in which wars might occur. To ensure their adequacy, the plans are frequently tested in realistic operational-readiness inspections and overseas deployment exercises. In essence this is the primary function of the Tactical Air Command—to prepare and maintain combat-ready forces for reinforcement of overseas theaters and for CASF duty.

The presence of tactical air units in the initial stages of a small war can have a profound effect on the morale of local ground forces. This is especially true in a situation in which the aggressor is advancing on the ground and the defender has not yet had time to organize his defense. The sight and sound of U.S. air power, as a symbol of much greater assistance to come, not only would tend to bolster Allied forces but at the same time could have a demoralizing effect on enemy troops. In most cases tactical air forces would be the first visible assistance the U.S. could offer. Quick reaction of our air forces can afford us a decided advantage at the outset.

Of course the advantage of early participation by tactical air forces is a product of the special characteristics of the tactical aircraft—i.e., flexibility, mobility, visibility, and the ability to loiter and to alter flying routes to maximize political and psychological effects. The tasks of tactical air forces in a prolonged limited war would, however, resemble those of World War II and Korea. Except for the increased performance of modern tactical aircraft and the potential of nuclear weapons, one can expect the same pattern of counterair, air defense, interdiction, close support, reconnaissance, and troop-carrier operations.

The usefulness of surface-to-surface missiles in this type of conflict is limited, particularly if political or military considerations prohibit the employment of atomic weapons. Under this restriction we would most likely be required to deliver large amounts of ordnance against targets developed from information gained by the pilot himself or from shifting battle conditions. Many of the missions in such a war will be in support of either local or our own ground forces. The very nature of close-support targets rules in favor of the flexible tactical fighter.

Much has already been written on the controversial subject of employing atomic weapons in a limited war. Whatever the decision made by our political and military leaders, our tactical air forces have an important additional deterrent effect by their very readiness to use nuclear weapons against limited aggression. At the same time they provide us with a substantial capability to fight in some instances without nuclear weapons. Because of this flexibility we believe forces of this type still have a long and useful life in our military structure.

The years since World War II have been distinguished by a protracted struggle between the Communist nations and the Free World. More often than not, fortunately, critical differences have been settled by arbitration instead of by war. Yet the United States must maintain now and well into the future military forces which can intervene in a variety of situations, support our allies, and meet Communist challenges in many areas. The better prepared we are for meeting each eventuality and the more widely understood and appreciated our capabilities are, the less likely it is that we will have to actually employ those forces.

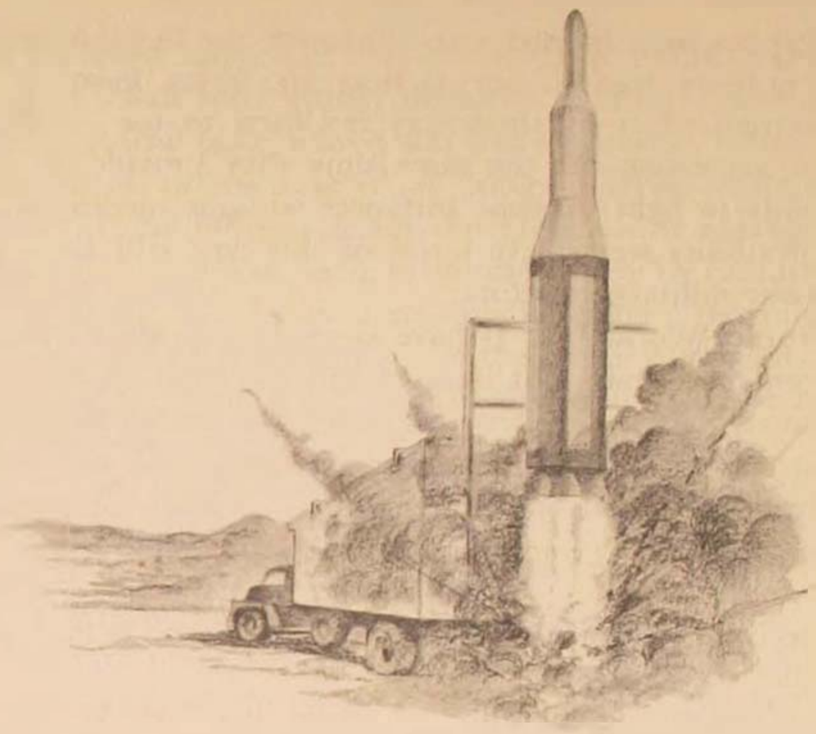
Tactical air forces will continue to afford the Free World important political and psychological benefits in the cold war because of their combination of power and versatility. They demonstrate U.S. intentions and capabilities to resist aggression and to aid beleaguered people, and this gives them an important role in the cold war.

future tactical air weapons

As mentioned earlier, there has been a demand for a medium-range ballistic missile (MRBM) to replace a portion of the tactical aircraft in the overseas theaters. To be effective in a general war under any condition of warning, it should have these characteristics:

mobility by truck over secondary road networks
amenable to hardening for areas with limited real estate
solid or storable liquid propellants
quick-reaction capability
1000- to 1500-mile range
low circular probable error
crew of 3 to 5.

There is every reason to believe that a missile with these characteristics will be well within the reach of technology during the next few years. One of the major complications might be in developing a positive command and control system to permit random dispersal and still guarantee quick reaction. A solution to this problem should be forthcoming during the missile's development cycle. The addition of this missile to the tactical aerospace forces should greatly enhance deterrence against local aggression, and preliminary studies indicate that it can be produced and maintained at less cost than the manned aircraft it is to replace. At the same time it can be dispersed and protected more readily than present aircraft.



Medium-range ballistic missile (MRBM).

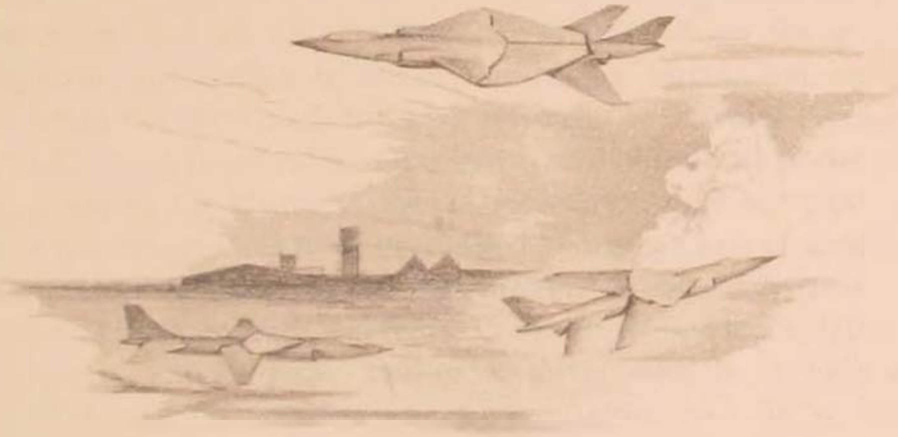
In addition to tactical missiles, versatile manned aircraft will still be necessary both for general- and limited-war tasks. The Republic F-105D Thunderchief, now entering the inventory in numbers, is the first airplane to be designed at the outset to accomplish all the functions of a tactical fighter. In the past the Air Force has attempted at some expense to specialize in fighters for certain assignments, such as counterair, escort, and close support. The F-105 is a multipurpose vehicle that can accurately deliver both nuclear and nonnuclear ordnance in adverse weather, as well as perform air superiority and close-support missions. It is already proving to be one of the best tactical fighters yet produced.

In the next cycle of modernization, which should commence in another five years, a fighter will be required with even greater performance. By that time tactical air forces should have an aircraft capable of supersonic speed at low as well as high altitude, operations from a sod field of 3000 feet, and ferry range of over 3000 miles. Commonly referred to as STOL for its short take-off and landing characteristics, this new fighter type will most probably incorporate a variable-sweep wing in order to perform the many functions required of it.

The STOL fighter should be most useful in any type of war. With its extended ferry range, it will be able to deploy rapidly to the overseas theaters without dependence on tanker support. Its high speed at low altitude should permit it to slip under most enemy radar and air defenses. Because of its short-field capability, it will operate from secondary air strips or from undamaged segments of major airdromes. The STOL aircraft will also be able to fly to the scene of a local conflict in short order. Furthermore airfields that in the past could accept only the C-47 and similar aircraft will now be available to the STOL fighter too.

In anticipation of the weapon restrictions which might be placed on limited wars, this new fighter will be able to carry the complete spectrum of nuclear and nonnuclear ordnance. Like the F-105, it will be designed for the Sidewinder air-to-air missile and Bullpup air-to-ground missile as well as other modern weapons. Of interest to the ground force commander, it should be ideally suited for close support. On a typical mission it will be able to loiter at slow speeds in the target area for eight to ten hours, a dramatic gain over the fighter-bombers of the past.

In the same time period, we have asked that the tactical air forces be furnished with a new transport possessing many of the same characteristics as the Lockheed C-130, except for substantially increased range and payload. Such a vehicle could be used for both long-range and short-range airlift. It should be the answer for Army mobility and could also be used to support our mobile air striking force. After the STOL, depending on technological advances in engine performance, there may be developed a satisfactory vertical-take-off-and-landing combat aircraft, which some consider the ultimate solution for tactical operations.



Short take-off and landing (STOL) aircraft.

I HAVE attempted to develop a rationale for tactical air forces in the various military operations anticipated in the future. Also I have covered briefly our major requirements for tactical air weapon systems during the period under examination. Certain conclusions seem evident:

- This Nation must have a combination of aerospace forces which not only represents the most credible deterrence to general war but also can win if deterrence fails.
- Tactical air forces will retain important functions in both general and limited war.
- The missile will assume an increasingly important role as a theater weapon for preplanned general-war targets.
- The highly flexible, responsive, manned aircraft will still be the best solution for certain general-war tasks and almost every variety of air operation in lesser wars.
- There is a need for a mobile ballistic missile for theater deployment and a requirement for the development of a STOL aircraft as a replacement for our present-day tactical fighters.

Headquarters Tactical Air Command

Aerospace Defense

Major General Arthur C. Agan, Jr.

HISTORICALLY the United States has always had time to mobilize and train for war, to use our unexcelled industrial might to produce the weapons with which to win. The development of the Soviet long-range air arm, equipped with the atomic bomb and later with the hydrogen bomb, dissolved mobilization potential as a sound basis for our military planning and forced us to a strategy of keeping a strong counterattack force protected by early warning and an active air defense system. The protection provided by our air defense system gave validity to our position as the bastion of democracy and comfort to our people by shielding our population and industry from destruction. The counterforce was safe and could strike an overwhelming blow against any enemy that might initiate a direct attack on the United States or on one of its allies.

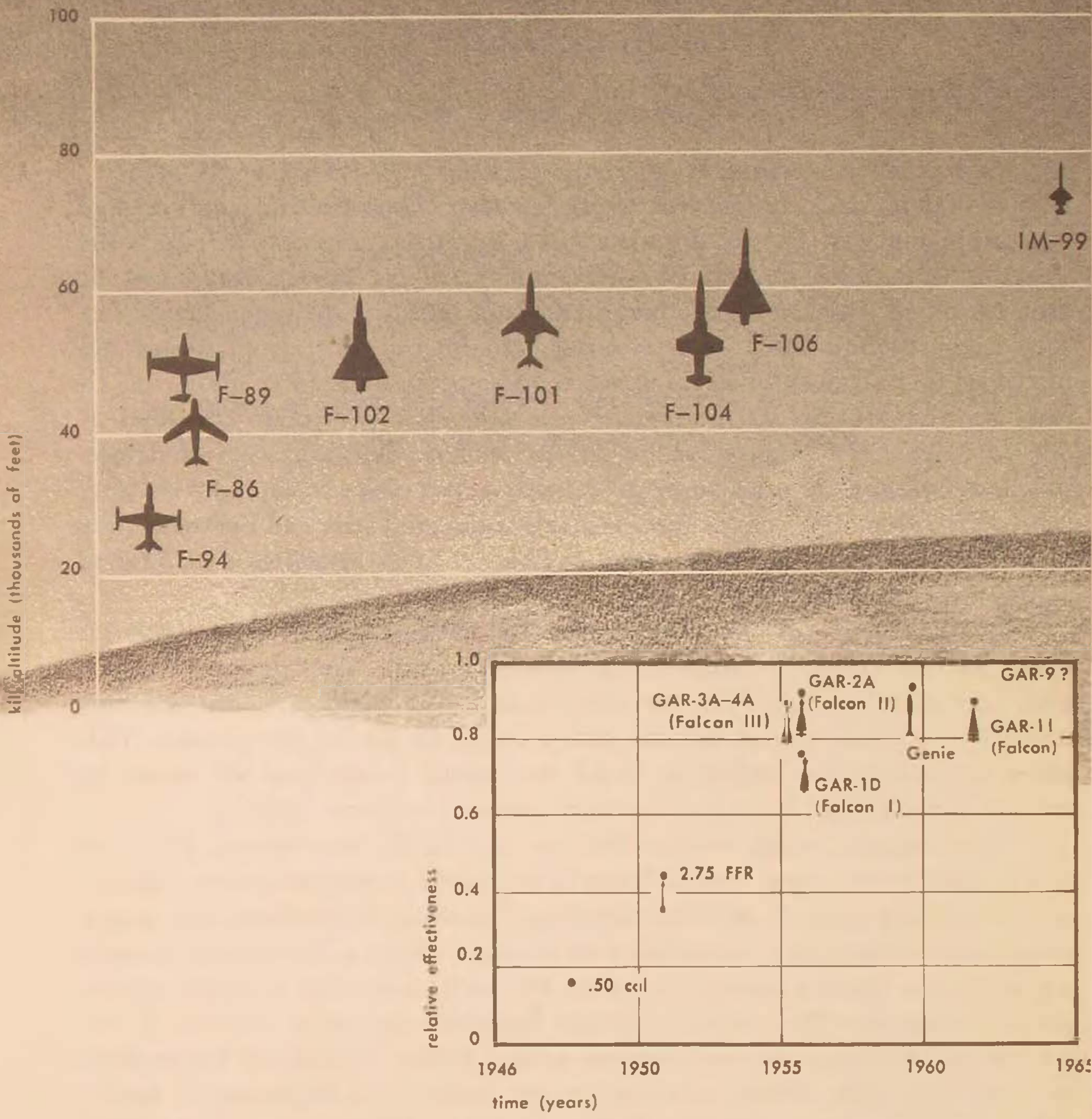
The emergence of the intercontinental ballistic missile in Sino-Soviet hands has necessitated a change in our military posture. We can now be struck with very little warning. The warning could be so slight that our strategic striking forces and our air defense forces might be hit on the ground. This could so degrade our ability to strike the enemy forces that we would be unable to sustain the dominant military position we have enjoyed.

This condition is intolerable. Our free way of life must persist. If it is to do so, a militarily strong United States is necessary. Aerospace power can give us that military strength. We have developed a strong force of strategic bombers and are developing a strong force of strategic missiles. We have developed a good defense against manned bombers. We need to develop a defense against ballistic weapons. This defense against ballistic missiles, I believe, is our greatest unfilled military requirement today. Before looking at the realistic goals for aerospace defense, now and in the future, it is important to review the evolution of the current air defense system and the impact of the space threat on our military posture.

defense against manned bombers

Shortly after World War II it became apparent that this country could be subjected to an air attack from Russia. The Soviet Union had begun production of the Tu-4, a copy of our B-29. After some delay we began to deploy a defense against this piston-engine bomber threat. World War II radars were overhauled and pressed back into service. Available fighter aircraft were deployed near major cities. In the meantime as the U.S.S.R. developed the

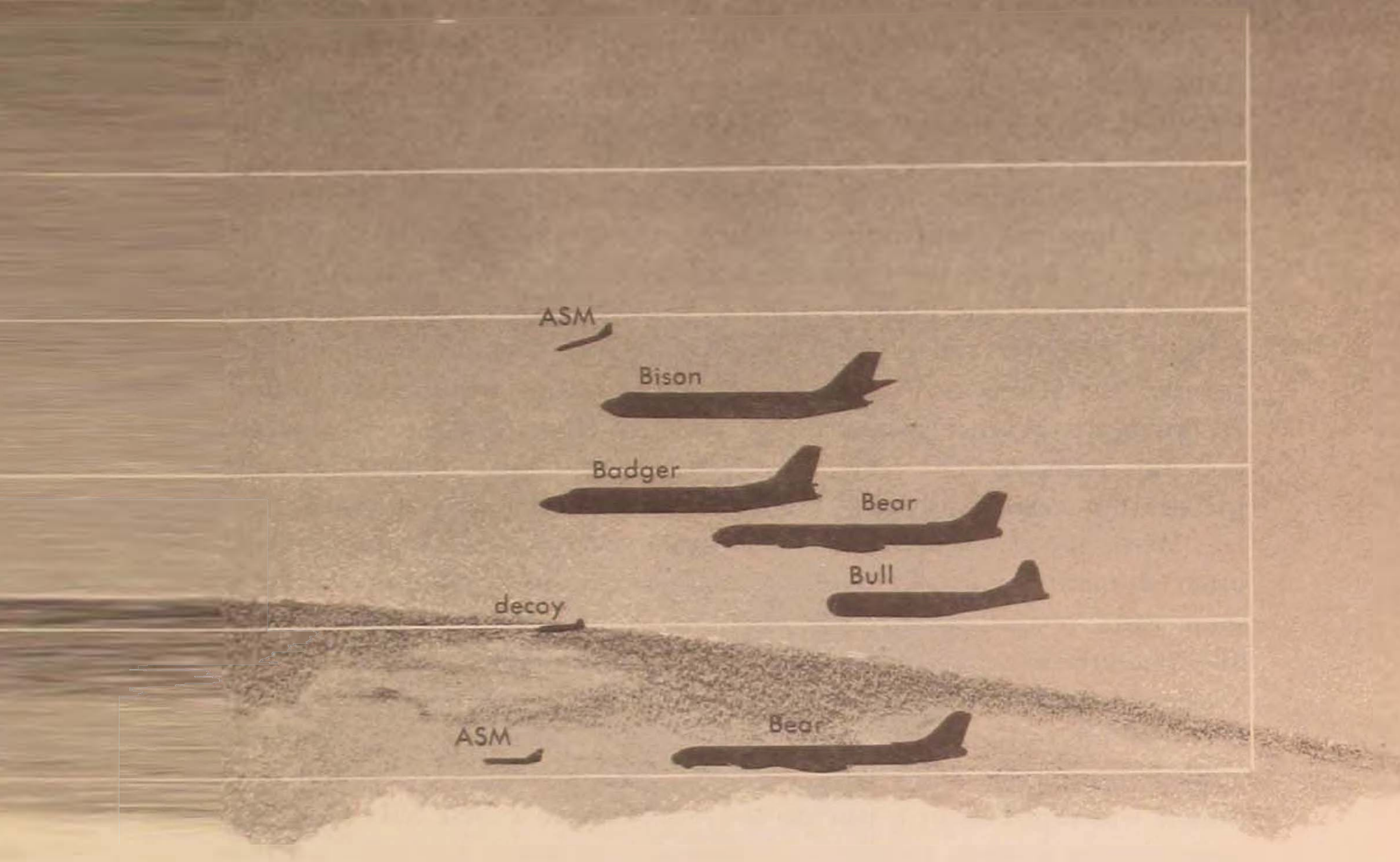
Defense against Air-



atomic bomb, research and development began on improved radar control techniques and interceptors.

Initially the radars and fighters were deployed in the most densely populated sections of the country, but as additional postwar equipment became available, it was deployed more extensively throughout the United States. Since the range of these early radars was quite limited, it was seldom possible for a single radar to complete the task of positioning the airborne fighter throughout the complete intercept. For this reason and to obtain more effi-

Breathing Bombers



The last decade has seen a large improvement in the U.S. defense against the air-breathing threat. The threat has grown from piston-engine bombers of World War II type, to subsonic bombers that can launch decoys and air-to-surface missiles, to supersonic bombers equipped with extensive penetration aids. Defense has kept pace with new interceptors and armament. Today's interceptors are equipped with all-weather radar fire-control systems and extensive counter-countermeasure capability. Interceptor armament has moved from machine guns to unguided rockets to guided missiles. The recent introduction of atomic warheads for the Genie unguided rocket and the GAR-11 guided missile has further increased defense kill capability.

cient commitment of available interceptor forces, radars were placed in direct communication with adjacent radars and all were tied to control centers via telephone and teletype links. A control center was made the command post of each air division commander, who exercised control and tactical direction of his weapons.

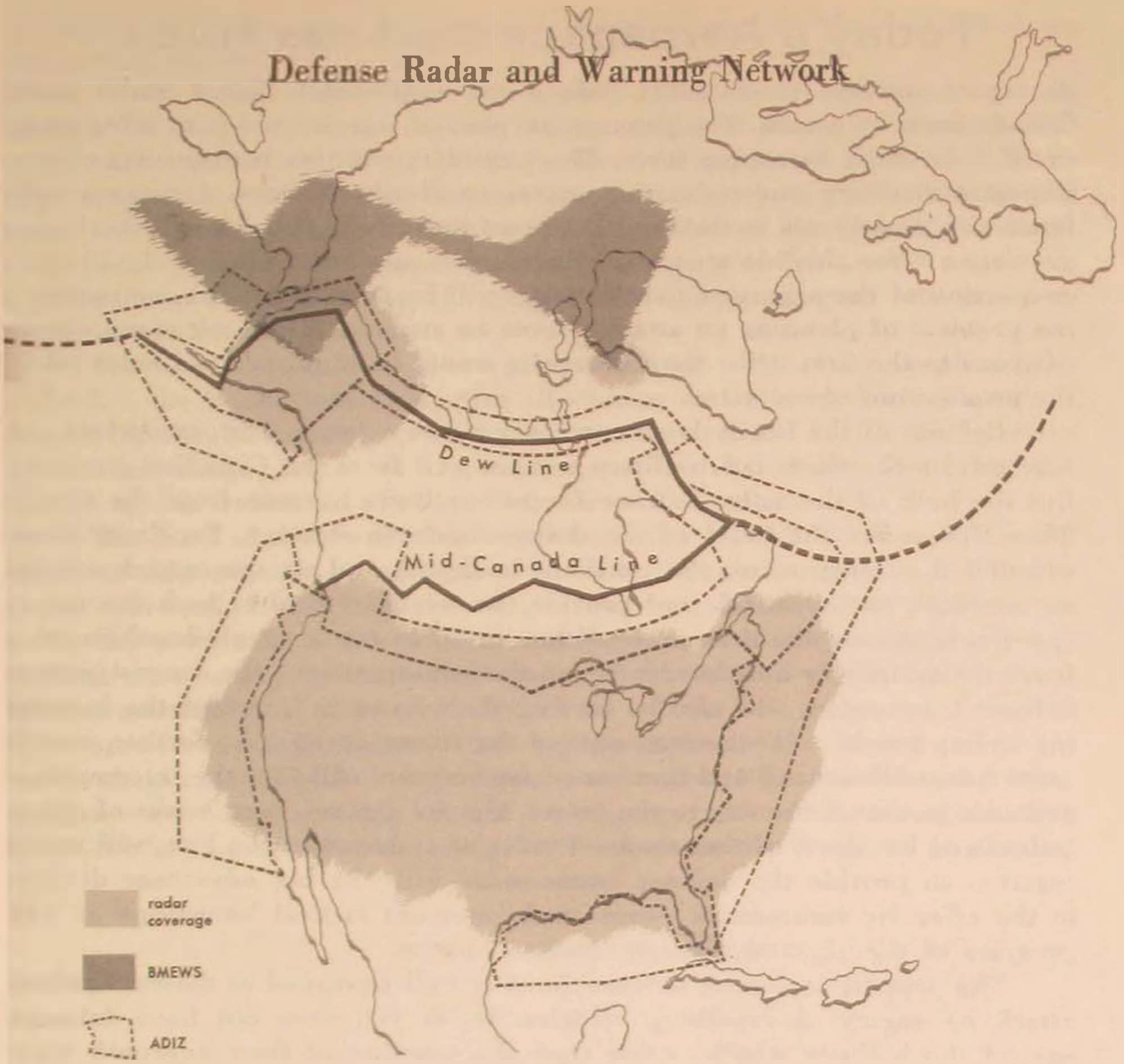
About the time that this system had been deployed fairly extensively throughout the U.S., the Soviet Union successfully detonated a hydrogen bomb in 1953 and began to build a fleet of jet bomber aircraft. It was now possible for an enemy to strike our homeland with immense destructive power. A sneak attack by these bombers could cause great destruction to our counterstrike forces, our industrial strength, and our population. The seriousness of this threat prompted many evaluations of possible improvements to the air defense system, and research and development programs were accelerated or initiated for early-warning systems, more sophisticated radars, ground control networks, advanced all-weather interceptors, and interceptor missiles.

The speed of the jet bomber required that potential enemy attacks be detected much farther from our counterstrike bases in order to provide sufficient warning time for launching our counterattack and bringing the air defense forces to the highest state of alert. Initially radars were deployed in southern Canada, forming the Pinetree Line to provide earlier detection. Then early-warning Doppler radars were deployed across Canada at about the 55th parallel, the Mid-Canada Line. Finally authorization was received to build the Distant Early Warning Line, which stretched from Alaska to Greenland near the 70th parallel. The Dew Line, plus its sea flanks of radar aircraft and picket ships, provided several hours' warning of an enemy jet bomber attack.

While the above improvements in early warning were being implemented, other segments of the air defense system were also being modernized and in some cases revolutionized. Manned interceptors acquired all-weather radar-directed attack capability with rocket, guided-missile, and, finally, nuclear-warhead armaments. Speed, altitude, radius of action, and terminal lethality of these interceptors all increased markedly. The Nike-Ajax ground-to-air guided missile was extensively deployed around major cities, and later this missile was replaced by a nuclear-warhead version called Nike-Hercules. The surface-to-air Bomarc missile, SAGE-guided, long-range, and with nuclear warhead, was deployed in the northeastern section of the United States. The overall weapons deployment thus provided defense in depth. The longer-range interceptors could engage an enemy attack hundreds of miles from its intended targets, to disrupt the raid and attrite the attacking enemy forces. The intensity of the interception could be progressively increased as the raid came within the radius of additional interceptor bases. Bomarc missiles could then be rapidly committed against the attacking force, and finally the Nike missile could engage any survivors who reached the target area.

The achievement of this intense, highly coordinated, and long-range commitment against large raids required a highly sophisticated and centralized radar surveillance and control system. Replacing the old manual weapon-control system, a semiautomatic ground environment (SAGE) system was made possible by the rapid development of large digital computers and digital data-transmission equipment. Associated with the SAGE system are high-powered, frequency-diversity radars with considerable counter-countermeasure capability and ground-to-air digital data links to provide automatic transmission of control information to interceptors and the Bomarc missile. SAGE is a centralized system, by which radar data from many radars within a geographical area are transmitted to a direction center, where they are combined and displayed by the central SAGE computer.

Defense Radar and Warning Network



Two of the four functions of an aerospace defense system are detection and identification. For defense of the North American continent, these functions are performed by the far-flung, interlocked radar and communications network shown here. Across the northern land mass and extending out to sea is the giant radar fence, the Dew Line. Backing it up to the south is a second line of radar, the Mid-Canada Line. Within the United States there is blanket radar coverage. All this exists primarily for the detection and tracking of enemy aircraft. The second function, identification, is provided by the ring of air defense identification zones (ADIZ's), wherein every aircraft must respond properly to the controller's challenge and must match up against a flight plan already on file. Newly superimposed on this defense against the air-breathing threat is the Ballistic Missile Early Warning System (BMEWS), which provides 15 minutes' warning of ballistic missile attack.

Today's Aerospace Defense Force

Aerospace defense forces must defend the continental United States and Canada from air attack. The primary purpose of this defense is to safeguard the U.S. strategic aerospace force. The secondary purpose is to protect other important military and industrial targets on North America. Aerospace defense also contributes to the total deterrent posture by denying potential aggressors a "free ride" in an attack. Strong defenses ensure that a significant proportion of the aggressor's strike force will be destroyed. This compounds the problem of planning an attack, forces an attacker to commit many more weapons to the first strike than otherwise would be required, and helps take the promise out of surprise.

Defense of the North American continent is a joint effort, comprised of forces from the three U.S. military services and from the Canadian services. But the bulk of the active defense forces continues to come from the USAF. These forces are the heart of the defense-in-depth strategy. Far-flung lines of radar that reach across the northern land, sea, and air spaces pick up an approaching enemy attack and provide the warning to alert both the aerospace defense and the aerospace offense. Even as our strategic bombers rise from their airfields and head out for the counterattack, the longest range defense interceptors will also be leaving their bases to intercept the incoming enemy bombers. As the remnants of the enemy force press farther south, more waves of manned and unmanned interceptors will join the interception and continue it all the way to the target. On the ground, long banks of computers and hundreds of thousands of miles of communication lines will work together to provide the defense commander with the big advantage denied to the offensive commander—moment-by-moment tactical knowledge of the progress of the gigantic three-dimensional battle.

The present aerospace defense force is well equipped to defend against attack by enemy air-breathing vehicles. It, as yet, does not have defense against the ballistic missile, other than the warning of their approach provided by the Ballistic Missile Early Warning System (BMEWS). Keystone of defense against the air-breathing threat is the family of manned interceptors

F-102A

Speed	supersonic
Ceiling	above 50,000 ft
Range	beyond 1000 mi
Weapons	6 Falcons plus 24 folding-fin rockets
Crew size	1

armed with guided rockets. These are supplemented by the unmanned interceptor missiles.

Of the manned interceptor force, the F-102 Delta Dagger was the workhorse for the past several years. It is now employed primarily overseas. Operational since mid-1956, the F-102 was the first supersonic all-weather interceptor and was the first of the modern interceptors to be built with the data-link system. Data-link enables the controller on the ground to direct the interceptor into the general area of the enemy aircraft, after which the F-102's own radar locks on the target, flies the interceptor into position, and fires Falcon missiles.

The newest air defense interceptor, which has substantially replaced the F-102, is the F-106 Delta Dart. Also all-weather and equipped with data-link, the F-106 has all-round improved performance over the F-102, with greater speed and range, improved electronic gear, and capability for firing the Genie nuclear rocket and Falcon air-to-air guided missile.

The third of the manned interceptors is the F-101B Voodoo. Originally built as a long-range escort fighter for the strategic forces, the F-101 has been converted, in the B model, into a long-range, hard-hitting interceptor. It is the only one of the present interceptors with a two-man crew, the second man acting as radar observer and fire-control-system operator. It carries essentially the same armament as the F-106.

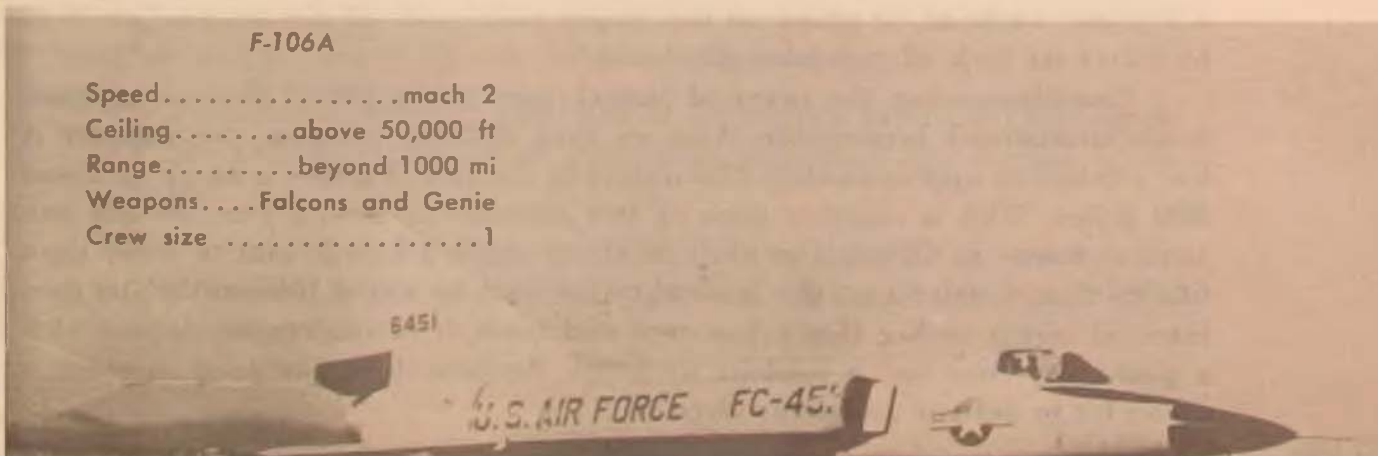
Armament for the manned interceptors embraces the Falcon and Genie air-to-air missiles. The Falcon is actually a family of five models, all having guidance systems. The GAR-1D and 3A employ versions of radar guidance; the GAR-2A and 4A use infrared guidance systems that home in on the hot

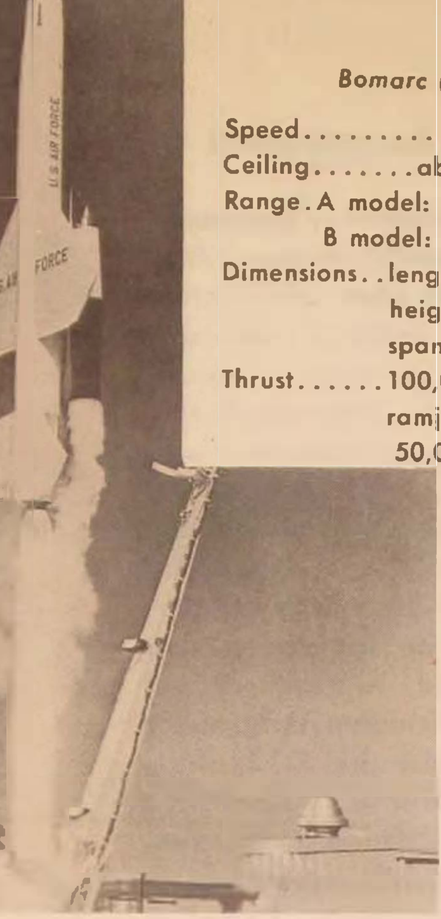
F-101

Speed	mach 1.7
Ceiling	above 50,000 ft
Range	beyond 1000 mi
Weapons	combinations of Genie and Falcon missiles
Crew size	2

F-106A

Speed	mach 2
Ceiling	above 50,000 ft
Range	beyond 1000 mi
Weapons	Falcons and Genie
Crew size	1





Bomarc (IM-99)

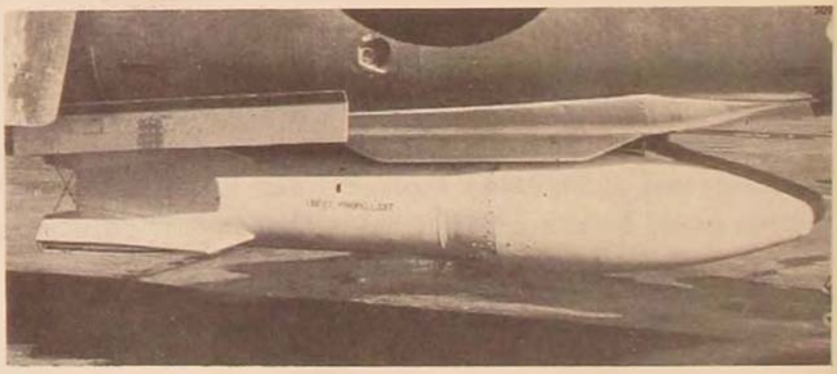
Speed..........about mach 3
Ceiling.......above 60,000 ft
Range. A model: approx. 200 mi
B model: approx. 400 mi
Dimensions..length: 47 ft 4 in
height: 10 ft 3 in
span: 18 ft 2 in
Thrust......100,000 lb (from 2 ramjet engines) and 50,000-lb booster

Falcon (GAR-1D, 2A, 3A, 4A, 11)

Speed ....mach 2
Ceiling........above 50,000 ft
Range...........beyond 5 mi
Dimensions..length: 78–84 in
diameter: 6.4–11 in
span: 20 in; undisclosed for 3A, 4A, 11
Thrust....about 6000 lb; undisclosed for GAR-11

Genie (MB-1)

Speed ....supersonic (approx. mach 3)
Ceiling.......above 50,000 ft
Range...........approx. 6 mi
Dimensions....length: 114.86 in
diameter: 17.35 in
Thrust..............36,000 lb



tailpipe of the enemy craft. These four models all carry a conventional warhead, but the latest model, the GAR-11 Super Falcon, has the capability for a nuclear warhead. The MB-1 Genie is a supersonic unguided missile with a nuclear warhead. It relies on the larger blast area of the nuclear warhead to offset its lack of precision guidance.

Complementing the manned interceptors is the IM-99 Bomarc ground-to-air unmanned interceptor. Also an area defense weapon, the Bomarc A has a range of approximately 200 miles; in the new B model a range of about 400 miles. With a reaction time of two minutes or less, a Bomarc site can send as many as 60 missiles aloft at about mach-3 speeds and to more than 60,000 feet. Guided into the general target area by SAGE, Bomarc has its own internal target seeker that takes over and leads it to the target. Armed with a proximity fuze and a nuclear warhead, Bomarc does not need to score a direct hit to destroy an enemy aircraft.

The SAGE system also displays tactical information to the direction center commander and his staff, to allow the most efficient utilization of weapons from various locations within or in the immediate vicinity of the sector. In this manner the SAGE system provides a capability to direct simultaneously hundreds of interceptors and missiles against hundreds of targets.

It was necessary to increase the extent of the contiguous radar cover within the air defense system to ensure the early application of weapons on an attacking force. The advent of air-to-surface missiles that could be launched by aircraft a hundred or more miles from their target enhanced the requirement for greater cover. Additional radars were deployed northward into Canada. Picket ships and Texas Towers equipped with heavy radar were deployed off our coasts. Finally radar-equipped aircraft were employed off both coasts to provide low-altitude coverage. The net result of these additions was an essentially solid radar cover over the continental U.S., extending several hundred miles into Canada and off our coasts.

Over-all these improvements provided us with a very effective air defense system against the manned-bomber threat. But as the system was reaching its final stages of deployment, a new and seemingly revolutionary threat emerged in the intercontinental ballistic missile.

defense against new weapons

The ICBM really had its operational birth in the German research and development of the V-2, conducted before and during World War II. The continued development of larger rocket engines and finally the development of the hydrogen bomb resulted in a missile with intercontinental range and a payload of megatons of destructive force.

Although the ICBM is not the ultimate weapon, it does have a major impact on our current military planning. It allows the enemy to fly over our existing defenses against the manned bomber and to strike our counterattack forces with little warning. Even with the best conceivable warning systems—and we are rapidly deploying or developing such systems—the maximum warning now available is only 15 to 30 minutes. The ICBM is an ideal weapon for surprise attack and is extremely effective in the hands of a country that might use it to strike without warning or provocation.

The ICBM had other major implications on our future posture, in that it opened a way to a whole family of space weapons. The development work on large rocket boosters, on excellent precision guidance systems, and on re-entry vehicles is the foundation on which many other research and military space systems are being or will be built. Some of the aerospace systems that will probably present problems for our defense in the next decade are:

- bombardment satellites—manned or unmanned satellites carrying nuclear warheads that can be ejected to impact on the surface of the earth
- glide rockets—rocket-boosted aerodynamic vehicles with a long, lifting re-entry, whose major advantage over the ICBM is greater payload for a given booster size

- supersonic low-altitude missile (Slam)—intercontinental range at low altitude
- global-range ballistic missile (GRBM)—super ICBM with a capability of being fired at targets anywhere in the world
- manned space platform—satellite with reconnaissance and warhead-delivery capability
- manned spacecraft—maneuverable vehicle with various offensive capabilities.

Current analyses indicate that the ballistic missiles, primarily the ICBM and the submarine-launched ballistic missile, are the most immediately severe of these threats and that they will exist in the enemy inventory in large numbers in the very near future.

Research and engineering studies also indicate the first great change in military posture to result from space weapons will be a defense against the ballistic missile. Our national policy since World War II has been defensive. We generally did not anticipate inimical moves or developments but usually reacted after the antagonist had asserted himself or we recognized his development of new capabilities. We emerged from the war in a position of great strength, with "the bomb," powerful military forces, and great industrial mobilization potential, but we rapidly disarmed. In the meantime the Soviets, recognizing the potency of air power and nuclear weapons, pressed the development of both. When we realized that they were building a strategic air arm, we started a modest program to increase the capability of the Strategic Air Command and to build an air defense system. Even after we recognized that the Soviets had an atomic capability and an extensive air defense system, we did not significantly increase our strategic and air defense programs.

It was really the Communist aggression in Korea that caused the upsurge in our military spending. During the Korean War the Soviets detonated a hydrogen bomb. Because of this achievement and our realization that they were going to continue pressing for world domination, our defense spending after Korea was maintained at a level well above that of the pre-Korean military budget. This increased spending provided for extensive improvements in our offensive force and our air defense system.

The deterrence concept, which came into being after the Korean War, was also defensive. We operated on the assumption that we could deter general war by possessing sufficient counterstrike forces to make any enemy uncertain that he could win the war he was starting. This had to hold true even when the enemy had the advantage of the initiative and of surprise. The crucial problem in deterrence has always been "how much is enough?"

Deterrence is a state of mind—the opponent's mind—and if he does not fear the effect of a decimated counterstrike he is not deterred. Even as we increase the survivability of our retaliatory forces, he can be implementing measures—active and passive defense—to absorb a larger blow.

There are other ways by which deterrence can fail. The enemy might miscalculate relative capabilities and assume that he can attack with great success. There is a chance that a third power could initiate an exchange between the U.S. and the U.S.S.R. by firing missiles at both. Lastly, we cannot completely rule out irrational or insane acts by potential enemies.

We must face the fact that war really could break out in the next decade, and we must, with new weapons, maintain a war-fighting and a war-winning capability. A capability to fight a war and win is the strongest kind of deterrence to war and the only kind the United States can afford to rely on. If we get and keep a true war-winning capability, we will remain in control of our destiny whether the enemy is deterred or not. Aerospace defense plays a major role in this capability. Without an effective aerospace defense system, winning is impossible.

military goals of aerospace defense

We must have the capability to destroy the enemy military forces during and after his initial attack. We must have a capability to destroy his industrial facilities if such action should be required. We must also ensure that the U.S. and its military forces survive as nearly intact as possible. The first goal, the counterforce capability, has received, I believe, insufficient attention in the past few years. There will undoubtedly be considerable enemy strength in forces not employed in the first attack. These forces, which could include bombers and missiles held in reserve or aborted first-strike tactical weapons, must be attacked and destroyed on the ground or after launch, to prevent their later employment.

The military posture required to achieve these goals would include several elements:

- A powerful, protected strategic offensive force to carry out attacks on the enemy's remaining forces.
- An effective aerospace defense system to provide warning of an enemy attack and then to destroy enemy attackers and limit damage to our offensive forces, our population, and our industry.
- Those tactical forces necessary to provide support for efforts to deny enemy access to Allied territory.

Initially protection of those offensive forces which cannot be flushed on early-warning information will have to be achieved by passive defense measures and concealment. These approaches—dispersal, hardening, and concealment—have deficiencies, but we have no other choice until we have an effective defense against the ballistic missile. If the enemy strikes first, these concepts allow him to deliver his first attack on his preselected targets. We must be sure that sufficient forces will survive to counterattack and win.

Our goal should be to ward off the first attack—to destroy or deflect the multimegaton warheads. This objective can only be accomplished by an effective active defense system. Its achievement is absolutely essential if we are to be able to take counterforce action against his forces.

Protection of our population and industry should be accomplished by both passive and active defense measures. Passive defense measures—shelters, evacuation, and other means—will offer some protection for our population. Again we must depend primarily on active defense to provide protection to our cities and make them less vulnerable to enemy attack.

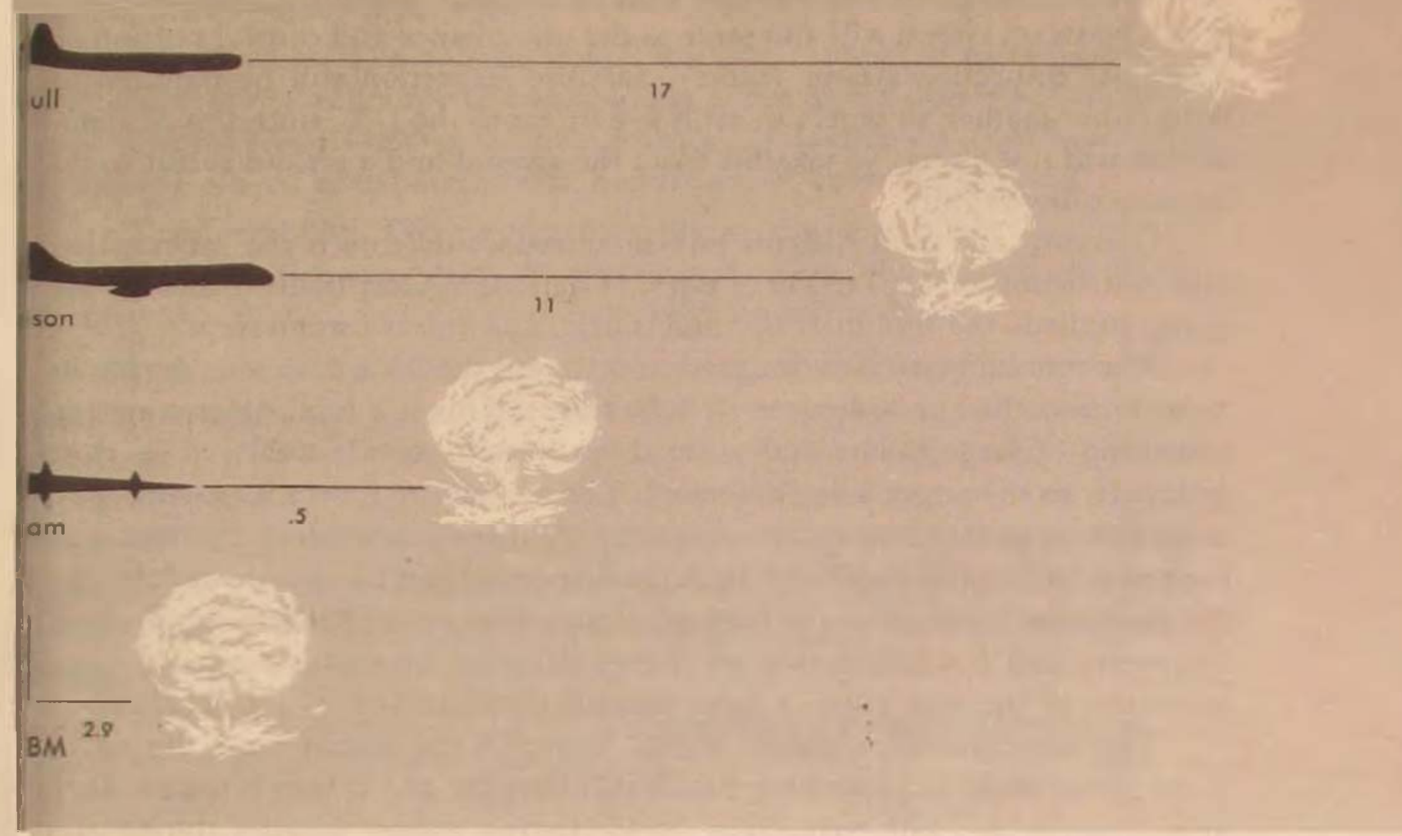
The appreciation for the necessity and the extreme importance of active defense against the ICBM got little action as people began to learn how difficult the problem was and to question the feasibility of its solution. The fact that ballistic missile defense is difficult has no bearing on the necessity for obtaining this capability. We must develop a ballistic missile defense. One of the most urgent tasks facing us today, in our efforts at deterring war, or surviving and winning if war should break out, is the development and deployment of an effective defense system—combined of course with superior counterattack capability. If the enemy develops such a system before we do, the possibility of general war increases markedly, and our chance of winning such a war is endangered. The aggressor can become provocative and increase cold-war activities with little fear that we would fight. Our choice, I believe, is obvious: we have to obtain ballistic missile defense just as rapidly as our scientific and military talent will allow.

In the meantime we cannot let down our guard against the manned-bomber threat or extensions of it. Our existing defenses should be maintained and modernized to provide defense capability against new air-supported offensive weapons such as the Slam and the B-70 type of bomber. We must also rapidly develop the capability to inspect other space vehicles, satellites, and glide rockets, which could become a threat. We have a chance of staying abreast of the threat of these vehicles instead of lagging as in the case of the ICBM. We are making progress in this regard, and certain aerospace defense systems are well along in the development-deployment cycle.

defense against future weapons

New space weapons do not change the basic concepts of defense. We must still detect, identify, intercept, and destroy. These four basic functions entail obtaining the earliest possible warning of attacking forces, accompanied necessarily by the decision that the detected forces are indeed hostile. Defense weapons must then be committed to destroy the hostile force as far from its target as possible. This engagement must take place as soon as possible and must continue with increasing intensity until the attacking force is disrupted or destroyed.

The detection and identification of an ICBM attack will be initially accomplished by the Ballistic Missile Early Warning System (BMEWS). This system, which consists of three large radar sites located in Alaska, Greenland, and the United Kingdom, will provide Allied counterstrike forces an average of 15



Time Factor in Defense (Hours)

The total time of flight from launch to warhead delivery has decreased by more than an order of magnitude in a decade. The implication of this time compression on the defense system is greater automaticity of decision and reaction procedures.

minutes' warning of an ICBM attack. The Greenland site became operational on 1 October 1960.

Detection of global-range ballistic missiles (GRBM's), which can be fired at the U.S. over the Southern Hemisphere, as well as backup on detection of ICBM's, is expected to be provided by the missile defense alarm satellite (Midas). A system of these satellite detectors, when deployed, is expected to warn of an ICBM attack approximately 4 to 15 minutes in advance of BMEWS.

A space warning and control system (SWACS) is being placed into operation and is planned, when completed, to provide detection, tracking, and identification of all orbital vehicles. Since satellites may stay in orbit for years, they will be repeatedly passing through the beams of the SWACS sensors. Hence the ephemerides of these vehicles must be established, be catalogued for future reference, and be updated as required. As an object passes through the surveillance area of a SWACS sensor, it is detected and tracked and its ephemeris correlated with the ephemerides of objects already in the catalogue. If the new trajectory cannot be correlated with any old trajectory, the new object's ephemeris will be catalogued and updated with subsequent tracking data.

The SWACS system will also serve as the surveillance and control portion of a satellite inspection system (SAINT). Satellite inspection will be required to determine whether an object in orbit is a threat to the U.S., since this determination will not always be possible from the ground and a serious threat could develop quite rapidly.

Currently the most difficult task in aerospace defense is the interception and destruction of ICBM's. Three types of defense against ballistic missiles are being studied—the terminal, the mid-course, and the boost-intercept.

The terminal system is designed to intercept the ICBM nose cone during its re-entry into the atmosphere to strike a target. This is a local defense system, consisting of large radars and a very-high-velocity missile deployed in close proximity to the target being defended. The mid-course system is essentially an extended-range terminal system with a capability of intercepting the ICBM nose cone well back up its trajectory. Both these systems must be capable of detecting the nose cone from among a mass of objects that could include missile tank fragments and a whole group of decoys designed to simulate various characteristics of the nose cone—a most difficult problem and as yet unsolved.

The boost-intercept system would intercept the enemy ICBM during its boost phase while its propelling fuel is still burning and it thus is most vulnerable. Nonnuclear kill techniques could destroy enemy missiles during this phase of their flight because a slight disruption to their structure would cause them to explode or take an erratic path. Interceptors would strike soon after the target missiles have left their launch pads. This latter system has the advantages of an area defense in that it destroys the enemy force the farthest possible distance from the United States and its allies. In that case we do not have to decide which points to defend and which to leave exposed; our strike force, our industry, and our population are all defended.

Research and development on all these techniques must be accelerated. Never before in our history have we had such a pressing requirement for the development of a weapon. Other elements of the aerospace defense system will evolve as new space threats become feasible. Since it will not be possible to build and deploy defense systems against all possible potential threats, we must hedge against these threats by maintaining a vigorous research and development program in aerospace defense techniques.

To BE effective against a determined enemy, aerospace weapon systems will have to exhibit certain characteristics to the maximum degree:

- Readiness. Every element of the system—detection, identification, decision processes, and interception—must be geared to react with sufficient speed to engage and destroy hostile forces before they reach their target.
- Reliability. Effectiveness and cost are inextricably associated with reliability. Reliability becomes even more important as defense systems are adapted

to the future aerospace threat, since the price of failure will be higher and the costs of these systems much greater.

- Effectiveness. The defense system must be capable of carrying out the destruction or neutralization of enemy forces in the face of degrading influences created by the enemy—decoys, countermeasures, and feints—or those which exist in aerospace, such as radiation belts, meteorites, or other phenomena.
- Invulnerability. The aerospace defense system must possess the inherent capability to survive any enemy attack directed against the defense system and be adaptable to measures aimed at decreasing its vulnerability.

The planners and developers of the aerospace defense system must strive to stay abreast of the threat with operational weapons that will counter any enemy attack. We must design a defense against every offensive weapon we can foresee. We must build a defense against every offensive weapon we find the enemy building, and devise a defense against every offensive weapon we know to be possible. We must not be caught unprepared. The price of obsolescence has become intolerable in this aerospace age. We can and must meet this challenge with vigorous research, planning, and ready weapons.

Headquarters Air Defense Command

Strategic Airlift

LIEUTENANT GENERAL WILLIAM H. TUNNER

IN THE early evening of 3 November 1959 a giant C-133 Cargomaster slanted down from its cruising altitude in the substratosphere toward the concrete runways of Francis E. Warren Air Force Base, Wyoming. In its cavernous cargo fuselage, gently cradled, lay the product of thousands of minds and hands—an Atlas intercontinental ballistic missile. Destination: an operational launching pit of the Strategic Air Command.

The event was the first portent of the decade ahead. But it was perhaps the most significant—a working blend of man, machine, and missile into the operational forces of the aerospace age. Behind the Cargomaster's aircrew lay the experience of nearly two decades of strategic airlift around the world. In the four-engine turboprop C-133 was captured the best propulsion and aerodynamic know-how of American industry in the production of very heavy cargo aircraft. The Atlas, embryonic first citizen of the missile era, was a symbol and a promise of more awesome power still to come.

Roles and Missions: The Strategic Concept

As the United States Air Force crosses the threshold of the Sixties, its operating force structure has hardened into three distinct yet inevitably related functional operating elements: offensive aerospace forces, defensive aerospace forces, and strategic airlift forces. No one of these forces can operate for long without the other two. They are interdependent.

The working relationship between offensive aerospace forces and strategic airlift forces is undoubtedly closest of all. Upon strategic airlift falls the major burden of ensuring that the first strike of manned offensive forces is not the only strike. Follow-up missions can be made possible by rapid airlift deployment of men, materiel, and weapons to recovery bases. Not only within the aerospace force but in the other armed forces as well strategic airlift has heavy responsibilities. This is particularly true in relation to the Army's strategic forces held in the United States for deployment where needed.

Airlift's relationship to Army forces in fact requires a new concept of organization. The World War II concept of distinct and separate strategic and tactical airlift functions has been superseded, in large part, by modern technology. Under modern strategy a long-range strategic airlift force is the only means of delivering Strategic Army Corps (STRAC) troops and their equipment directly from the United States to overseas combat zones. Additional local airlift would be required only if it was desired to send the MATS-deployed STRAC troops directly into battle by assault aircraft or by airdrop. This mission could be accomplished by short-range theater airlift forces under control of the theater air commander. There is no requirement for two long-range airlift forces.*

Strategy can be called the art of moving men and materiel so that the battle, if it must be fought, is fought on the most favorable terms. Tactics involves the manipulation of forces during the battle. Thus strategic airlift is concerned with and becomes a part of the grand design by which a nation deploys and maintains its offensive aerospace forces.

Strategic airlift forces are also deeply involved in aerospace logistics, the science of supply and mobility, the foundation stone upon which all meaningful strategy must be based and sustained.

operations and planning

While strategic airlift forces constitute a major operating aerospace component, the requirement that they be responsive to the needs of the offensive forces places upon airlift planners and commanders the responsibility of tailoring airlift to the demands of the offensive force structure. Equally important, but less well recognized, is the responsibility of the developers and planners of grand strategy to approach the over-all aerospace force structure with awareness that strategic airlift cannot be relegated to a secondary category to be considered after the combat forces have been shaped.

While relating the strategic airlift force to the total aerospace force, planners must also give consideration to the demands of surface forces, both land and water. Though it operates within the aerospace force, strategic airlift is one of a kind—unique, serving the total defense establishment as well as the aerospace force of which it is a part. Its structure is directly influenced by the offensive posture of all forces. At the same time strategic airlift capabilities directly affect the type of offensive structure which can be developed.

Though the nature and form of the combat forces will exert profound influence upon the composition and origin of strategic airlift forces, the capabilities of global strategic airlift are too vast to be relegated to a minor role. There is no denying that the initial offensive strike of total war will be intercontinental in nature. But within the foreseeable state of the aerospace art it is inconceivable that global combat could be mounted on a sustained scale without equally sustained reliance upon strategic airlift forces for the very lifeblood of the combat elements.

Apart from their relationship to aerospace combat forces and logistics, airlift forces offer a unique capability to those who conceive and implement our national policies. The airlift organization can make significant contributions to international relations through psychologically beneficial operations

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*Since the beginning of World War II, 95 per cent of all "troop-carrier" airlift missions in general or limited war have involved moving troops and material from airfield to airfield, and only 5 per cent of the effort was devoted to airdrops of Army forces. With the future improbability of sharply defined combat zones and war theaters, a result of long-range combat aircraft and missiles, the concept of a war theater must expand to include one or more whole continents. Adequate strategic airlift forces, plus short-range theater airlift forces, will meet all military requirements for intercontinental airlift of troops and for theater air assault or airdrop of troops.

in peacetime. Military airlift can assist during periods of disaster, provide a good-will gesture when warranted, and, without resorting to open warfare, overcome limitations to surface transport established by the enemy.

In light of the awesome power existing in modern weaponry, there are times when rapid and decisive action is mandatory if an explosive situation is to be kept peaceful. A modern national "show of force" depends heavily upon the responsiveness of military airlift forces, in being, ready upon a moment's call to move—behind a positive cloak of security—those fighting forces needed to maintain the peace, however uneasy it may be.

The importance of aerospace logistics to national policy and strategy is axiomatic. Whatever forces we as a nation construct in preparedness for general- or local-war situations must include an adequate aerospace logistics capability as a principal component of our national strength. Mobility in the missile age cannot be measured in days or weeks of surface travel. The time compression of warfare by intercontinental delivery vehicles has upped the logistic time scale to read in hundreds of knots.

The passing years have not changed the basic principle of military mobility. However, the dimensions against which aerospace-age mobility is now measured inevitably spell out the increasing demand for airlift. If the primary logistic goal is to be achieved, i.e., world-wide, timely support of all U.S. armed forces during peace or war, the logistics structure must lean heavily upon the responsive capabilities of in-being, military strategic airlift.

The history of strategic airlift is relatively brief. Yet in less than two decades strategic airlift forces have demonstrated time and again their diverse capabilities. They have operated into the flame of hot war; they have flown peaceful missions in the name of international relations and common humanity; they have operated in that hazy area which is neither hot war nor cold. And through it all they have provided that dependable, routine airborne supply without which no theater of operations could have been as militarily effective.

Airlift sustained the forces of China in World War II, enabling that nation to hold down a substantial number of enemy combat units which would otherwise have been freed to stiffen resistance elsewhere in the Pacific. This was strategic airlift—its effect was to relatively strengthen U.S. combat forces thousands of miles away.

Airlift kept the people of Berlin alive for 14 months with almost 2.5 million airborne tons of food and fuel when the blockade of that city became the first major test of the cold war. This was strategic airlift—its use and success demonstrated a unique vitality and suitability as a major instrument of national cold-war policy.

Airlift played major roles in the initial and continuing response to the Korean conflict. This was strategic airlift—it made possible accelerated military reaction to a threat 7000 miles from our nation's borders. Strategic airlift's lifesaving component, aeromedical evacuation, made its appearance and airlifted more than 62,000 combat casualties and patients from the Far East to United States hospitals.

Airlift moved nearly 4000 Arab pilgrims from Beirut, Lebanon, to their holy city of Mecca during a religious pilgrimage. This was strategic airlift—

it was performing as an instantly responsive tool of international diplomacy.

Airlift in three action-packed months in 1958 moved 5500 tons of cargo and 5400 troops to the Middle East in response to the Lebanese government's request, supported the move of a Tactical Air Command composite air strike force to the Middle East, and supported the move of a composite air strike force to Formosa. Subsequently an entire squadron of F-104 Starfighters—men, materiel, and aircraft—was airlifted to Formosa. These were strategic airlifts, operated under the centralized control so vital to the concept of Joint Chiefs of Staff allocation of aerospace forces in terms of those cold-war reaction priorities which can be determined only at the highest Government levels.

But strategic airlift is more than aircraft and communications, centralized command control, and responsiveness to airlift priorities. It is the flesh and blood of men, the cumulative know-how of succeeding crises met and calmed as the concept of strategic airlift grew to maturity in the aerospace age. It is the man who flew the Himalayan Hump as a first lieutenant, captained a C-54 into Berlin, flew aircrew check rides as a major across the lonely Pacific to Korea, and today commands the airlift squadrons or plans and shows the way to those who have come after him. It is courage and conviction —much work, and all too little glory.

The airlift doctrines which were tested, refined, and adopted with the passing years have never been static. They are as dynamic as the air vehicle itself. The salient features of today's airlift doctrine can be simply stated.

Airlift forces enhance the inherent mobility of aerospace combat elements and ensure their sustained striking power by expediting the mobility portion of the logistics function. Within the over-all military aerospace organization, close cooperation is achieved between the airlift forces and the striking components. Airlift forces have the capability of rapid and direct augmentation by military reserve forces and civil air transport organizations in time of emergency to meet rapidly expanding routine logistic requirements. In this sense during emergency periods the civil augmentation contribution must be confined insofar as possible to the safest or quietest zones. Only the uniformed, in-being military strategic airlift force can be counted on for immediacy of response and for operation into the hazardous areas of general war or lesser emergency.

The greatest flexibility of airlift forces is attained by consolidating all military airlift elements within the aerospace force and organizing the function within a single world-wide command to provide airlift to all armed forces within priorities established only at national Governmental policy levels, in consonance with the national global strategy.

Finally, since ton-mile costs are the vital consideration in the economics of airlift forces, the airlift vehicle must be economical to build, economical to operate, easy to maintain, and easy to load, with sufficient versatility to accept various types of cargo.

organization and requirements

The Military Air Transport Service is the U.S. Air Force command which contains the strategic airlift know-how of the Nation. It is the Nation's only strategic airlift force, with wartime allocation of its capability determined by JCS requirements.

The mission of MATS defines its reason for being and outlines its areas of responsibility. The primary mission is to maintain, in being, the military transport, troop-carrier and service forces, and en route bases and air routes to meet the approved wartime requirements of the Department of Defense as established by the Joint Chiefs of Staff. MATS peacetime operations are conducted to maintain this state of readiness.

The operational strategic airlift forces are the Eastern Transport Air Force and the Western Transport Air Force. The 442 four-engine aircraft of the strategic airlift force operate into more than 50 locations in 42 nations throughout the Free World. About 32,000 personnel are directly involved in the strategic airlift mission. Another 20,000 are involved in base-support activities, for both the strategic airlift force and other Air Force operational activities. The remaining 60,000 personnel in MATS are in the technical services—weather, rescue, communications, and photographic and charting—and in several independent units.

Strategic airlift is operated under the area-control concept. Headquarters MATS establishes the mission directives in accordance with priorities developed at the top levels of military authority. The operating air forces, EASTAF and WESTAF, are assigned specific missions, and they control the strategic airlift aircraft operating within their geographic areas of responsibility. MATS strategic airlift is global. EASTAF's area extends from the east coast of the United States to Saudi Arabia; WESTAF's area begins at the west coast and joins the EASTAF area in Saudi Arabia.

Like Strategic Air Command and Tactical Air Command, MATS is combat-ready, maintaining a strategic airlift task force always at runway alert to support the initial deployment of the aerospace striking forces. In addition, through its global communications and area centers MATS can control the movement of any airlift aircraft that is airborne en route or on the ground overseas, diverting the needed number of aircraft to whatever spot national policy may decree. So in effect MATS possesses an "airborne alert."

The strategic airlift forces conduct three basic types of war-readiness training operations. The first is scheduled airlift to support the U.S. armed forces overseas. It is "scheduled" for simple reasons of efficiency.

The second type is the special-mission operation, which takes the strategic airlift forces literally to the ends of the earth. Newest of the special-mission airlift operations are those in support of the missile program, varying from down-range support of the Patrick AFB Joint Long Range Proving Ground at Cape Canaveral to the movement of Thor intermediate-range ballistic missiles to launching sites in England. Latest special mission in regard to missiles is the responsibility to airlift the Atlas missiles from manufacturer to SAC launching sites.

The third type of war-readiness training involves operational-readiness tests, training with SAC and TAC in deployment of offensive air forces, and routine training with the Army to maintain familiarity with airlift operations.

Today's Strategic Airlift Force

Strategic airlift today must be able to place missiles, troops, supplies, and outsize equipment anywhere in the world on immediate order in direct support of strategic and tactical strike forces. Once these forces are in operation, the strategic resupply must be furnished to keep them operational either until the job is done or until the surface pipeline can be established.

The dual wartime requirement for quick, full-scale reaction and sustained operations calls for a strategic airlift force centrally controlled, fully equipped, and trained to combat readiness. To a unique extent among aerospace forces, the strategic airlift force can accomplish combat-readiness training through its normal activities supporting the peacetime military structure—airlifting of personnel and high-priority military freight, transport of ballistic missiles from depots to operating and testing sites—as well as through participation in joint exercises and in task forces or expeditions in support of national policy.

In the three fundamental requirements—central control, full equipment, and combat readiness—the most serious deficiency shows in outmoded equipment. The present force of 478 four-engine transports (including 36 overseas on TDY, assigned to theater commanders) is some 90 per cent

C-124

Cruising speed	230 mph
Cruising ceiling	20,000 ft
Maximum range	4400 nm
Capacity	66,000 lb or 200 equipped troops or 127 litters
Crew size	5

C-133

ruising speed	300 mph
ruising ceiling	30,000 ft
aximum range	4750 nm
apacity	over 100,000 lb
rew size	5

obsolescent in terms of the demands upon a modern strategic airlift force for speed, range, cargo capacity, passenger capacity, dimensions of cargo compartment, and ability to load and unload quickly to achieve a fast turnaround time.

In 1960 funds were appropriated by the Congress to begin the modernization of the strategic airlift force. Some $50 million was provided to initiate development of a high-performance turbofan transport. Until this equipment is available, the force will be provided a degree of interim modernization by limited purchases of aircraft now in production or in advanced stages of development. These purchases will include a number of C-130E's, the long-range version of the C-130B medium troop-carrier aircraft. Not only will modernization strengthen the airlift force, but larger capacity, greater speed, and a quicker turnaround time will also reduce the total number of aircraft needed for the assigned strategic airlift mission.

The four transports that figure prominently in today's force are the C-118, the C-121, the C-124, and the C-133, of which the C-124 Globemaster is most numerous. One of the first large transports designed exclusively for airlift requirements rather than being an off-the-shelf commercial model, the C-124 became operational in 1950. By the time the last of these aircraft was delivered to the Air Force in May 1955, as many as 446 had been built. The largest of the heavy-cargo transports until the C-133, the C-124 has an elliptical cargo compartment that can accommodate bulky, heavy vehicles, and weapons.

Older and smaller than the C-124 are the other two types of piston-engine transports, the C-121 and the C-118. The C-121 Super Constellation is a military adaptation of the Lockheed Constellation familiar in airline use. Of the C-121's bought by the Air Force, most were the 1049 model, transcontinental in range and with an extended fuselage. The C-118 Liftmaster is the military version of the Douglas DC-6A, which is a larger cargo version of the DC-6, also an airline favorite. The C-118 can lift only three quarters of the cargo weight carried by the C-121, which in turn has a capacity less than that of the C-124. Slightly more than 100 C-118's were bought by the Air Force before the program ended in 1955.

Newest, largest, fastest of the strategic airlift aircraft is the turboprop C-133 Cargomaster. Operational since 1958, the C-133 is primarily a long-range freighter, with a cabin specially designed to accommodate the Atlas and Titan ICBM's. Two C-133's can do the work of five C-124's. A limited number of these modern transports are now in the strategic airlift force.

C-118

Cruising speed	270 mph
Cruising ceiling	25,000 ft
Maximum range	4000 nm
Capacity	28,000 lb or 76 passengers
Crew size	5

C-121

Cruising speed	27
Cruising ceiling	25
Maximum range	40
Capacity	37, or 76 pas
Crew size	

Special exercises such as the recent Big Slam/Puerto Pine are conducted periodically. In the future they should be held more frequently than in the past.

Actually Big Slam/Puerto Pine was an exercise within an exercise. A major concern of airlift commanders is to be able to respond to the war-plan requirements for an instant surge to a trouble area and a sustained providing of airlift at high aircraft-utilization rates. Big Slam was a test intended to measure MATS' ability to increase its aircraft-utilization rates to a level approximating the wartime requirement and to hold this level of operations for a two-week period. Of course this level produced a large amount of additional usable airlift. So MATS and the Army's Continental Army Command developed Exercise Big Slam/Puerto Pine, a test of the overseas deployment of Strategic Army Corps units.

In the total operation, Big Slam, MATS planned to fly 46,295 hours between 14 and 28 Mârch. Actually 50,496 hours were flown, about 4000 more than planned. In Big Slam/Puerto Pine, MATS planned for 2536 airlift missions and actually flew 2526. The plan called for the movement of 21,030 Army troops from 14 onload bases, and 21,095 were actually moved. Airlift of 10,949 tons of Army cargo actually took place against 11,096 tons planned.

Of the 447 strategic airlift aircraft available to MATS during the two-week period, 222 were used in Big Slam/Puerto Pine. The remainder, through accelerated operational activity, plus some augmentation from civil sources, met MATS' routine airlift support responsibilities to U.S. armed forces overseas. At the peak of the Big Slam/Puerto Pine operation almost a hundred aircraft were airborne in a continuous stream between the east coast of Florida and the Puerto Rico offload bases, Ramey AFB and Roosevelt Roads Naval Air Station.

As already stated, the wartime mission of MATS is established by the Joint Chiefs of Staff. Similarly in peace, MATS is directly concerned with Department of Defense instructions. The Secretary of the Air Force is the "single manager" of airlift service for the Department of Defense. MATS is his operating agency to provide airlift to all United States armed forces.

As the airlift service agency, MATS is unique in that it conducts war-readiness strategic airlift training operations with funds provided by the armed forces in return for the training-generated airlift used for logistic support of overseas forces. The resulting Airlift Service Industrial Fund is unique to a war-ready military force. But it is an administrative funding device only and should not be permitted to becloud the true nature of MATS' reason for being and the logic of MATS' airlift training operations.

MATS works closely with those forces which can augment the in-being military airlift forces' capability in times of national emergency. This reserve at present includes two wings in the Air National Guard in five states and the U.S. civil airline industry. The use of contract civil airline air transportation to augment the strategic airlift force requires a delicate balance of judgment. There is much to be gained by familiarizing the civil airlines with military airlift operations in peace so that they can make emergency contributions within their capabilities in time of war. On the other hand the understandable desire for profit in civilian industry causes political pressures that could erode the military strategic airlift force. Acquiescence to persistent demands by some airlines for increased contract operations at the expense of war-readiness training by the military strategic airlift force would result in reducing the level of training or in the imposition on the taxpayer of unnecessary costs for procurement of civil air transportation, or both.

The Decade Ahead: Demand and Capability

In outlining the strategic airlift concept for the new decade it is desirable to examine briefly the probable national policies which will in turn dictate the composition of the offensive aerospace forces that the strategic airlift force will be called upon to support.

National policy probably will call for the maintenance of armed forces capable of deterring global conflict. National strategy in the missile era undoubtedly will stress the development of an aerospace force consisting of a blend or mix of manned aerial vehicles and unmanned missiles, both with a ready capability of delivering firepower ranging from nuclear devices down the scale to weapons with less-destructive impact.

At present the airlift resources of the national defense structure are mainly within the Air Force, the air arm of the Department of Defense. But within the Air Force they tend to be scattered among different commands, a violation of basic organizational principles that in part contributes to the deficiencies in airlift existing today. Assignment of all Department of Defense airlift capability to a single airlift command—in *fact,* not merely in name—would overcome some of the present airlift deficiencies.

There are heavy airlift aircraft assigned to both AF Logistics Command and Strategic Air Command, and even Tactical Air Command, which are used for specific airlift tasks. During limited or all-out emergencies some of the capability of these units is wasted or engaged in secondary or low-priority missions at the time the primary airlift system is accelerated to the maximum on the top-priority jobs. There are other examples of segmented airlift resources which are subject to increased productivity by assignment to a single airlift command.

Airlift control and management would be enhanced in an emergency if war-readiness training were conducted under standardized procedures within a global airlift system under the authoritative direction of a single command. The reorganization would provide a single point of contact directly responsive to all Joint Chiefs of Staff priorities and requirements for long-range airlift.

Today's airlift deficiencies point to the need for a more effective utilization of resources, primarily by creation of a single airlift command in actuality —not in name only.

the force and the mission

In planning and programing forces for the period 1960–1970, primary emphasis must be placed on the provision of ready, in-being forces, including aerospace logistic forces, for the initial decisive phase of both general and local wars. Long-range plans for strategic airlift in this period must base the size of the airlift force not only upon the requirements of the aerospace force, of which it is an integral part, but also upon the requirements of the land, sea, and undersea combat forces which strategic airlift must support.

The capacity of the civil airline industry to augment the airlift force in time of emergency must be recognized, and presently is required. But it must also be realistically appraised in terms of civil airline ability and willingness to operate under conditions of strict military control. It is idle to speculate about and dangerous to rely upon civil airlift for the movement of combat forces in event of an actual emergency operation. Only a ready military force can be counted on or expected to do the job. The Civil Reserve Air Fleet as now constituted must be confined as much as possible to the safest or quietest zones in augmenting the military airlift force in a general or limited war. No purely contract arrangement which does not guarantee without doubt the responsiveness of the entire system (crews, aircraft, maintenance, supply, and management) can meet the demands of modern war. The primary ingredient lacking is the positive control and individual discipline equivalent to that found in the military strategic airlift force.

During the period ahead we must exploit to the maximum the concept of routine airlift supply and resupply directly from manufacturer to user. Stockpiling of supplies, world-wide, is costly and economically hazardous to the Nation. Stationing intermediate-range ballistic missiles at foreign bases has already brought home the full economic significance of strategic airlift in the aerospace age. The problem of keeping missile units at peak effectiveness carries enormous economic implications. Missiles are far too expensive to buy and stock in quantity as we once did with guns and even with aircraft. In addition to the prohibitive expense, large missile inventories would create tempting targets for enemy attack and sabotage. With emphasis on overseas airlift, missile preparedness can be militarily sound and economically sensible. High-speed mobility, by strategic airlift from manufacturer to user, can keep an operational number of these infinitely complex weapons available for use at all times at minimum cost and can keep them maintained and up-to-date as technological changes in design occur.

Not only in overseas theaters is missile mobility a prime consideration. In the United States the airlift delivery of missiles from manufacturer to test or offensive launching sites has proved operationally feasible, economically justifiable, and—perhaps more important—capable of reducing that most critical commodity in developmental programs: time. The strategic airlift forces must be ever ready to support the operations of the offensive aerospace forces, including manned vehicles, in either global or limited emergencies. The surface elements of our national military strength also demand the mobility of deployment and the guarantee of rapid resupply—with its enormous economies—which only strategic airlift can offer.

The strategic airlift force must be constantly on the same terms of ready alert as the offensive aerospace forces if the immediate response demanded is to be forthcoming. But airlift forces cannot guarantee fulfillment of emergency missions if they are restricted to alert status and periodic training exercises. The nature of an airlift force is not comparable to that of a strategic-offensive aerospace force. The offensive force must be geared to an initial series of swift, devastating strikes. The airlift force must be capable of both swift initial reaction in the decisive phase of a global or limited war *and* sustained airlift operations at a very high level of individual airlift-aircraft utilization. Thus it is mandatory that the airlift force be continuously exercised in peace at an aircraft-utilization rate delicately balanced between the demands of economy and the demands of instant emergency surges to sustained airlift operations.

It so becomes possible for the strategic airlift force in times of peace to yield a by-product of its war-readiness training. This by-product is usable deployment and resupply airlift. No realistic airlift policy within the aerospace force can ignore the economics of utilizing this airlift in normal peacetime support of deployed overseas forces. Not only does it save money; more important, it gears the entire aerospace logistics system to that form of deployment and resupply which would be utilized in the fast-paced aerospace operations of an emergency situation.

But the composition and character of the strategic airlift force aircraft cannot be predicated upon the by-product airlift produced by war-readiness training. The peacetime operations of the airlift force cannot be permitted to becloud the bedrock reason for its existence as an emergency, war-ready force. The characteristics of its airlift aircraft, for example, must be compatible with the hard realities of its wartime mission.

Compatibility with the wartime mission should not be construed as evidence of a desire to lead the way in the design, development, and operation of aircraft which press hard against the limits of aeronautical knowledge. While the airlift force cannot be permitted to lag too far behind the offensive forces in speed, range, and other operational characteristics of its aircraft, there is no requirement to take the lead. The strategic airlift aircraft, both in war and in war-readiness training, has too grave a responsibility for human lives and vital cargo to permit willing acceptance of advanced and untried equipment, with the inherent period of "teething troubles" before reliability is ensured.

the equipment

It is essential that this Nation maintain in being a strategic airlift force compatible with the aerospace-offensive forces it must support. To be compatible with the strike forces, the strategic airlift force must be modernized and equipped with jet-powered aircraft.

Outsized cargo airlift requires a large aircraft capable of airlifting missiles, tanks, vehicles, and even entire short-range aircraft when necessary. The present requirement is being satisfied with turboprop-powered aircraft, which should be replaced during the decade with turbofan-powered aircraft of at least comparable size, payload, and range. The work-horse aircraft, backbone of the strategic airlift force, must be capable of transocean flights with a practical and substantial payload. It must also be capable of operating under marginal base conditions, lifting a maximum payload from short runways with low-weight-bearing surfaces.

By the period 1965–1970 the strategic airlift force should not rely on the island bases now used. It is important that we exploit to the maximum the nonstop intercontinental airlift operation. To do so, proper equipment is a critical item. Most of the aircraft now in the airlift force are deficient in range, speed, and altitude performance. In event of war, destruction or saturation of the few island refueling bases could slow the flow of critical personnel and cargo to combat forces in overseas theaters of operations.

Future strategic airlift aircraft should have a normal range of 4000 nautical miles with a 20-ton payload. True airspeed should be what proven technology can provide. It is feasible that Air Force criteria for personnel, moderate-weight, and cube-cargo aircraft can be met by off-the-shelf procurement from industries now in the process of building jet transports for the civil airlines. However, under normal technological advancement, it is clearly evident that turbine-powered strategic airlift aircraft will be required in the inventory by the mid 1960's. Such an aircraft would have the required ranges, carry from 150 to 200 military personnel, and be capable of operating from established bases located both in the U.S. and overseas with runway lengths of 5000 feet.

Modernization of aircraft alone is not the total solution. As more hours are devoted to ground handling than to flying, it is mandatory that the antiquated World War II cargo-handling system be phased out and replaced at an early date with automatic high-speed loaders. It is imperative that ground times be compressed to absorb some of the ever decreasing emergency reaction time.

Toward the end of the 1960–1970 time period, consideration must be given to the phase-in of supersonic airlift aircraft if we are to keep pace with the aerospace strike forces and take full advantage of the satellite communications systems now envisioned. Development of this strategic airlift aircraft would be expensive. Yet much could be saved in both time and money by the adoption of advanced aircraft now under development for offensive weapon systems. The aerospace force must recognize its own requirement and accept the cost of a minimum number of these aircraft, planning for their operations in such a way as to take advantage of their tremendous speed. They would be maintained as a ready force for the initial, decisive phases of either general or limited war.

With the phase-in of the supersonic airlift aircraft, ground-air communications must be capable of automatic traffic control. A supersonic strategic airlift aircraft with a Doppler navigation system should be capable of departing a terminal and arriving at its destination, regardless of distance, and automatically be controlled during its penetration until traffic-pattern altitude is reached, all without the necessity of communication between aircraft and ground control.

To take advantage of the satellite communication systems, aircraft must be equipped with communications and navigational aids compatible with the satellites. Operational flexibility, world-wide control of the strategic airlift forces at a moment's notice, and air-traffic control during the latter part of the time period should be enhanced by use of the satellites.

The minimum acceptable strategic airlift capability for the 1960–1970 time period for the aerospace force must be predicated on the offensive weapon systems in being and under development. The strategic airlift requirements associated with weapon systems employment will determine an objective strategic airlift force. In any given time period this strategic airlift force not only must be capable of satisfying the total ton-mile requirements associated with deployment of the weapon systems but in addition must have the capability of supplying the number of airframes for the required sorties in support of offensive aerospace operations.

This warning should not be glossed over lightly. In terms of ton-mile requirements the ever present temptation is to move toward larger and larger strategic airlift aircraft. This goal, desirable in one sense of the requirements posed, could, if taken too literally, defeat the ever present need for sortie flexibility within the strategic airlift force. It is difficult to define optimum size of strategic airlift aircraft which can strike a balance between the often divergent requirements of total ton-mile capability and volume of airlift aircraft sorties. Aerospace force planners would do well to keep this consideration always in mind.

In the decade ahead a major consideration for all the armed forces is a continuous appraisal of those force elements suited by value or scarcity for dependable, routine resupply by strategic airlift. Within the aerospace force, past experience has already identified trained manpower as perhaps the most critically scarce item. In addition, certain complex items of aerospace equipment, costly and scarce, are ideally suited for routine airlift movement to overseas aerospace forces. Significant dollar savings have already resulted through Air Force use of airlift. It behooves planners in all the armed forces to critically examine their force's most valued supplies and equipment for inclusion in the lists of airlift-eligible cargoes.

combat readiness

The present organizational structure of the Military Air Transport Service appears to be adequate for the strategic airlift force from 1960 to 1970. But satisfaction with present organization and the flow of mission priorities from the very top level of the Department of Defense structure should not be permitted to obscure an ever present danger.

It is basic Air Force doctrine that flexibility is the basis of the great strength of aerospace forces. AF Manual 1-2 cautions,

> For this flexibility to be exploited fully, the forces must be responsive at all levels of operation to employment as a single, aggregate instrument. . . . Of the many impacts on military operations caused by the continuing development of high speeds, extended ranges, and greater striking power in aerospace forces, the requirements for centralized preplanning and prudent allocation of control are two of the most significant. As the capabilities of the forces increase, every arrangement which could possibly act to limit the attainment of their full operational potential is more critical.

The tendency of those who do not fully understand the capabilities and strengths of strategic airlift forces is occasionally to conclude that a comparable airlift support of the aerospace force can be attained through increasing reliance upon the civil airline industry. Nothing could be more hazardous to the optimum strength of the total aerospace force. Responsiveness, military training, certainty of compliance with military orders, knowledge of the far-flung airlift routes of the world, security of operations, familiarity with the operational procedures of the offensive aerospace forces—all these are characteristics found only in an in-being military strategic airlift force. Money cannot suddenly purchase these characteristics on some future D-day. The strategic airlift force must be military. It must exist in-being. It must be equipped for the tasks at hand. It must be trained.

After this warning it may seem paradoxical to state with equal force that the civil airline industry must be prepared to work hand-in-glove with the in-being military strategic airlift force in time of emergency. But there is no paradox when it is understood that there are certain missions which only the military strategic airlift force can perform and certain missions in which the civil industry can augment the airlift force effectively. It is not in the best interests of the Nation to maintain a military airlift force equal to the total airlift tasks of a global emergency. Conversely it is unrealistic to assume that a civil industry can suddenly handle the complex requirements of strategic airlift, under contract and with little experience in emergency military demands.

It would be a disservice if the past contributions of the civil airline industry to emergency air transportation requirements were not properly recognized. The civil airlines have augmented the in-being capability of both the Air Transport Command and its successor, the Military Air Transport Service, well and faithfully. During World War II about one third of the total ton-miles of airlift was provided the Air Transport Command by commercial contractors. During the Korean conflict the peak of civil contract augmentation saw some sixty-six aircraft from nine prime airline contractors working for MATS. Nevertheless it is well to restate that only military airlift in-being can meet the rigid requirements of airlift into combat areas.

A balanced judgment is urgently required when the proper relationship between an in-being military strategic airlift force and civil airline augmentation is being discussed. And the source of this best judgment will always be found in the ranks of the aerospace-force professionals who have spent their lives with strategic airlift.

the prospect of spacelift

The emerging responsibilities of the new decade would not be complete without a brief examination of the impact of space exploration upon the strategic airlift force. As it trains and equips itself to continue to meet its military mission responsibilities upon this planet, the commanders of the strategic airlift force must increasingly turn their eyes toward the stars.

Whether the new decade sees the successful operation of a satellite bearing the insignia of the U.S. Air Force depends upon many considerations—scientific, economic, military, and national determination. But whenever man enters space, however halting his initial steps may be, the logistics requirement of deployment and resupply will become as critical as man's survival in a new and totally hostile environment.

The word "airlift" is now a fixture in professional military terminology. Two decades ago it did not exist. It is inevitable that "spacelift" also will enter the military lexicon in the years just ahead. The man who flew the Hump, captained a C-54 into Berlin, commanded a strategic airlift squadron into Lebanon, and today provides leadership and vision for his strategic airlift aircrews will complete his service career concerned with the logistics of space.

The requirements, tools, and techniques of space logistics are inevitably the next concern of the men who today move the missiles. The vision which made global strategic airlift a working reality should not be lacking as the aerospace force moves beyond the horizon.

As the Nation enters the new decade, the strategic airlift force so essential to success in past conflicts will be more and more important in conflicts of the future. A strategic airlift force on a ready status, with intercontinental capability today, with the vision to be ready for strategic spacelift tomorrow, is an indispensable operational component of our aerospace forces.

Ware Neck, Virginia

Tactical Reconnaissance

BRIGADIER GENERAL THOMAS R. FORD

THROUGHOUT history intelligence concerning the movement, disposition, and capabilities of the enemy forces has been a fundamental requirement for military operations. Intelligence information is the basis for planning every military action.

Timeliness, accuracy, and completeness of information are even more essential in modern war. A comprehensive knowledge of the enemy's capabilities and dispositions is a major criterion in formulating theater war plans. Tactical reconnaissance aerospace forces have the inherent capability to penetrate deeply into enemy territory to obtain necessary and timely intelligence information. They will be the major source of active intelligence information once hostilities have begun, and they are vitally necessary in view of the great degree of mobility with which we must credit our potential foes.

the mission

The search for battlefield intelligence is of course as old as warfare itself. For thousands of years the means of acquiring it fell roughly into two categories: passive observation, where a man in a tree or on a hill watched enemy troop movements and estimated the enemy's strength and capabilities; and active reconnaissance, where foot soldiers or cavalry attempted to circle or penetrate the enemy lines to develop information. Observation first took to the air in the Battle of Fleurs in 1794, when the French used a balloon to observe enemy troop concentrations. By the time of the American Civil War and the Franco-Prussian War, balloons were used to direct artillery fire as well as to observe the enemy; photographs were taken aloft in addition to the visual sightings by the observer.

When World War I began, the balloon became the principal means of observation. But the size of the battlefield and of the mass armies required battlefield intelligence more cohesive in form and extending farther behind enemy lines than static observation from tethered balloons could provide. So aerial observation took the first tentative steps toward becoming aerial reconnaissance as airplanes began to probe behind enemy lines with observers and cameras. The idea was quickly picked up in the United States and first put to use during the pursuit of Villa in Mexico in 1916, when airplanes photographed 19,000 square miles in support of General Pershing's columns.

As airplanes gradually took over air intelligence in World War I, they forecast the death of the observation balloon. Not only did they perform the job more effectively but, as firepower was added to their mobility, they shot the stationary balloons out of the sky. In rudimentary form this development was the first in a series of lessons on the aerial reconnaissance vehicle. World War II quickly pointed up the same lesson: vehicles for air reconnaissance had to be equal or superior to the best operational weapons of the enemy if they were to penetrate enemy territory and return with their information. Thus the early days of American participation in World War II saw the hasty discard of obsolete, slow, special types such as the O-47's and O-52's and ancient camera-fitted bombers such as the Martin B-10. From then until the end of the war, reconnaissance aircraft were modified versions of the latest operational fighter or bomber aircraft available. The roll call of reconnaissance aircraft used in World War II precisely parallels the backbone of the combat air forces: F-3 (A-20 Havoc), F-5 (P-38 Lightning), F-6 (P-51 Mustang), F-7 (B-24 Liberator), F-8 (British Mosquito), F-9 (B-17 Fortress), F-10 (B-25 Mitchell), and F-13 (B-29 Superfortress).

The emergence of air operations as a full if not always equally recognized complement of land and sea operations greatly increased the responsibilities of tactical reconnaissance. The old missions of battlefield intelligence and artillery spotting for the Army remained. To them was added the more complex requirement of reconnoitering the tactical air battlefield for the tactical air forces. Since this battlefield ranged hundreds of miles behind the enemy lines and embraced as targets all tactical warmaking capability within a large part of an entire theater of war, the job of tactical reconnaissance jumped by several orders of magnitude. This was reflected in the U.S. reorganization of tactical air in 1943, when the term "observation" was dropped in favor of "tactical reconnaissance" and the mission was broadened to specify the air intelligence functions for air forces as well as for support of army and naval forces.

Tactical air reconnaissance came into its own in World War II. As developed and refined by the Allies, it gave air, land, and sea commanders a degree of certainty about enemy tactical capabilities never before enjoyed. The payoff on the battlefield was shown in 1944 when General Patton, after breaking out of the Normandy beachhead, was able to sweep along the Loire River and drive for the German border with his right flank guarded only by tactical reconnaissance elements of the Ninth Air Force, which kept him informed of enemy movements south of the river.

As a result of the increased importance of tactical reconnaissance in World War II, development was begun on aircraft designed specifically for reconnaissance—the Hughes XF-11 for tactical reconnaissance, the Republic XF-12 for strategic reconnaissance. These projects failed to reach fulfillment, and as jet aircraft came into the combat forces a certain number were fitted out for tactical reconnaissance.

At the start of the Korean hostilities tactical reconnaissance was using the RF-80 and the RB-26. The 67th Tactical Reconnaissance Wing, augmented by one SAC squadron of RB-29's, furnished the main intelligence-

The RF-101, mainstay of tactical daylight photographic reconnaissance. Shown mounted from left to right are the KA-2 nose-oblique, the KA-2 left-oblique, and the KA-1 split-vertical cameras.

gathering forces of the Korean War. Visual and photo reconnaissance was responsible for 90 per cent of all intelligence information gathered during the three years of conflict. Plans for the Republic RF-84 and the Martin RB-57 were initiated, but they came into service only after the end of conflict.

Our present-day tactical reconnaissance forces are now equipped with the RF-101 supersonic Voodoo for daytime visual and photographic activities and with the Douglas RB-66 for night-photo and weather-reconnaissance missions. Tactical reconnaissance wings equipped with both types of aircraft are in the theaters, and the 363d Tactical Reconnaissance Wing at Shaw Air Force Base, South Carolina, forms an important part of TAC's Composite Air Strike Force, which is geared for rapid reaction to such threats to peace as developed in the Taiwan Strait and in Lebanon.

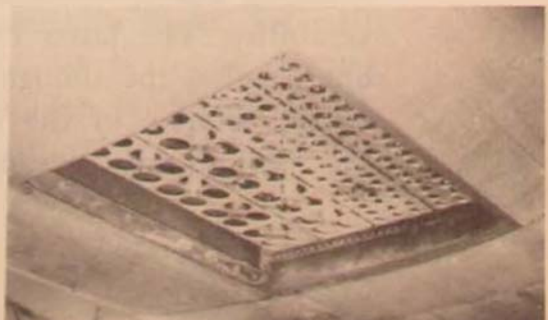
In event of hostilities, traditionally the first objective of our tactical air forces is to gain aerospace superiority. For conduct of the counteraerospace force battle, the principal intelligence requirement is to determine the enemy's air, radar, and missile order of battle. Fairly reliable information concerning his strength and disposition will usually be available before the outbreak of hostilities, but this general information needs immediate detailed elaboration and confirmation. Thus the first task of the theaters' tactical reconnaissance forces is to gather comprehensive data about the enemy's opposing air force disposition, his radar control centers, and the locations of his fixed and mobile missile forces. Damage assessment must be performed by both visual and photographic means on targets after the initial preplanned strikes have been made, to confirm the success of the tactical effort and determine the enemy's capability to continue or to recover. Weather conditions may have an important bearing upon our strike capability. The source areas and deployment routes of enemy forces must also be periodically examined.

The second general task of the tactical reconnaissance forces relates to interdiction. Adequate surveillance must be exercised over the enemy's main lines of communication in order to obtain information for planning interdiction strikes and to confirm the effectiveness of these strikes.

The third task, one of the most important and least evident means by which the tactical air force influences the success of army operations, is performed to assist the army commander in meeting his needs for information on enemy troop dispositions and strength. Specific objectives are delineated in the daily plan of tactical reconnaissance operations as the need becomes apparent. Army requests for tactical reconnaissance data are processed through the air-ground operations system. Each request is evaluated to determine its priority in relation to the current intelligence requirements. The tactical reconnaissance mission to be flown may then incorporate several such army requests and satisfy selected tactical air targeting objectives as well.

All the above tasks may be carried out almost simultaneously, by virtue of the inherent flexibility of the manned tactical reconnaissance weapon system. Through the tactical air control system, the objectives of a tactical

For night and all-weather tactical reconnaissance, the RB-66B is outfitted with a variety of photographic equipment, yet retains firepower. From left: T-11 gyroscopic camera mount, T-11 mapping camera, K-38 camera with 12-inch cone mounted (24-inch and 36-inch cones behind camera), K-46 night cameras (trimounted), K-37 night camera, photoflash detector, and O-15 radarscope camera. In front are the M-120 photoflash bomb, M-112 and M-123 photoflash cartridges, and 20-mm ammunition. In the plane's belly (photo to the right) is the RB-66's photoflash cartridge rack.



reconnaissance sortie may even be changed while it is in progress, in order to accomplish another, higher-priority task.

the tactical reconnaissance vehicle

For the immediate future it appears that manned aircraft offer the most effective and efficient means with which to perform the tactical reconnaissance mission. Literally thousands of electronic gadgets and automatic systems have been investigated to improve the present reconnaissance sensors or replace them altogether. The Army is conducting extensive research on unmanned drone systems as an important part of its combat surveillance project. The Air Force is continually testing new and exotic means of gathering intelligence. Two main important difficulties soon become evident when attempting to rely on the automatic unmanned system: the complexity of the problem of recovering the information quickly and in a form that is immediately usable; and the lack of ability in the automatic systems to discriminate—to sort out the vital information from the mass of unwanted or less important data.

Since under any technique except pure visual reconnaissance a great deal of sorting may in any event have to be done, one might presume that the sorting could best be carried on in an air-conditioned bombproof shelter. But for the automatic unmanned systems the problem of data transmission reduces "home base" sorting to a doubtful value. The automatic unmanned system would be a supersonic vehicle with a great variety of sensors, each contributing its bit to the intelligence picture. This complex would gather more intelligence than could be transmitted within the same time period. Certainly this is true of information at the large scale or high degree of resolution that suits tactical intelligence needs.

For this reason most tactical reconnaissance authorities conclude that during the next few years a great deal of dependence must be placed on a manned, very-high-performance aircraft that is capable of surviving during aerospace conflict. Ideally this would be a two-place aircraft, with one of the aircrew serving as a highly skilled airborne interpreter who operates and monitors the sensors and sifts out for transmission only the information that is critically needed or is of a highly perishable nature, such as data concerning mobile forces on the move.

The survival of such manned tactical reconnaissance aircraft during the era of highly effective surface-to-air and air-to-air missiles presents a complex challenge to research and development. Several different possibilities exist, ranging from the very-high-altitude supersonic aircraft that employs an extensive array of deceptive electronic and infrared countermeasure equipment to the on-the-deck subsonic or supersonic aircraft capable of avoiding enemy detection and kill by means of speed, silence, and maneuverability. The latter choice appears highly attractive to many authorities, but it raises the thought that the enemy can resort to erecting various obstacles, similar to the World War II barrage-balloon defenses, to hinder the minimum-altitude operation of aircraft.

advanced sensors and their employment

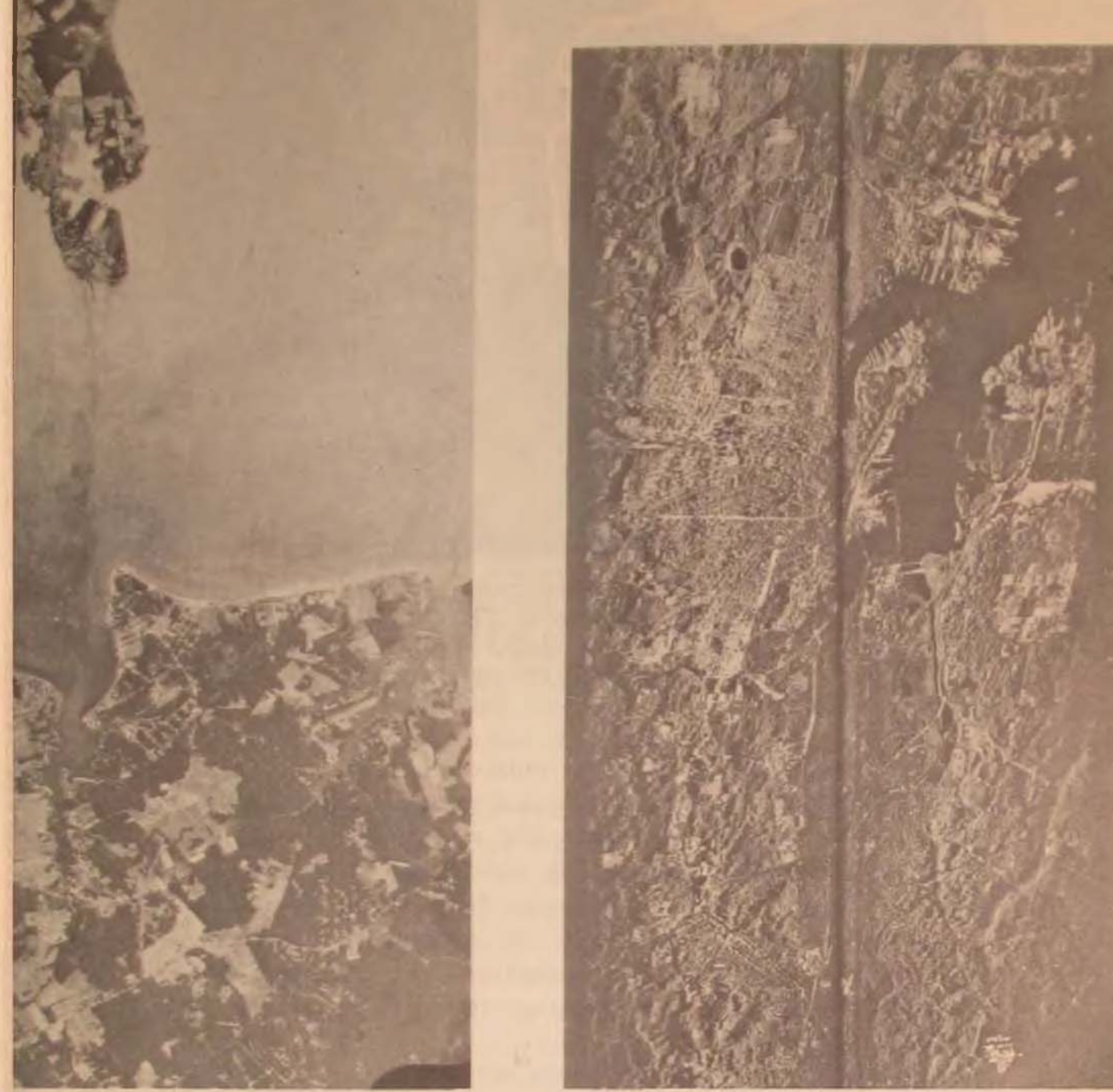
In the past, tactical reconnaissance has been dependent upon clear atmospheric conditions and after dark the use of artificial illumination. Tactical reconnaissance systems have been separated into specialized packages, such as photographic, weather, or electronic-ferret. The aircraft themselves had no armament and thus provided little flexibility for other tactical operations. These limitations, generally true today, should vanish in the near future. With the bilateral introduction of tactical nuclear weapons, traditional operations methods no longer suffice. The enemy's nuclear capability represents a threat of great magnitude that must be destroyed at the earliest instant possible. Rapid and accurate gathering, processing, and assessment of intelligence become highly critical. The introduction of nuclear weapons for small-war targets renders conventional reconnaissance techniques obsolete.

The specific mission flown by an aircraft on reconnaissance is a function of the type of target and the sensing and recording systems installed in the aircraft. A basic and continuing problem is determining the actual size of the target and its distance from the sensor. Anyone who has flown on a clear day at 30,000- to 40,000-foot altitudes realizes that the objects on the ground which can be recognized from this height are of greatly different apparent size than those which can be recognized from a low altitude. In the same manner that the resolving power of the eye varies with distance from the object, the resolution of the reconnaissance sensors varies. Further, at high altitudes the eye is not adversely affected by high speed, but at low altitude it is necessary to concentrate on objects or groups of objects one at a time, since their angular position with respect to the line of vision is rapidly changing. Reconnaissance sensing devices whether visual photographic, radar, or infrared, all have their own peculiar limitations or advantages in resolving power. For example, radar can see reasonably well through most clouds or at night and can record variations in the profile and radar reflectivity of the earth's surface. Infrared sensors that distinguish temperature differences between objects or areas can be used to identify manufacturing plants, power stations, and even moving military equipment such as trucks or tanks. Radar can be designed and adjusted so that it sees targets moving relative to the background and at the same time does not see fixed targets.

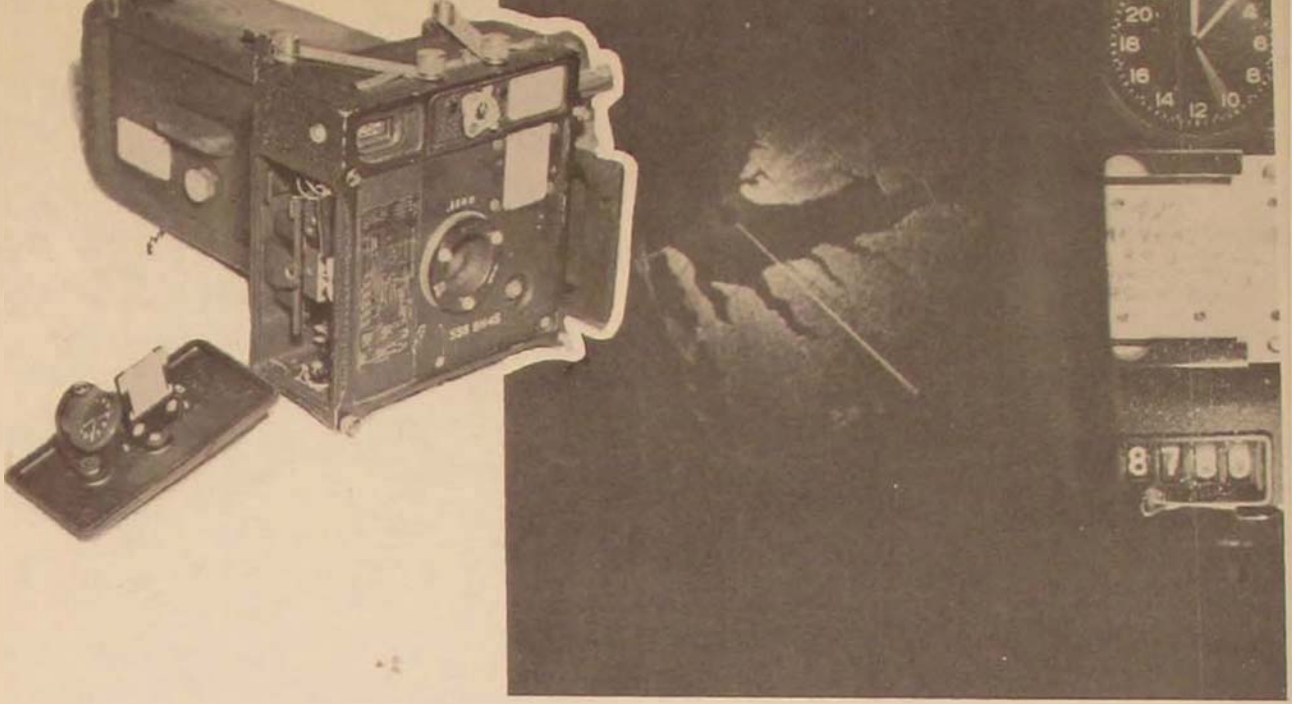
Despite the time lag in processing and the requirement for visibility and proper illumination, the photograph is still an important intelligence source. It offers high acuity and permanency as well as excellent reproduction and interpretation possibilities. For this reason side-looking, high-resolution radar and infrared sensors generally incorporate photographic recording methods. The problem then is to shrink the time lag by processing the film in flight, so that it may be viewed and interpreted in flight. Selected information can then be electronically transmitted, and as follow-up the films can be ejected over the Army or Air Force unit charged with target destruction. To be worthwhile each photograph must include an accurate record of the exact geographical location covered.

Reconnaissance photography as returned by a variety of sensors is exhibited in three comparable views of Baltimore: a conventional aerial photograph (above), an infrared photograph (below), and a side-looking radar photograph (right). The conventional photo is the most detailed but requires clear-weather visibility.

Infrared photography joins radar photography for night and all-weather reconnaissance. Its basis is that all objects of a temperature above absolute zero (—273°C) generate infrared radiation. Since this radiation increases as the fourth power of any increase in absolute temperature, small temperature differences make striking differences in radiation pattern. Though severely attenuated by fog or heavy rain, infrared offers better resolution than radar for certain terrain patterns (as city streets, runways, and other objects with temperature contrast), for definition of critical points in large targets by picking out heat sources (as boiler of ship, pointed to by white arrow), and for spotting moving or camouflaged vehicles. This infrared photo was taken at 10 P.M. from an altitude of 4000 feet. Its coverage is the oblique small rectangle on the conventional photograph.



Side-looking radar is a useful addition to aerial reconnaissance. Radar's degree of resolution depends on pulse length and beam width. Side-looking radar offers the advantage of a very narrow beam, transmitted by two long antennas fixed low on the sides of the fuselage and scanning below and to each side of the aircraft course. Because the beam is narrow and sweeps a spot on the ground only once (as opposed to repeated sweeps by rotating radar) side-looking radar is very difficult to jam. Uses: battlefield surveillance, complex-target intelligence, and radar mapping. At low altitude resolution improves, since azimuth resolution is inversely a function of slant range to the target. The side-looking radar photo above, right, covers the upright large rectangle on the conventional photo.



Radarscope photography is useful for target identification and for orientation. The O-15 radarscope camera with clock and data plate shown above took this scope photo of Albemarle Sound, N.C. The clock indicates time of the photo.

Side-looking, high-resolution radar combined with infrared technique greatly expands the horizons of tactical reconnaissance. Data can be gathered without the necessity of passing the reconnaissance vehicle directly over the target area. When integrated, these sensors also provide a reasonable degree of night and all-weather capability without the use of artificial illumination. For day reconnaissance the addition of a television view finder improves the resolution of the observer's eye. Distances to target may be compensated for, and electronic tape recording is possible for permanency and re-viewing.

All these reconnaissance sensors are well within the present state of the art and have been extensively tested by Army and Air Force research agencies. Combined viewing of the products of these sensors by an airborne observer, together with a highly accurate position-recording system and a suitable map reference of the area being overflown, similar to that provided by the Decca system, makes possible a capability for immediate interpretation and on-the-spot decision never before envisioned. For example let us visualize a typical night mission employing the future tactical reconnaissance aircraft.

The flight path is planned to pass over or near a forested area that is suspect. The normal photographic equipment and the TV view finder offer no capability without artificial illumination, but the aircraft crew knows when the target area is near by observing their flight path on the map-position indicator. The aircraft's high-resolution moving target indicator (MTI) radar scans the area and detects the movement of enemy vehicles within the forest. The infrared scanner simultaneously confirms the same targets by sensing the difference in temperature between the targets and their background. To this capability can be added an automatic, miniaturized, electronic-ferret package designed to search through a specific band of the radio-frequency spectrum that earlier electronic reconnaissance has identified as the one being used for communications by the enemy's armored forces. Similar application is also possible to detect and pinpoint missile-launch and guidance radars, air defense control radars, gun laying, and surface-to-air missile radars. In addition to alerting the aircrew that radar emissions may be interrogating the aircraft, the ferret package may also be automatized to initiate certain electronic-countermeasure protective devices that cause a deceptive decoy image to position on the enemy's radar screens.

The intelligence sensing capability described constitutes a highly accurate tactical target-location system for a completely all-weather strike capability. It can provide a large amount of recorded useful intelligence data at no sacrifice to the basic attack mission. For this reason the combined reconnaissance–strike mission concept comes into sharp focus as an effective method of seeking out and immediately destroying certain classes of enemy targets, such as active missile launch sites and occupied airfields, without further reference to the controlling agency. For complete flexibility and conduct of the pure reconnaissance mission when not required in a strike configuration, the reconnaissance–strike aircraft would carry specialized reconnaissance packages in place of the usual attack ordnance as alternate mission equipment.

THE ultimate tactical reconnaissance aircraft as envisioned will have the facility for world-wide deployment to support the local-war deterrent objectives of the Air Force. Here the needs might cover all types of targets from small guerrilla bands roaming jungle paths to large airport installations and population centers. Mapping terrain and urban features, locating enemy electronic installations, and recording damage from previous attacks would all constitute some phase of the tactical reconnaissance mission in the local war. Tactical reconnaissance in these peripheral areas, many remote from established U.S. bases overseas, demands a modicum of first-class equipment and maintenance support. The aircraft must be capable of sustained operations from forward area bases with very limited support facilities. Although larger, more sophisticated aircraft compound the support problem, the trend is toward such aircraft, and the problem must be met with suitable plug-in pods and miniaturized systems. These pods and systems are now being developed and will introduce greater versatility into tactical reconnaissance operations.

As the Air Force and the Army missile capability grows, tactical reconnaissance forces must keep pace. The nuclear warhead, coupled with a fast-countdown missile, emphasizes the growing requirement for pinpointing targets with ultimate precision and assisting in their immediate destruction when so required.

Headquarters Tactical Air Command

Operational Posture of the Aerospace Force

Major General John K. Hester

It was on 31 March 1949 in Boston that Sir Winston Churchill made his oft-quoted statement: "It is certain that Europe would have been Communized and London under bombardment some time ago but for the deterrent of the atomic bomb in the hands of the United States."

Since those words were spoken, military capabilities have changed relatively, through scientific advancements, varying pressures of world politics, and public opinion. But the basic problem of opposing doctrines remains and forms the framework within which our operational aerospace posture is planned.

Now both the opposing powers have significant numbers of thermonuclear weapons, whereas in 1949 the U.S. alone had the great advantage of a nuclear weapons stockpile. Now both have the ability to deliver the weapons anywhere in the world, while then only the U.S. had any major long-range striking forces. The weapons themselves have been improved and simplified in terms of destructive power, longer shelf life, and immediate availability. Delivery systems have improved to the extent that the time in which plans must be translated into action has been compressed from days to minutes. Although the basic strategic problem of achieving the ability to direct superior firepower on the opposing force has not changed, the technology which determines the means of solving the problem has changed tremendously.

Churchill's statement is still correct, but the Communist decision to substitute bombs for butter in furtherance of their doctrine of world domination has narrowed the margin of advantage which constituted our deterrent at that time. Our problem is to ensure that the deterrent gap never closes and to convince the world that even though the aggressor strikes first we can retain the capability of inflicting unacceptable damage to his opposing military force.

In the late 1940's and early 1950's we faced only a very limited military threat, in that the potential attacker possessed a very small number of nuclear weapons and his delivery vehicles for them were slow and short-ranged. As a result there was only moderate concern over surprise attack on the strategic force, and few passive defense measures were used. Because of the limited range and speed of the B-29 and B-50, some units were deployed to forward overseas areas on a rotation basis, exercising their mobility plans while other units in the U.S. continued normal training and alert status. At the same time the long-range B-36 was introduced into the force, and it could remain stationed in the U.S. Alert status involving several hours for reaction was considered adequate; mobility plans required days to execute and necessitated considerable airlift support; yet against the threat facing us at the time this posture provided deterrence.

The next phase saw the introduction of more substantial numbers of nuclear weapons into the Soviet Air Force, and an increased delivery capability. Faced with this strength, we tightened and extended our warning network, improved our active defense weapons, and started realistically improving passive defense and reaction time of the strike force.

Still more recently jet bombers have more than doubled the speed of the attacker and further complicated our problem. We have reacted with active defense by manned all-weather interceptors, unmanned interceptors (Bomarc), and other ground-to-air missiles. We have pushed our radar warning network farther and farther from our shores through the Distant Early Warning (Dew) Line, airborne early-warning and control aircraft, and picket ships. We have still further refined the passive defense of our counterstrike force. This force has been dispersed to make the aggressor's targeting more difficult, and force reaction time has been reduced to the extent that one third of the bomber force can be airborne on 15 minutes' warning.

These steps as they were applied have provided a high degree of force security against the threat of bomber attack; but the newest introduction into aerospace forces, the intercontinental ballistic missile (ICBM), bypasses all warning devices and defenses against the manned bomber. It should be emphasized that the ICBM threat has not replaced the bomber threat but has been added to it. There is a real requirement that defenses against the bomber be kept responsive for as long as that threat exists; but a defense system against the ballistic missile must also be provided.

The picture of defense against ballistic missiles as of today is not bright, either for us or for a potential aggressor. Although it is a matter of highest national priority and will certainly be resolved, the fact remains that we do not have today an effective anti-ballistic-missile weapon. We have started to build a warning network, and the Ballistic Missile Early Warning System (BMEWS), which is now operational at one of its three sites, will give an average of 15 minutes' warning of ICBM attack, depending on launch site, trajectory, and target. Midas, the missile defense alarm satellite, is designed to detect missiles during the launch phase and thus will add to our warning. BMEWS has no capability, however, against submarine-launched or air-launched ballistic missiles.

Strategic warning of intent to attack is increasingly more difficult to obtain before the attack is launched. Against manned aircraft we might anticipate some strategic warning through detection of preparation for mass attack. Against fueled missiles constantly on alert in growing numbers, we can visualize a situation in which the only prestrike preparation would be the final decision to launch.

We must, then, prepare to meet a situation in which our warning is at best approximately 30 minutes, and at worst zero—the impact of enemy missiles on our territory.

The quick reaction of our strike force from ground alert may no longer be adequate; we have a requirement now for an airborne-alert capability and are taking steps to achieve that capability. Under the airborne alert system, a proportion of the bomber force would be airborne at all times, thus ensuring a force that would survive even a zero-warning attack. The aircraft would be fully combat-loaded and could, on command, proceed directly to preassigned enemy targets. This force would have the advantage of recallability, so that it could be started toward its targets on the basis of very early—perhaps equivocal—warning. In that case, under positive control procedures, at a designated point along his route the aircraft commander must have received a positive message telling him to proceed to target on the authority of the President, or he must turn back to base. Thus a loss of communication with the command center would not result in the bombing of a target after release of the force on what proved to be a false alarm.

The enemy problem of targeting our bomber force can also be made much more difficult by further dispersal. In the past we have used dispersal by unit. Now we think in terms of more extensive dispersal of small numbers of our medium bombers to many of the civil and military airfields throughout the country. This procedure is being tested.

Our ICBM force is being planned and installed with passive defense by several means, to ensure that a major portion of the missile force would survive a surprise attack. Dispersal, protective construction, mobility, and rapid reaction are all used. Some of the systems rely on only one of these measures, while others have the additional security of combining them.

Atlas squadrons are widely dispersed at several bases within the United States, and future construction of missile sites will provide still further dispersal. Missiles within each squadron are also dispersed according to realistic separation criteria, which will require that each missile be individually targeted by an attacker. There are also the missile forces of our allies located overseas, the Polaris submarines under the ocean, the Thor IRBM in Great Britain, and the Jupiter IRBM in Italy.

No protective construction is afforded the current Atlas, but the follow-on Atlas and Titan will have varying degrees of hardening, and the fixed Minuteman will be in widely dispersed, hardened silos. The second configuration of Minuteman will have the benefit of mobility, affording protection through targeting difficulty, and to some extent concealment. These missiles will be carried on railroad trains, utilizing the rail net of the United States as their base. Random movement of the trains throughout the country presents an enemy with the fantastic problem of keeping track of all trains at all times and constantly reprograming his aggressor missiles to the new target locations. Missile units are also designed for fast reaction. Under conditions of tension even the early missiles can be launched in less than ten minutes, and the hardened or mobile Minuteman is expected to have almost instantaneous reaction capability.

As a part of over-all strike force security, provision must also be made to ensure that the command and control structure, from the Commander in Chief, Strategic Air Command, down to the vehicles themselves, is secure and reliable. At this time hardening of command posts and hardening and duplication of communications are being programed. Many other devices, such as airborne command posts, ground-wave transmission systems, and communications satellites, are being investigated to make certain that command control will continue during and after an attack. Continuing aggressive efforts in this direction are certainly warranted and critically necessary.

It is obvious that all these techniques are very expensive and represent a significant proportion of our military expenditures. They are necessary because they make the problem of an attacker more difficult and our deterrence more convincing. Unfortunately they do not solve the most pressing problem—how to destroy attacking missiles before they reach their targets.

Conceptually there are three applications under consideration in resolving the problem of intercepting and destroying hostile ballistic missiles. These applications consider destruction in the re-entry or terminal phase, in the mid-course phase, or in the launch phase of the missile's flight. Each has its possible techniques, advantages, and disadvantages:

- Terminal-phase destruction is currently of great interest, primarily because it appears to be technically achievable in the near future. But it has the disadvantages of the possible nuclear explosions directly over our territory and of its last-chance connotation, in that there would be no chance for a second defensive shot if the first shot failed to destroy.

- Mid-course destruction tends to move the missile battle area away from world populations, but it may involve the addition of permanently stationed satellites in orbit and introduces the difficulty of determining the intent of the missiles so as to provide the unequivocal warning necesary for the command to launch interceptor missiles and the unrecallable missiles of our strike force.

- Launch-phase destruction puts the nuclear blasts clearly over the aggressor's territory where they belong, but it also may involve satellites, further complicates the proof of intent, and reduces the time for command decision. It is possible that considerations of timeliness, cost, reliability, and survival may force us into a mix of weapons such as we have in the manned-bomber defenses. It seems clearly desirable, however, to destroy the hostile missile in the launch or mid-course phase if it is technically feasible.

Whatever the method used, it is imperative that we achieve a truly effective anti-ballistic-missile capability before the potential enemy does. If he beats us in this race, he will have an immediate advantage in that his missile force will still be able to hit us with impunity while our missiles can be killed en route by his counter weapons. Our deterrence would be most seriously downgraded.

In the future, while striving for peace, we shall continue to search for better ways to provide military security. Military planners recognize that technological improvements impose such rapid changes in military equipment that the weapon system currently in use already is obsolescent. As technology provides weapons, it follows with counter weapons, and capabilities are soon faced with counter capabilities. In this context the ballistic missile and the orbital satellite are interim systems which will be countered and replaced by manned spacecraft, capable of maneuvering under human judgment and control. They can provide information as to enemy capability, thus once again giving us the advantage of some degree of strategic warning. They can provide clear and unmistakable warning of the launch of aggressive weapons and employ their own counter weapons to destroy them. They can, if necessary and as ordered, initiate the counterstrike on the enemy's forces.

We need the manned spacecraft, quite simply, because it may afford the advantage of performing the military job quicker and more efficiently. We need to be first to achieve the superiority of manned spacecraft, because this promises to be the next step in the deterrent force of the future.

Throughout the period embraced by this discussion the complexity, expense, and capability of military hardware, and with these the complication of military planning, have increased enormously. We deal with a technology which requires ever more of us and allows us ever decreasing time in which to do our job. Fundamentally, however, our problem has not changed. We are still, as Churchill saw us in 1949, striving to ensure an aerospace posture which will convince a potential aggressor that he cannot, by the use of military force, impose his will. This is our contribution to peace and to the security of the Free World.

Headquarters United States Air Force

Command and Organization of Aerospace Offense and Defense

COLONEL CAMPBELL PALFREY, JR.

COLONEL JAMES W. BOTHWELL

VITAL to an effective aerospace force in the next decade are not only the numbers, composition, and tactics of this force but also—and equally important—how the force is organized and commanded. We contend that a military force should be organized on a functional basis to the maximum extent that the nature and role of the force will allow. This goal is attainable in the strategic offensive and defensive elements of the aerospace force to a degree not possible in most other military activities. After functionally unified commands have been established by bringing together as many functionally similar units as possible, we believe it of prime importance that the closest coordination be fostered and maintained between these separately commanded forces whose activities are closely interrelated and interconnected. In short we feel that our country should possess a singly commanded and unified strategic offensive force and a singly commanded and unified aerospace defensive force, and that both—being functionally different but closely related—should operate under single over-all direction. We shall attempt to show the urgent need that these aims be achieved for our 1960–1970 aerospace force in order to give this force the potency which its critical mission demands.

Providential circumstances seem to have favored our country's armed forces in the past. Despite lack of both unity and real coordination between the services—and even between various branches of the same service—we have managed to survive such reversals as Pearl Harbor and surely if rather ponderously to build and organize a superiority that enabled us, in time, to crush our enemies. If anyone thinks that future conflicts will allow us this sort of time to gird our loins, he is out of touch with reality.

Faulty organization could be the Achilles' heel that costs this country its existence. Here we continue to ignore time-proven, accepted principles. Can it be doubted that single command of functionally organized forces has been held a desirable goal throughout military history? Or that technology, advancing through the centuries, has made singly commanded functional forces increasingly desirable, necessary, and possible? As technology has brought weapons of greater speed, power, range, mobility, penetrative ability, and flexibility—as well as faster, more reliable, and more effective means for command and control—the size and scope of forces under field commanders have grown accordingly. Witness the historical expanding of forces, from those commanded by the earliest tribal chieftains to the huge forces under MacArthur, Eisenhower, and Nimitz.

As mentioned before, there is not only an urgent need for single command of strategic offensive and defensive forces, each under its own functional commander, but also a pressing necessity for the closest interaction under single over-all direction of these commands. The interaction of offense and defense is basic to any consideration concerned with deterring a fight or—if necessary—winning one. This premise is universally understood in the boxing world. It permeates hockey, football, basketball, and practically every other competitive endeavor. The sword and the shield go together. Generally speaking, one is not worth much without the other, but together in complementary roles they can make pretty efficient, if very basic, fighting partners. The effectiveness of interaction between the aerospace offensive and defensive teams will be a big factor in deciding the aerospace battle of the future and thus the outcome of the war.

Single Command of the Strategic Offensive Force

TODAY our nation has only one type of military force whose technological attributes and singleness of mission offer the desired goal of functional unity on a global basis. That force, which now provides the United States' strategic offensive capability, is presently split among various services and commands. It can and should be unified. The Strategic Air Command packs a vast preponderance of our nuclear punch—well over 90 per cent in TNT equivalent. But significant and growing capabilities for the strategic offensive exist in other commands and services. The Commander in Chief, European Command, possesses a substantial number of aircraft which can, should, and undoubtedly will take part in the strategic offensive. The Navy's Polaris, when operational, will most certainly have an important place in the strategic offense. No single commander, however, today tells the various forces what strategic targets to strike and when to strike them.*

The need for single command of the strategic offensive force is certainly not new. The strategic offensive is an operation which can and must be carried out on a global basis—and perhaps sooner than we imagine on a universal basis. Whether strategic weapons are launched from under, on, or above the earth's surface matters little. Nor does it matter whether these weapons reach their targets through space, through the atmosphere, or even by boring holes through the earth. What does matter is that the forces participating in the strategic offensive should be accomplishing a single mission and that the planning and execution of this single mission must be under a single commander.

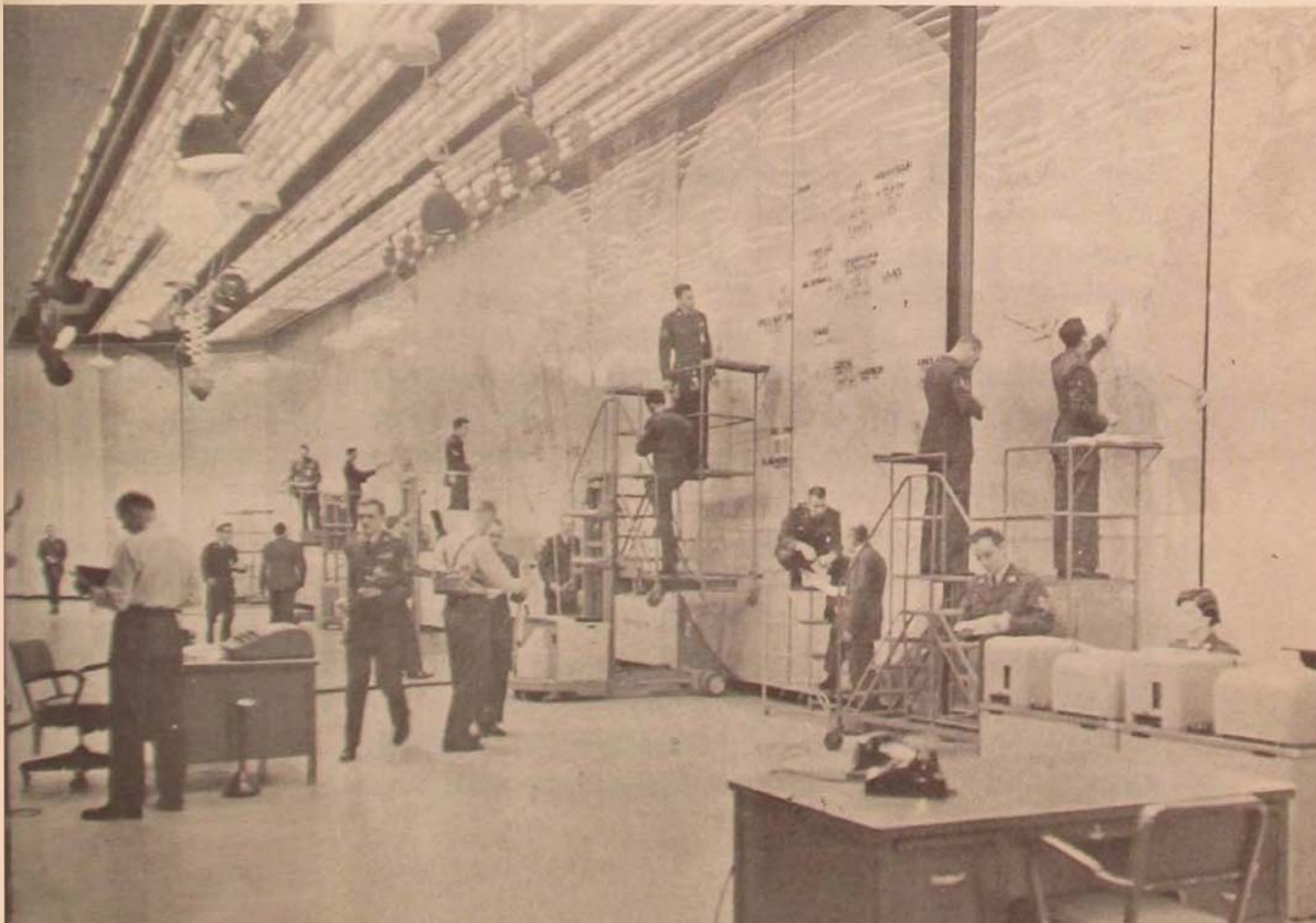
What is the mission of a strategic offensive force? Simply stated, it is

*A decision announced by the Secretary of Defense on 17 August 1960 created a Joint Strategic Target Planning Agency under the directorship of the Commander in Chief, Strategic Air Command. General Power's Deputy Director is a Navy vice admiral. The first assignment of nuclear weapons to strategic targets by this agency was scheduled to be completed in December 1960. It is safe to say that the new targeting procedure is a definite step in the right direction. This central targeting agency may well be the harbinger of the essential functional alignment of forces proposed by the authors.

to be able to destroy the enemy's strategic target system, this system being comprised of those targets which should and can be the subject of preplanning and which together form the vitals of the enemy's capacity and will to wage war. All policy-making authorities in the Government and military may not recognize the fact that this strategic target system exists as an entity, or they may disagree as to what targets constitute the system, but logic tells us that there is such a single system. The task is to identify it accurately and be able to attack it in a timely, effective, optimized manner, with minimum losses to our own side, and exploiting to the fullest the capabilities of each of our strategic weapon systems. Will anyone seriously argue that this single target system should be attacked by completely separate strategic forces carrying out plans made by separate planning authorities?

As a matter of fact there are those who contend that the job can be done in this separate fashion through coordination. In the past this coordination method has not resulted in anything like optimum effectiveness, and there is no assurance of improvement in the future. During the past few years representatives of the various commands possessing an atomic capability have met at irregular intervals at what are known as world-wide coordina-

Modern warfare has made it essential that the strategic offensive forces have a single commander. Only this commander, with all deployment and status information focused on his display boards from a global communications net—as in the SAC command post shown here—can make quick, interrelated decisions committing widely dispersed, complementary forces to a complete yet economical pattern of attack.



tion conferences. Here targeting conflicts that might inhibit rather than aid the strategic offensive were discussed, and attempts were made to resolve them. Any resolution of conflicts had to be by mutual consent, for there was no authority to force agreement. Importantly, these conferences have been held not to promulgate new plans but in actuality to compare plans already made by separate authorities. With each represented commander having a prime concern for his own duties and responsibilities and the security of his own forces, it is not difficult to see why little progress has been made. Results of these world-wide coordination conferences have been educational to a degree, but uniformly disappointing. In essence these attempts have not succeeded because of organizational arrangements that allow overlapping and duplicative roles and because of separate planning, after-the-fact coordination, and lack of exercise of over-all authority. Our ever increasing stockpile of weapons, growing and duplicative strategic attack capabilities, and broad and overlapping mission assignments will add complexity to an already vexing problem if we continue under our present system. Future strategic weapon systems of fantastically increased speed, range, power, flexibility, and reaction capability will bury once and for all any anachronistic ideas concerning coordination as a substitute for single command of the strategic offensive.

Since coordination alone cannot result in an effective strategic offensive force, why can we not compromise a bit with the idea of having a single commander and instead have a committee of appropriate representation to fill the command gap? For the required integration of our strategic effort we need targeting know-how, single execution authority, directed weight of effort, before-the-fact planning, secure and effective communications, weapon systems that supplement and complement each other, and a recognized singleness of mission.

Can we achieve these goals by committee action? Committees are suitable, and often necessary, for exploring, for counseling, for recommending; but by their very nature they are inherently incapable of continuing direction of an activity of real complexity. This is particularly true when they are composed of members of diverse backgrounds and strong beliefs, however honest, patriotic, and competent they may be. There is a very real need for committees, and the committee concept will be of great value in its proper role within a single strategic offensive command. As someone has remarked, though, a camel is a horse that was designed by a committee; and decisions on complex major questions upon which the very existence of our country depends must be made by a commander—even if based on advice given him by one or more committees.

Because of the very nature of their proper role and function, the Joint Chiefs of Staff cannot reasonably be expected to fill the command void and take over the actual detailed planning and execution of the strategic offensive. Lack of an appropriate staff, lack of prompt command action inherent in any group, and required continuing modifications of strategic plans all militate against the Joint Chiefs of Staff exercising active command of the strategic offensive force.

Other factors urging us toward single command of the strategic offensive force stem from the speed and degree of surprise with which our adversaries may be capable of attacking us. This warning problem bears heavily on command considerations. Our national policy of deterrence probably denies to us the huge advantage of surprise. This denial is the price we pay for something we as a nation believe in strongly, and we would not have it otherwise. Be that as it may, the fact that the denial offers the adversary the tremendously favorable circumstance of surprise onslaught must be faced, and we must solve the serious problems thus posed to us.

These problems are inextricably tied in with the communications difficulties inherent in any situation where contact must be speedy, clear, and absolutely reliable. If war ever comes, friendly warning devices must detect and identify enemy attack weapons and then transmit warning and alert information to the appropriate control authority. There speedy but extremely accurate decisions must be made, and they must be transmitted rapidly and reliably to the operating forces. Each additional decision-making authority and each additional communication link detracts from the speed, reliability, and precision so desperately needed at a critical time. These processes, recently measured in hours and now in minutes, will have to be accomplished in seconds. Strategic plans, carefully laid out in advance and tested time and again in realistic exercises of the whole force, will have to be implemented immediately. These plans must set into motion the units of our strategic offensive force—whether they be based above, on, or under the surface of the globe. There must be one chain of command in the strategic offensive function, making the decisions and transmitting them to the operating forces quickly and surely.

If we were to grant for the moment that the needed degree of strategic planning effectiveness can be obtained in peacetime by coordination alone—and that assumption exceeds reasonable bounds, for such has not been the case—we must face the fact that coordination (as a substitute for single command) cannot possibly be effective when the chips are down and this country is counterattacking with whatever forces survive an initial surprise attack by masses of enemy weapon systems.

Depending on when such an event occurs and the efficiency with which it is executed, our strategic offensive forces would have varying numbers and types of weapon systems available for strike. The numbers and types will depend on the answers to many questions. Will we have guaranteed, reliable, usable warning? If so, our ground-alert forces and perhaps our follow-on forces will be potent factors indeed. If not, for the sake of our country we had better have hundreds of weapons in the bays of airborne-alert heavy bombers, at least until we achieve significant quantities of other highly survivable offensive systems. Will such attack come at a time when we have substantial numbers of mobile Minutemen? How many of our hardened missiles will survive? How many of our Polaris submarines—a very welcome addition to a diversified strategic offensive force—will be caught in port or at tender, and how many will have been tracked and located for destruction by the enemy during the weeks before his attack? The response to these and many other similar questions will determine what portion of our strategic force will, in actuality, be able to strike.

Unfortunately the answers will not and cannot be forthcoming until after the event. Then big decisions must be made; they must be made fast and right. With the country under attack by multimegaton weapons, the mere idea of coordinating strategic strikes by separate forces is ridiculously unrealistic. If there is not strong unity of command at that time, there simply cannot be effective counterattack—even in the initial phase in carrying out carefully preplanned actions, much less in the subsequent phase when reconnaissance must feed information to a central authority for restrike planning. The inevitable result, if there is not single command, will be a combination of overdestruction and underdestruction—in other words, a strategic effort that falls short of what it could and should be. And if the enemy foresees inept counterattack, there is no deterrence. It is the same old story. If he knows we can strike effectively, we shall probably never have to.

Another pressing reason for single command of this functionally organized force has to do with optimizing the make-up of our strategic offensive force. A very happy—and sorely needed—result of single command of our strategic offensive force will be centralized determination of the force-structure requirement. Insofar as strategic weapon systems compete with each other rather than complement and supplement each other, they detract from our country's power rather than add to it.

As the cost and complexity of weapon systems continue to increase at an ever quickening rate, there will hardly be enough money and scientific talent in the whole world, much less in our country, to support the multi-duplicative programs we have seen. This country must spend whatever is required to maintain an adequate deterrent margin. Diversity in our weapon systems, both manned and unmanned, is essential; but redundancy is a luxury no country can afford. A proper ratio, or mix, of various weapon systems in our strategic inventory is highly important. This ratio will change more or less continually. To determine the proper make-up of this mix in terms of numbers and types of weapon systems, and then to monitor these systems through the design and development stages into the operational inventory, will be a huge task. The grab-bag, racing-off-in-all-directions-at-once technique just cannot be tolerated. For pressing reasons of both economy and strategic effectiveness, our country needs centralized determination of requirements for strategic weapon systems.

As we said before, how our strategic offensive force is organized and commanded is as important as the type and quantity of the weapon systems that make up the force. Having discussed the impact of single command on force structure, let us see how command considerations can affect other aspects of deterrence.

First let us take a quick look at what we mean by deterrence. To deter, Mr. Webster says, is "to prevent from action through fear of consequences." What "action" do we seek to prevent? Is it an all-out attack on the United States? Does it include the initiation of limited war? Does it also take in unacceptable aggressive acts short of war by an enemy, wherever they may occur? The answer to all these questions is a resounding "Yes!" Any deterrence short of preventing these actions is really no deterrence at all and would eventually leave the United States isolated, insulated, and impotent.

One aspect of deterrence that can be stated with complete assurance is that it is not a static condition. Deterrence is made up of many factors, some of which are under our control and some of which are not. For example, it is rather doubtful that we can alter certain environmental factors in the lives of key Soviet leaders. Certainly their domestic affairs and the states of their digestions have a real bearing upon their emotions, which in turn have an equally real bearing on such attributes as pugnacity, recklessness, confidence, calm, etc. There are other fields, however, where we can strongly affect their attitudes of audacity or caution. In such fields we must strive mightily to dissuade them from taking disastrous steps. They must be made to feel that these actions will bring them only catastrophe. The strategic offensive force, wisely used in this area, not only is our chief deterrent to war but also serves as a potent tool in day-to-day international political dealings.

Soviet leaders are quite aware that numbers of weapon systems alone will not spell doom for them. How these weapon systems are commanded and controlled will determine whether we can strike effectively or whether our commitment of forces can only be piecemeal and impotent. This organizational factor adds to or detracts immeasurably from our deterrent posture. And the deterrent posture of this nation may well decide whether or not this planet becomes one vast slave-labor camp in the future. With this fate in the balance, neither tradition nor sentiment nor timeworn myth should speak in deciding whether we shall have a truly functionally organized and singly commanded strategic offensive force.

If we can achieve a singly commanded, functionally organized United States strategic offensive force, the next logical step would be a Free World strategic offensive force. This project would involve many complex international problems, but they should by no means be insurmountable. Such a step could only be taken after we have put our own house in order, and it is alluded to only as a prospect.

The Necessity for Single Command of the Aerospace Defense Force

SINGLE command of military operations means many things to many people. It can mean merely top-level policy and guidance from a combined intergovernmental group. To some it means complete integration of various service and international components at all echelons, with a single individual exercising command. Another group defines it as operational control of combat functions.

For aerospace defense of the United States, we believe that single command must mean centralized control and decentralized execution. This concept is in effect to some extent today. Tomorrow it must prevail for the reasons that we will discuss. This single-command philosophy means giving one commander—the Commander in Chief, North American Air Defense Command—necessary responsibility and authority to state requirements, to develop concepts, to specify deployments, and to direct engagement of the enemy. It also means acceptance by all concerned of a common doctrine and knowledge of basic principles underlying the doctrine. Today aerospace defense is plagued with service bias, and we do not have a common creed. Single command does not demand or imply that a single commander evaluate each radar sighting, identify each possible enemy vehicle, or order each engagement. Execution of these and many other tasks is decentralized in good and sound order to most effective levels.

Single command of aerospace defense, as used in this discussion, does not disregard sovereignty considerations or presuppose a global functional defense organization. It is concerned with concepts, not geographical specifics.

Why is single command of aerospace defense so important now and in the future? There are many reasons, of which three stand out: the element of time in warfare of the future, the effects of advancing technology, and economy. Let us look at what these factors mean to aerospace defense.

Defense is part of deterrence now and must continue in this role. The aerospace defense force of the future must be designed to aid in the deterrence of attack and to react against the enemy's weapons if he should attack. Functionally defense must continue to detect, identify (and warn), intercept, and destroy or neutralize the attack.

Although there will be no foreseeable change in these aerospace defense functions, some modifications in the dimensions of time and geography are now apparent and more will develop. As the enemy develops new capabilities to attack the U.S. with aerospace weapons, the defense force must improve commensurately.

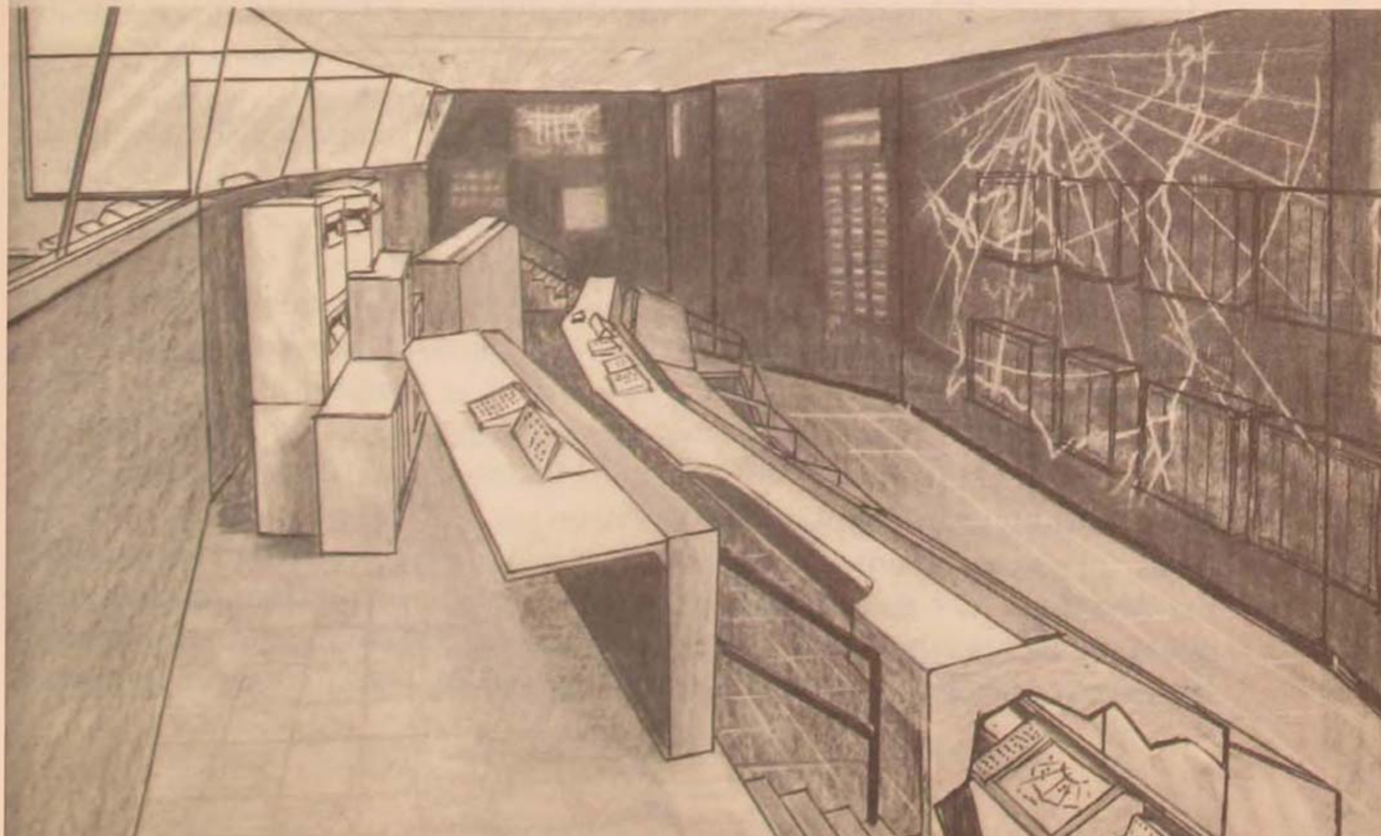
Defense in the aerospace age will continue to be a reactive type of operation. Unidentified or enemy attacking forces are detected; the defense reacts and takes appropriate action. Because of this sequence or reaction requirement, aerospace defense is particularly sensitive to changes in the amount of time available to carry out its functions. The time element in military operations, with all its ramifications, overshadows all others in consideration of single command of the aerospace defense force.

In the context of aerospace defense, people and governments react and decide at about the same rate today as they did ten years ago. It appears that no major change can be forecast for the next ten years. On the other hand technology is advancing at a tremendous pace, particularly in speed of weapons. Military situations that developed and were acted on over a matter of years, days, or hours in the past are now measured in minutes and seconds. This compression of time demands direct and simple high-level decisions, engendered by single command of all phases of aerospace defense. In past wars there have been numerous decision points. In the future there will be only one; the point at which hostilities are initiated is also the point of decision.

The element of time has a marked influence in the execution of decisions and, correspondingly, on the organizational structure involved. In terms of speed, defense in the near future must engage enemy vehicles traveling at thousands of miles per hour. This is many orders of magnitude different from the problem posed by a mach-1 or mach-2 bomber. In practice this new dimension of speed means that detection, identification (warning), interception, and destruction of hostile aerospace vehicles must now and in the future take place in scant fractions of the time we have thought of before. In a sense, defense will become a "mousetrap" operation: the very offensive enemy action itself triggers the mechanism that defends. Whereas with systems such as the Dew Line times on the order of from one to three hours would be available to complete all defensive functions against a typical modern bomber, the maximum possible time for defensive action against an ICBM is 30 minutes or less.

The factor of time also applies to the cumulative defense problem. When an offensive force was limited to slow delivery systems and high-explosive (HE) bombs, many sorties were required by an offensive force to achieve any substantial objective. Under such conditions defense could hold many councils of war and could change strategies, deployments, and tactics over a period of days or perhaps months. Mutual support between different national, area, or service organizations could be achieved by coordination. New tactics could be chosen by trial and error. Today advances in technol-

Aerospace defense, now continental in area, spatial in depth, and split-second in timing, must have a single commander of all aerospace defense forces. Only one man, able to view the entire, vast air battle as a whole—as the NORAD commander does from the NORAD Combat Operations Center depicted here—can instantaneously deploy and maneuver all the dispersed, complementary forces to meet the attack



ogy, particularly in speed of vehicles and in the probability of fantastically high-yield weapons, end the era wherein coordination was the accepted doctrine.

Single command of effort in aerospace defense is a logical evolution of fundamental organization–technology relationships and principles. As weapons and means of waging war change, so do organizations. Where forces can operate only under the eye of the commander, so to speak, control is relatively simple and decisions affect only a small area. But as the range and capability of forces become greater—as when the cavalry went from the horse to the tank and the navy from the battleship to the carrier—the need for an organization to provide centralized direction becomes apparent. Specifically in aerospace defense, equipments and weapons that can intercept ballistic missiles, satellites, or advanced air-breathing vehicles will operate at great distances from their bases. Unanimity and coherence of action by these operational forces are possible only if their direction is centralized under a single commander.

Probably the clearest way of visualizing why single command of defense elements is so important in light of continued advances in technology is to picture a situation where many missiles are detected by means of a satellite warning system a few seconds after launch from hostile territory. Obviously it is difficult to pinpoint exactly where they are going to land—and correspondingly difficult to know how much time will be available to intercept and destroy. To take advantage of this early detection by making maximum use of the limited time available, extremely quick-reacting and long-range defense weapons must be employed. A similar situation can be envisioned wherein westbound, unidentified bombers are detected approaching the "iron curtain" in Germany.

The first and perhaps only evaluation possible for either the missile or bomber example will be to identify, in a gross sort of way, possible impact areas: North America, western Europe, England, etc. If at this point, because of conceptual differences (area or point defense, for instance), sovereign rights, or other reasons, various defense commanders must coordinate to see who takes what action, the chances of defense doing its part of the over-all task effectively are pretty slim. Great courage of conviction will be absolutely necessary for the decisions that will have to be made—if the defense is called upon in an active way. Less than the utmost in directness and simplicity of command for the defense of major areas of the world could be disastrous.

Economy is one of the most evident advantages of single command of aerospace defense. Even the best coordination in building and operating the elaborate components of an air defense system as complex as the one today in the U.S. and Canada leaves much to be desired. As pointed out previously, the job for the future will continue to encompass detection, identification (warning), interception, and destruction. All these functions must be done, they must be done faster, and they must be as nearly right as possible the first time. The cost in dollars, know-how, and capability to operate various components is climbing at a rate that demands elimination of unnecessary overlap and duplication. Single command of aerospace defense operations will eliminate unnecessary duplication of aerospace tracking and cataloging facilities. It will help obtain optimum identification procedures. A single source for planning will also ensure that separate weapon systems, command and control systems, radars, or other sensing and guiding equipments are not procured to support parochial interests or for reasons stemming from lack of coordination. Savings in manpower and operating expenses go hand in hand with having a single commander of aerospace defense.

Single Over-all Direction of the Offense and Defense

Heretofore we have discussed the need for single command of the strategic offensive force and for single command of the aerospace defensive force. Why, now, when considering the relationship between these two forces, will we speak of "close interaction" between them rather than advocate their union under a single commander? The answer lies in the fact that these forces are quite different functionally and hence do not lend themselves to union in a single active command. We shall see, however, that their activities are such as to require the very closest interaction under single over-all direction.

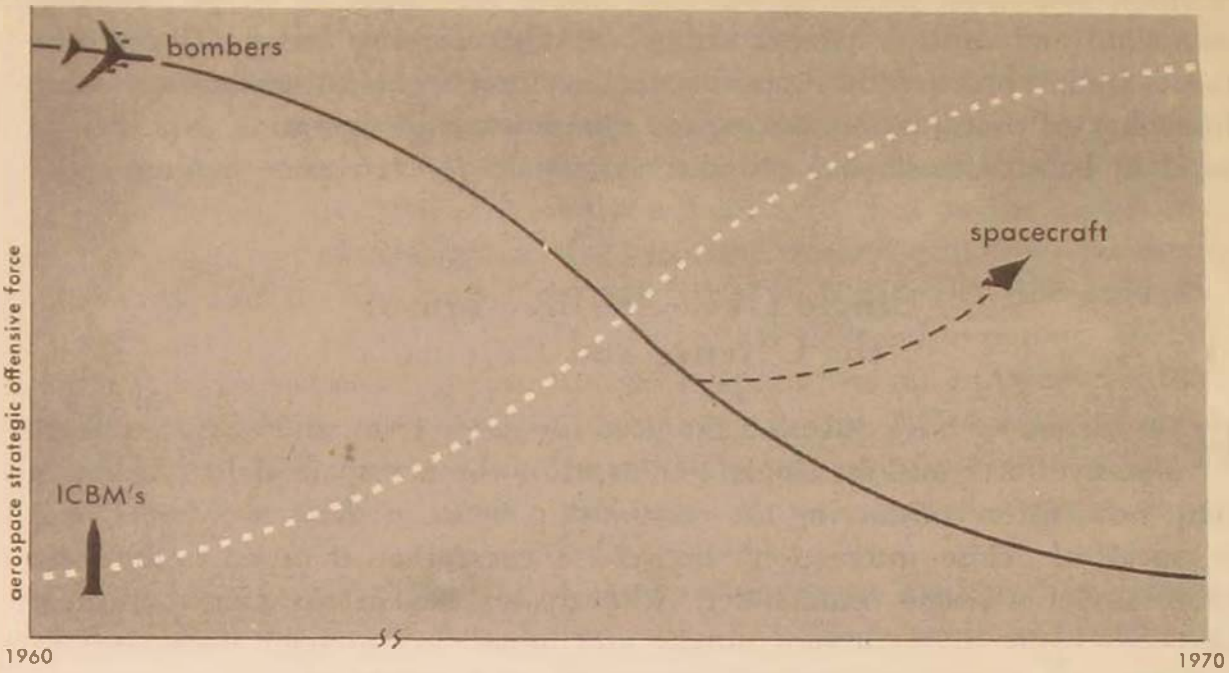
Although the detailed missions of offense and defense are not identical, the over-all objective of both is the same: to deter war, and, in the event hostilities eventuate, to defeat the enemy. In aerospace operations this common objective necessitates the very closest interaction between offense and defense in planning and execution.

In a sense, this need for interaction establishes an inseparable partnership between our strategic offensive forces and aerospace defense forces both in the deterrent role and during actual operations.

The main ingredient of our deterrent philosophy—the ability of our strategic offensive force to strike with war-winning strength—is characterized by diversification of weapon types and delivery means, by dispersed deployments, and by the ability to "go" when needed. Tactical warning, a defense responsibility, provides a basis for the "go" decision. Active elements of defense also interact with the offense in deterrence by preventing the enemy from mathematically calculating his chances of success. In other words, active defense prevents the "free ride." The existence of our defense compels the enemy to build greater numbers of more elaborate, complex, and costly strike weapons for overcoming it. All these factors raise the price of admission for the enemy, thus detracting from his own defensive efforts against our offensive forces. This detraction from his defense in turn increases the net deterrent capability of our strike forces.

Our offensive weapon systems must not be subject to losses through misdirected friendly defensive actions. Nor can we dilute the defensive strength of our over-all aerospace force by actions against friendly weapon systems. For example, by engaging and perhaps destroying friendly forces (possible if unidentified and within attacking range), our fighters or missiles would be

Probable Trend in
Strategic Offensive Force Mix



Another argument in favor of single command over all strategic offensive forces is the increasing urgency of constant, consistent evaluation and decision on the proper mix in our strategic aerospace forces. Consistent with a steady, maximum national posture, at what point in time and technological progress should the manned bomber relinquish the principal role in the force to the ballistic missile? When, to what extent, and how should the new space systems be integrated into the force? The security and the economy of the Nation may well depend on the answers.

helping the enemy. Or if our interceptors destroyed tanker aircraft returning to their bases to recycle and refuel other waves of our bombers, large gaps in our offense would result. This cannot be allowed to happen. Only very close interaction can prevent it.

The partnership between offense and defense that must exist needs single direction at a level above both forces. How time affects the offensive and defensive functions has been discussed. The same philosophy and rationale also apply to interaction between them. The need for common aerospace doctrine has long existed; the need for interlocking and simultaneous execution by separate functional forces of tasks based on common doctrine is only now coming to the fore. As the element of time shortens, many of the actions that combine to provide aerospace power must be performed all at once. The situation resembles a concert—only by playing their instrumental parts taken from the same score do all the musicians know what and when to play to achieve harmony instead of discord.

Today extensive plans exist among various offensive and defensive elements covering exit and recovery of strike forces. All these efforts are of the cooperation and coordination type. Months and even years are required to reach agreements or to make changes. As reaction times shorten, so must the time required to make decisions. The answer lies in active and effective single over-all direction of strategic offensive and aerospace defensive forces at a level above the active command of each force.

A Look Further Ahead

MILITARY organization and weapon requirements have always followed technology. This pattern will continue as new aircraft, missiles, and spacecraft are conceived and developed. Men resist change. It is natural to feel a sense of uneasiness when familiar equipment and familiar ways of doing things become obsolescent or obsolete. A real danger facing those responsible for over-all military organization and strategy is a misguided loyalty to the "good old days"—to past stages of our growth. Weapon systems have changed and will continue to change, and so must the organizational setup needed for winning the strategic offensive and for controlling aerospace.

As we progress further into the aerospace age it may become increasingly difficult to organize for separate military tasks with the degree of functional refinement now recognized and required. Operation of satellite communication systems, for example, will serve the entire community, and there will be extensive sharing between military and civilian agencies to prevent duplication and reduce costs.

There is a growing similarity in equipments being designed for different aerospace purposes. The Midas system is an excellent current example. In the near future one can envision requirements for manned and unmanned vehicles that are quite similar and perform many other space tasks, such as maintenance of equipment, transportation of personnel, and inspection of unidentified objects.

Ground command-and-control elements will be completely interlaced. Launch facilities for space vehicles will serve many civilian and military needs. Large boosters can be used with any number of different payloads. What does all this lead to? Is there a recognizable next step in organization beyond that previously discussed?

The attempt to answer reveals a challenging thought. Time is forcing greater interaction between military operating elements. Technology points to multipurpose equipments. Economy dictates prudent use of available resources. Perhaps inevitably the answer will be a merger of strategic offense and aerospace defense into a single strategic organization. The logic is clear when, for instance, during hostilities it becomes only a delicate matter of timing whether interception and destruction of a hostile space object is by an offensive strike at its launch base or by a defensive action against it as an attacking target.

Headquarters Strategic Air Command
and
Headquarters Air Defense Command

Effective Aerospace Power

1.

Deterrence: The Hard Questions

BRIGADIER GENERAL NOEL F. PARRISH

THE WORD "deterrence" stems from the same root as the word "terror," and its basic meaning is "to turn aside, restrain or discourage through fear." The deterrent concept as it developed in this country and in England followed the meaning of the word. It was simply the idea of preventing an action by posing the threat of a counteraction.

Like many overworked abstractions the concept of deterrence has now served as a grindstone for many axes. Its consequent deformation has somehow escaped notice. A review of the rapid shifts in the meaning attached to this word over the past few years is revealing.

From the beginning, deterrence had to mean more than mere resistance. It meant a prepared riposte of sufficient strength to inspire fear. When the Soviets after 1946 began to add territory through the pressure of their huge armies, they had to be deterred by the threat of military reaction. They were certainly not vulnerable to a counterinvasion or to blockade. The only counteraction they had reason to fear was air action. Because the United States possessed atomic bombs in sufficient numbers and the aircraft to deliver them anywhere on the globe, this counterthreat of air action was fearful enough to "discourage" further conquests by land armies.

It was this situation that inspired Winston Churchill's famous statement on 31 March 1949:

> I must not conceal from you the truth as I see it. It is certain that Europe would have been communized and London under bombardment some time ago but for the deterrent of the atomic bomb in the hands of the United States.

This was the most important early use of the word "deterrent" in the broad sense in which it was to be used in the succeeding ten years. Churchill's term was soon repeated in this country by Secretary of Defense Louis Johnson in June 1949 at the National War College:

> . . . [air power] has passed through a period of adolescence to find maturity in a concept of strategic air bombardment. Thus the threat of instant retaliation through an air offensive has become one of the greatest deterrents to war today.

It is interesting that Johnson used the phrase "deterrents to war." Churchill had spoken of a deterrent to Communization as well as to war. Communization without war had occurred in the case of Czechoslovakia in

1947. But when the road to Berlin was blocked a year later, the United States firmly determined to counter the pressure of Red superiority on land and immediately moved two squadrons of B-29's to England. This was the first overseas deployment of an important segment of U.S. power, other than occupation forces, since World War II. Mr. James Forrestal, then Secretary of Defense, explains very clearly in his published diary how completely dependent were the United States and the Free World on this counter to the threatened Communization of Berlin. Czechoslovakia had been lost without war; Berlin had been saved without war. So Churchill's reference to a deterrent against a Communist takeover was more accurate than Johnson's "deterrent to war."

Churchill, rather than Johnson, was again proved right when war was necessary to prevent a Communist takeover of South Korea. This event made it clear that our deterrent must be more than simply a deterrent to war. Certainly the Communists had no intention of getting into a war with the United States in South Korea. All they wanted was South Korea. President Truman surprised them when he decided that military force must be used if necessary to keep them from having it. As Churchill had indicated, deterrence was already a far more complicated problem than just deterrence of war. We were somehow deterred from using our most effective weapons while the Communists were not deterred from employing their unlimited manpower.

AFTER the beginning of the Korean War it was the practice to say that atomic weapons were a "deterrent to World War III." A considerable war was being fought, and these weapons were not being used. "Deterrence" had become a popular word, so it was not abandoned. Instead, its meaning was narrowed. General Hoyt Vandenberg stated at a Senate hearing in May 1951 that "the United States Air Force had, in my opinion, prevented the enlargement of the Korean conflict into World War III."

The dread of atomic war had already risen to such a point that the nonatomic "conflict" seemed relatively unimportant. The dread continued to rise, and it prevented the use of atomic weapons to save the French in northern Indo-China. This second failure to use the atomic weapon to prevent stalemate or defeat in conventional warfare led Denis Healy, a prominent member of the British Parliament, to summarize the matter neatly:

> It cannot be denied that the deterrent value of atomic striking power has seriously depreciated through the West's proved reluctance to use it. From the experience of the last five years, it would appear that a general threat of atomic retaliation may well invite the Communists to prove Western intentions by local military adventures.

Nevertheless after the defeat in Indo-China was written off at the Geneva Conference, it faded from public consciousness. The old theory that nuclear bombs are a deterrent to "war," per se, was revived. This revival was a necessary outgrowth of Secretary of Defense Charles Wilson's doctrine of "more bang for a buck" and his tendency to boast of the increased power of a reduced Air Force. Wilson's claim of increased effectiveness depended almost entirely on the production of more powerful nuclear weapons. Wilson and his fellow spokesmen seemed convinced that a simple increase in the area of destruction that our weapons could produce would deter war completely. The fact that the Russians were also producing more powerful weapons was flatly ignored.

The most explicit of these spokesmen was Secretary of the Air Force Donald Quarles (later Under Secretary of Defense), who made maximum use of the theory that merely increasing the terror of warfare would prevent any kind of war because any kind of war would surely develop into the most terrible kind of warfare possible. He often repeated this theme:

> . . . It seems clear to me that war between nuclear powers will be or will become an all-out nuclear war and that neither side can emerge from such a war with anything that can be called victory. . . .

This was a shaky premise indeed. It was resisted by many Army and Navy spokesmen, as well as some civilian theorists, such as Henry Kissinger, who argued that there could be such a thing as graduated deterrence involving packages of forces (mostly land and naval) to act as "fire brigades." These packaged forces, they said, could extinguish "brush-fire wars" or somehow "limit" wars which could not be "extinguished." Their theory was, and is, that so-called "limited wars" are not limited by superior strategic power. They ignored the fact that superior air and atomic power had limited the action of the Chinese Communist Air Force and enabled our troops to operate congested ports and supply lines in Korea without being bombed. They saw the Korean War "limited" principally by the presence of our numerically inferior ground forces, "supported" by sea and air forces.

It was during this period that all types of military organizations began announcing that they were "deterrent forces." The whole concept was rendered almost meaningless through its application to every kind of uniformed aggregation. It was often said that our land forces, our naval forces, our support forces—in fact everything we possessed—were part of the "deterrent." This application of the word to practically every military agency, and many civilian agencies, seemed to make them all happy. Since the meaning of a word can be inflated without financial loss, such inflation of "good" words is probably inevitable.

At this point the whole theory of deterring "limited" wars and "general" wars became rather confused, and so it remains today. There is talk of "limiting" local conflicts by conventional fighting and also talk of limiting them by atomic weapons seldom or sparsely employed by our side and never employed by the enemy. Army spokesmen, such as Secretary Wilber Brucker, painted a picture of deterring big wars by fighting little wars, while Mr. Quarles and others were speaking of deterring little wars entirely by the threat that they might become big wars.

It is easy to understand how the public confusion on these matters matches the professional contradictions. As years of relative peace go by, the hope arises that no wars of any kind need ever be fought. There are those who argue that the destructive power of the modern armament in our hands today deters war, and there are those who argue that war will be less likely if we give up these weapons. Strangely enough, it is often the same people who advance both these contradictory arguments.

There are those who argue that small "mobile" forces are the best guarantee against big wars because they prevent little ones from spreading. The majority, however, of those who speak of deterrence today have returned to the original position that was developed when atomic weapons were scarce in the Soviet Union. They maintain that the increasing destructiveness of modern air weapons deters all forms of war through the threat of devastation, although the devastation might now be mutual.

THE hardest question of all is what happens when an enemy, who was said to be deterred by superior weapons in our hands, begins to build similar weapons more rapidly than we. As we have seen, for a period of some ten years, from 1947 to 1957, the theory of deterrence, regardless of its ramifications and complications, was basically the theory that an enemy can be deterred from all types of aggression as long as we possess superior forces to defeat him at some higher level of conflict.

Mr. Finletter, General Vandenberg, and others repeatedly stated that in order to deter effectively our best weapons must be clearly superior to the enemy's weapons. Beginning in 1954, however, this position was undermined by an argument that we can somehow deter without matching our enemies man for man, or plane for plane, or missile for missile.

This new challenge to the theory of deterrence brought about a sudden and significant shrinkage in the meaning of the word. No longer did it mean deterring the Soviets from attacking our vulnerable allies or from pressuring, compromising, and Communizing them. Deterrence came to mean deterring a direct Russian attack against the United States itself. When the word is used today, it is almost always used in this new and very restricted sense.

If we are to be satisfied with an inferior force, and if this inferior force is to be, by our own choice, subjected to an initial Communist attack, then we can look forward to having very little residual strength for aiding our allies. If we once deterred, as we said we did, through the superiority of our forces, then an acceptance of the superiority of Communist forces would necessarily mean that we ourselves are deterred.

Our most important allies occupy areas that can be easily and quickly overrun by Communist land forces unless such a movement is stopped by powerful weapons that can be delivered very quickly. If responses of this type are ruled out, we must be satisfied with forces capable only of a desperate counterblow in case we are attacked directly. Then it is the United States that is deterred from carrying out its 14-year-old policy of containing Communist aggression by the threat of effective countermeasures.

IT SEEMS quite clear that we should now cease being complacent about a deterrent that can do no more than discourage a direct atomic attack against the United States. The real and present problem is to develop a force which could resist such an attack and still be strong enough to overwhelm an enemy, not merely damage him less than we ourselves are damaged. Our force has to be able to defeat an enemy and not merely to bring a superior enemy force down on our own heads.

Deterrence can be compromised in some degree by counterdeterrence, even where the counterdeterrence is inferior. Counterdeterrence has been an increasing problem for the past ten years. If the counterdeterrent force raised against us should become superior to our original deterrent force, then we would indeed be in trouble.

We do want to deter war and maintain peace, but we want to do it without abandoning the rest of the world to Communist pressures and penetrations. Those who have argued that we can achieve these aims without surpassing the Communists in the size and effectiveness of our most powerful forces have left all the hard questions unanswered. The answers will have to be provided, both in theory and in substance. The cost may be high, but the cost of procrastination will be higher.

Headquarters United States Air Force

2.

Counterforce

Lieutenant Colonel Donald F. Martin

DETERRENCE of war is a primary national objective. General nuclear war has been called "self-defeating" because the attacking nation as well as the defending nation would be "destroyed." Words like "holocaust," "mutual homicide" (preferred by some to the inaccurate term "mutual suicide"), "mutual annihilation," and "Armageddon," are used to describe the utter futility and finality of total nuclear war.

A common image of general nuclear war is one of a contest of carnage. The results of such a conflict are believed to be so terrible that most people can visualize only one massive exchange of destruction so enormous as to be beyond comprehension. The horror of such a vision is so repelling that it causes one to reject general nuclear war as impossible.

As part of this feeling, the fact that no general nuclear war has yet occurred is sometimes offered as proof that "deterrence through terror" really works. But for the military, and in particular the Air Force, which would have to employ most of these "terrible weapons of mass destruction," such a cursory examination of the problem is not enough. It is our responsibility to make a much more penetrating analysis of this thesis in an effort to determine its validity.

While most people agree with the intent of deterrence, there is a tremendous difference of opinion as to how we can achieve it. The two most contradictory views are (1) deterrence through indiscriminate terror, and (2) deterrence through military superiority. Deterrence through terror emphasizes and maximizes death and destruction. It is based on the assumption that because nuclear war is inherently so destructive we need only possess the capability to kill most of the attacking nation's people and devastate its urban areas to preclude war. Deterrence through military superiority sees the primary requirement for deterrence as an ability to win a war—with deterrence as the logical result of evident and superior visible military strength.

Because deterrence through terror is so easily understood by the general public and because American military superiority was long taken for granted, many Americans think that deterrence through terror is all we need today. The more complex requirements of a superior military force are often difficult to explain. Yet when the necessity for an adequate counterforce capability is well presented, the theory of deterrence through terror becomes questionable.

Unfortunately the nature of counterforce operations and the necessity for them are often misunderstood even by military men. The confusion that inevitably results from an attempt to integrate the two contradictory philosophies serves to produce a mongrel military force optimized for neither strategy and inadequate for both. The military force we have today and the force we are building for tomorrow can be directed toward one of two different goals: deterrence through terror or deterrence through strength. One goal would guarantee that our Nation and our people will not survive a nuclear war; the other would seek to ensure that we survive and perhaps win decisively.

deterrence through terror

It would appear, from the volume of material written about the destructive nature of nuclear war, that a segment of the Nation has accepted a nuclear stalemate as a desirable condition. There is evidence of a feeling in some quarters that we should today be acquiring systems of destruction designed to completely erase a nation from the face of the earth. Some people believe that the Air Force is actually in the process of building such devices for indiscriminate destruction. This, of course, is not true; if it were true, we would be concentrating on means more suitable to that approach, such as:

- large, multimegaton weapons. If the purpose of military force were simply to create widespread destruction, the problem would be simpler. There appears to be no upper limit on the size of nuclear weapons that could be used effectively for the purpose of devastation. Yet there is no indication that such multimegaton weapons are being prepared.

- larger missiles as delivery vehicles. Today and for some time in the future, ballistic missiles promise to be the simplest and surest method of delivering nuclear destruction upon an enemy. It would appear, then, that if indiscriminate destruction were our goal we should be building ever larger rockets to carry ever larger warheads. Simple calculations will show that a few hundred multimegaton weapons properly applied against an industrial, urbanized nation, such as the United States, can reduce that nation to ruins and its population to a small percentage of survivors. If deterrence through terror is to be our strategy, we should be seeking the most economical way to destroy an enemy. The military force which we are building today is hardly the most economical way to purchase deterrence through terror.

- surface burst for maximum fallout. If deterrence through threat of devastation were our goal, we would want to set the bulk of our nuclear weapons for surface burst so as to create a maximum amount of radioactive fallout. Not only would we attempt to kill people by blast and by thermal and initial nuclear radiation, we would also want to optimize the lingering radiation, since it would kill people over a much larger area.

- weapons for application primarily against cities. Perhaps the easiest bulk of the population. Again, a large number of weapons is not required. way to destroy a nation is to incinerate its major cities and with them the Cities are completely vulnerable to attack by nuclear rocket. The rocket with its nuclear warhead has made it comparatively easy to create a force which can eradicate urban areas.

- biological weapons for pestilence and starvation. If our search were for the optimum in terror, no method should be overlooked. Nuclear weapons are not the only means to create a force capable of causing terror. Biological weapons could offer the means to kill the majority of the people of a nation. They can be designed to kill animal life and destroy plant life. With these weapons the population of a nation could be greatly reduced through pestilence and starvation.

- gigaton weapons. Herman Kahn of RAND Corporation, author of *On Thermonuclear War** has used the term "doomsday weapon" to depict a device which could literally destroy the world and its inhabitants. On a smaller scale we might visualize gigaton weapons (i.e., weapons of several hundred megatons) carried aboard submarines or surface ships. The purpose in constructing such a device would be to cause a gigaton explosion close to the border of the enemy nation. If exploded offshore, it would throw up a surge of water that would inundate the surrounding low-lying areas. The radioactive fallout from the explosion would cover hundreds of thousands of square miles. Gigaton devices could also be placed in earth satellites in a low orbit. Since one of these devices could incinerate an area from Boston to Washington, a few such weapons could virtually incinerate a nation.

These are some of the means by which we could attempt to create a force truly capable of wiping out a modern nation. There is almost no limit to the fantastic weapons of mass destruction that can be built. They could perform the relatively simple task of killing civilians far more cheaply than the forces we have today. But would such a force, especially designed for

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*Princeton University Press, Princeton, New Jersey, 1960.

terror and mass destruction, actually deter an attack against our military forces themselves or against our allies?

How could we respond to an enemy attack directed solely at our military force if our cities and people had been deliberately spared? Comprehensive calculations indicate that if our military forces located within the United States were attacked with utmost discrimination by nuclear weapons we would suffer on the order of 10 to 15 million casualties—this is without a civil defense program. Although an attack on our forces which rendered 5 to 10 per cent of our population casualties would be unprecedented and certainly catastrophic, it would only preface a decision even more frightening. We would have three alternatives:

a. We could retaliate against the enemy's cities and people. If we did, the enemy in reprisal could raise our casualties to 90 per cent of our entire population, and we would still lose the war.

b. We could retaliate against the enemy's military force. Yet if we had only a force for terror, which does not need to be very large, the portion remaining after a surprise attack would be ineffective and inappropriate. It would be a mere remnant of a force which was never designed for the difficult job of destroying the enemy's military force. We would lose the war.

c. If we did not wish to sacrifice an additional 80 per cent of our population and recognized our inability to destroy the enemy's military force, we could choose not to respond at all. Of course in this case also we would lose, but the bulk of our people would still be alive.

Hope springs eternal, and it may be that our nation would not choose to die a futile death. If the terms of cessation advanced by the attacker were more attractive than "suicide," there is considerable reason to believe that we might elect to negotiate rather than end the life of both our country and most of its people.

It should be apparent that a terror force cannot be used to protect an ally. How could we protect an ally with a force which is self-defeating if employed? Even if we made a statement of intent to choose the course leading to national suicide, would the enemy—or our allies—really believe it?

Honest answers to such hard questions expose the fatal weakness of deterrence through terror: its inability to protect our country from anything except a direct, purely terroristic attack. It could not protect even our military forces themselves. We are extremely fortunate that this Nation has not, as yet, chosen to rely on the element of terror for our protection. The danger remains, however, that terror as an instrument of national policy will continue to be attractive for reasons of economy. The comfort which comes to the uninformed from thinking that nuclear war will not happen because it is simply "unthinkable" could be our undoing.

deterrence through strength

When two nations possess nuclear weapons and effective long-range delivery systems, the people and cities of both nations are vulnerable to indiscriminate, area-type destruction. Cities, because they and the people within them are so defenseless, are well suited to destruction by nuclear weapons. The need for accuracy in delivery vehicles to destroy such targets is minimal. So is the number of weapons required. Because the vulnerability is mutual, it is to the advantage of neither side to destroy the opponent's cities so long as the opponent has weapons with which to effect reprisal. City-trading is not a profitable military tactic, especially when most of the civilian population is lost in the trade.

The purpose of military force in war has been, is now, and must continue to be to achieve military dominance. If a nation has a force which can fight and win a war and if the possible opponent sees that this force can win, the result must be deterrence. Still deterrence can fail. The enemy in comparing our capabilities with his could decide that he will win.

"If deterrence fails . . ." is often said in the context that, because war has occurred in spite of a policy of "deterrence," deterrence then ceases to exist. In actual practice, deterrence does not cease to exist at the outset of conflict. Deterrence in some of its many forms continues throughout a conflict. As recently as World War II and the Korean War it has been to mutual advantage to spare hospitals, to designate open cities, to refrain from the use of poison gas, to keep prisoners alive, etc. These are all examples of a form of deterrence. Despite such examples of deterrence in war, some people have proposed complete elimination of such deterrence and deliberate resort to a national policy of "total destruction." Never before in modern times has it been proposed to wage "total destruction."

The Air Force has three principal objectives in general war:

- To gain military dominance over the enemy by destruction of his military force
- To limit damage to the United States and her allies
- By so doing, to achieve a favorable outcome.

The enemy's military force can be attacked and destroyed with minimum damage to urban areas. For example, a relatively small nuclear weapon accurately placed on Andrews Air Force Base in the environs of Washington would neutralize that base without extensive damage to the city. A multimegaton weapon used against Andrews would destroy a large portion of the city but would be inappropriate for the target. The result of using an overly large nuclear weapon would be the deliberate destruction of civilian population. Yet even this destruction would conceivably be less than that caused by dropping the weapon directly on the city itself.

Even military planners oftentimes forget that a one-kiloton nuclear weapon placed within 100 feet of a target will create an overpressure of 1000 psi on that target. With sufficient accuracy, there is no justification for using the largest-sized nuclear weapons to destroy even hardened and superhardened missile sites and hardened command centers. The requirement for explosive strength increases as the cube of the increase in distance off target. So lack of precision in the application of warheads can cause planners to resort to the use of the largest nuclear weapons to increase the probability of target destruction.

There are those who say that counterforce is a desirable objective but that you can't find the enemy's military force. Yet never in history has access to all targets been so complete. The enemy's military force can, of course, be located and destroyed. For some targets time and continued effort may be required, but all can be reached and attacked more quickly than ever in history. Fixed targets can be destroyed by aircraft and missiles. Even mobile forces can be found and attacked. Slowly moving systems can be located through reconnaissance and attacked with missiles. Swiftly moving systems will require hunter-killer tactics.

Let us suppose that an enemy decides to build a rail-mobile ICBM force. It is entirely feasible to employ aircraft such as the B-52 for hunter-killer operations against such a force until we possess a space force even more capable of hunting down and destroying mobile earth systems. If we stop thinking in terms of multimegaton weapons and consider employing the much smaller weapons which may be more appropriate for the most important military targets, we can use the B-52 to deliver many small nuclear weapons. A B-52 with a load of small nuclear weapons could very conceivably be given a mission to suppress all trains over a specified geographic area, provided that we have properly and effectively employed our missiles to degrade enemy air defenses to the extent that the aircraft could penetrate with acceptable attrition rates. The subsonic B-52 could be used then to destroy mobile as well as fixed and hardened targets.

One indispensable requisite of a hunter-killer aircraft is endurance. Hunting down targets is often a time-consuming business. We do not today have a true strategic hunter-killer aircraft. Our lack of a hunter-killer capability is not fatal today, but if a large part of an enemy's strategic force becomes mobile, or its location uncertain, then it will be of crucial importance to have a weapon system to search out and attack the enemy force with discrimination.

To seek out and destroy mobile or imprecisely located strategic forces requires time. The argument is used that we will not have that time. It would appear that this argument ignores the survivability which the United States is building into its military force today. It is inconceivable, for example, that an enemy surprise attack could wipe out the bulk of a Polaris type of force. The same is true for the mobile Minuteman, airborne-alert aircraft, and dispersed, hardened missiles. When survivability against surprise attack is built into strategic offensive systems, the result is a lengthening of the decisive phase of general war. When the decisive phase of general war is lengthened, time becomes available to implement a counterforce strategy, including hunter-killer operations. How else could military dominance, which is indispensable to successful conclusion of a military conflict, be achieved?

Some people argue that an enemy will fire his missiles before an aircraft has time to search out and destroy them. This argument, like the previous one, fails to take into consideration survivability of the strategic offensive force. If an enemy cannot destroy the majority of our strategic offensive force in his first strike, it would be suicidal for him to employ his remaining missiles against our cities. Of utmost importance in any war is the holding of forces in reserve.

Those who say that the enemy will promiscuously fire all his missiles at once ignore the principle of maintaining a force in reserve. If a nation exhausts its strategic offensive force without having completely destroyed the opponent's offensive force, it will have been beaten, for its opponent can apply his residual weapons at will and in whatever manner he may choose. And building survivability into a strategic offensive force denies the enemy the capability to virtually annihilate his opponent's strategic offensive force by surprise attack. Under these conditions both nations will probably consider it imperative to have nuclear weapons in reserve. One of the primary purposes of our withheld or reserve force is to deny the enemy the opportunity to destroy our cities without inviting the destruction of his own.

A very careful analysis as to the impact on the United States of a terror strategy versus a war-fighting strategy has led to certain conclusions:

a. If an aggressor launched a surprise attack against our military forces and we responded against his military forces, some 5 per cent of our population would not survive.

b. If an aggressor launched a surprise attack against our military forces and we retaliated against his military forces and cities, some 90 per cent of our population would not survive the counterattack against our cities.

Thus the difference between these strategies can be measured in terms of about 150 million more American dead under the strategy of retaliation against cities as well as military forces.

Looking ahead to 1965 when an increased number of nuclear weapons should be available, we can expect these differences in industrial damage to the United States:

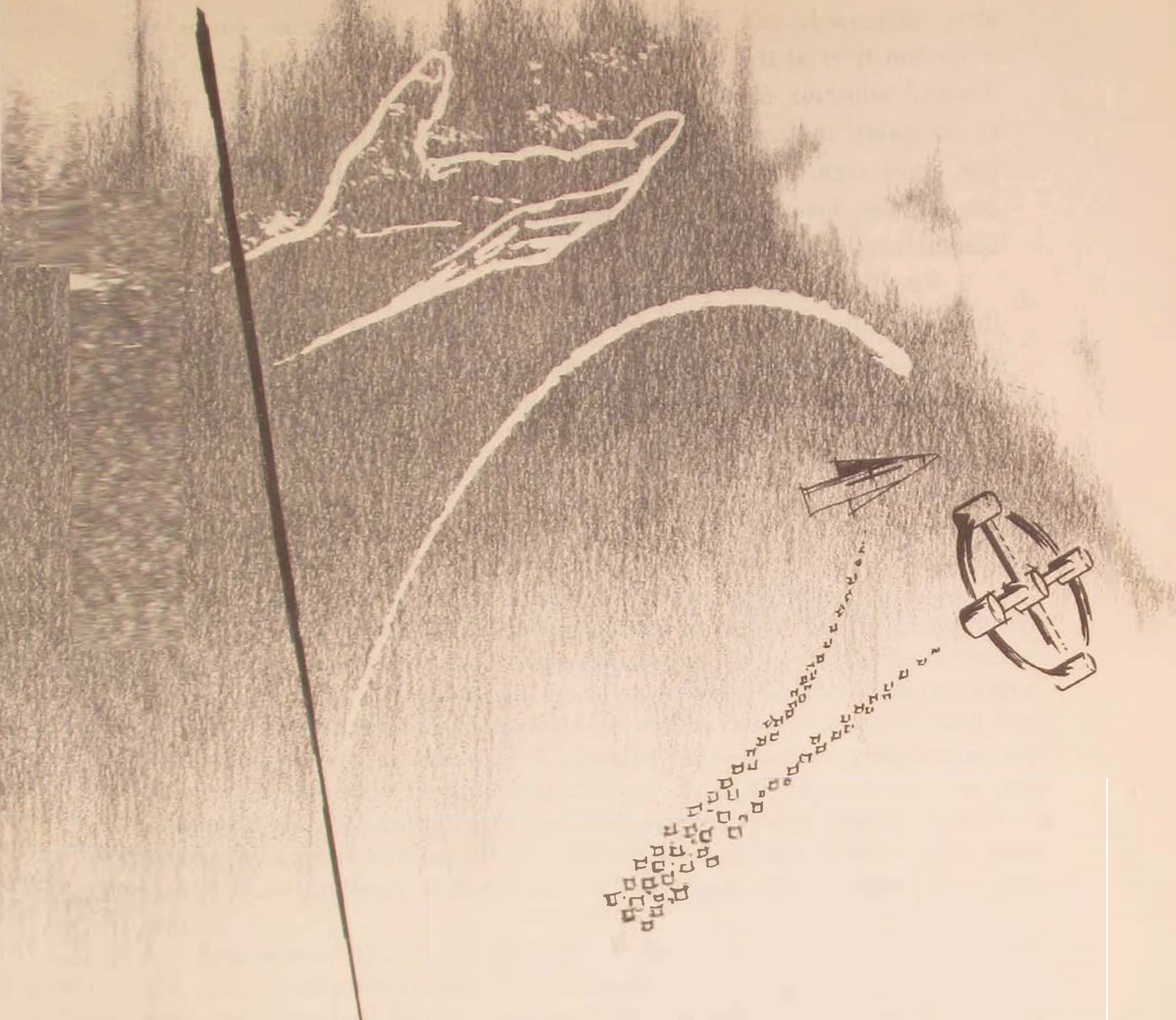
a. If an aggressor launched a surprise attack against our military force and we retaliated against his military force, we could expect less than 5 per cent damage to our industry.

b. If an aggressor launched a surprise attack against our military force and we retaliated against his military force and cities, we could expect 50 per cent of our industry to be destroyed.

The difference between these strategies can also, then, be measured in terms of losing one half of our industry as opposed to having almost all of it intact.

The foregoing are powerful arguments for accepting a counterforce strategy favoring survival rather than a strategy tantamount to suicide. The difference in the strategies can be measured in terms of this Nation's continued existence.

Headquarters United States Air Force



PART III

Support of Aerospace Combat Forces

As the horizons of aerospace combat have broadened and deepened since World War II, the support of aerospace forces has also extended to new dimensions. These dimensions must continue to expand if the combat forces are to remain dynamic. The tremendous compression of the decision time in modern war demands not only that the combat forces be ready to fight instantaneously but that their essential materiel be at immediate hand for their sure and swift resupply. Bases secure, alert, dispersed, and hardened must launch counterstrike forces in minimum time at the outset of war. The complexity of the action will demand superior men—men of training, motivation, and skill equal to accepting the trust, the task, and enigmas of combat such as man has never seen. And underlying all is the planning that must prepare for all, the dovetailing and blueprinting of the intricate processes of instantaneous, successful response to any attack.

Part III presents the logistics of aerospace forces, their basing, their manning, the systems for their command and control, the procedures for establishing their sound requirements, and principal considerations in their financing.

Aerospace Logistics

GENERAL SAMUEL E. ANDERSON

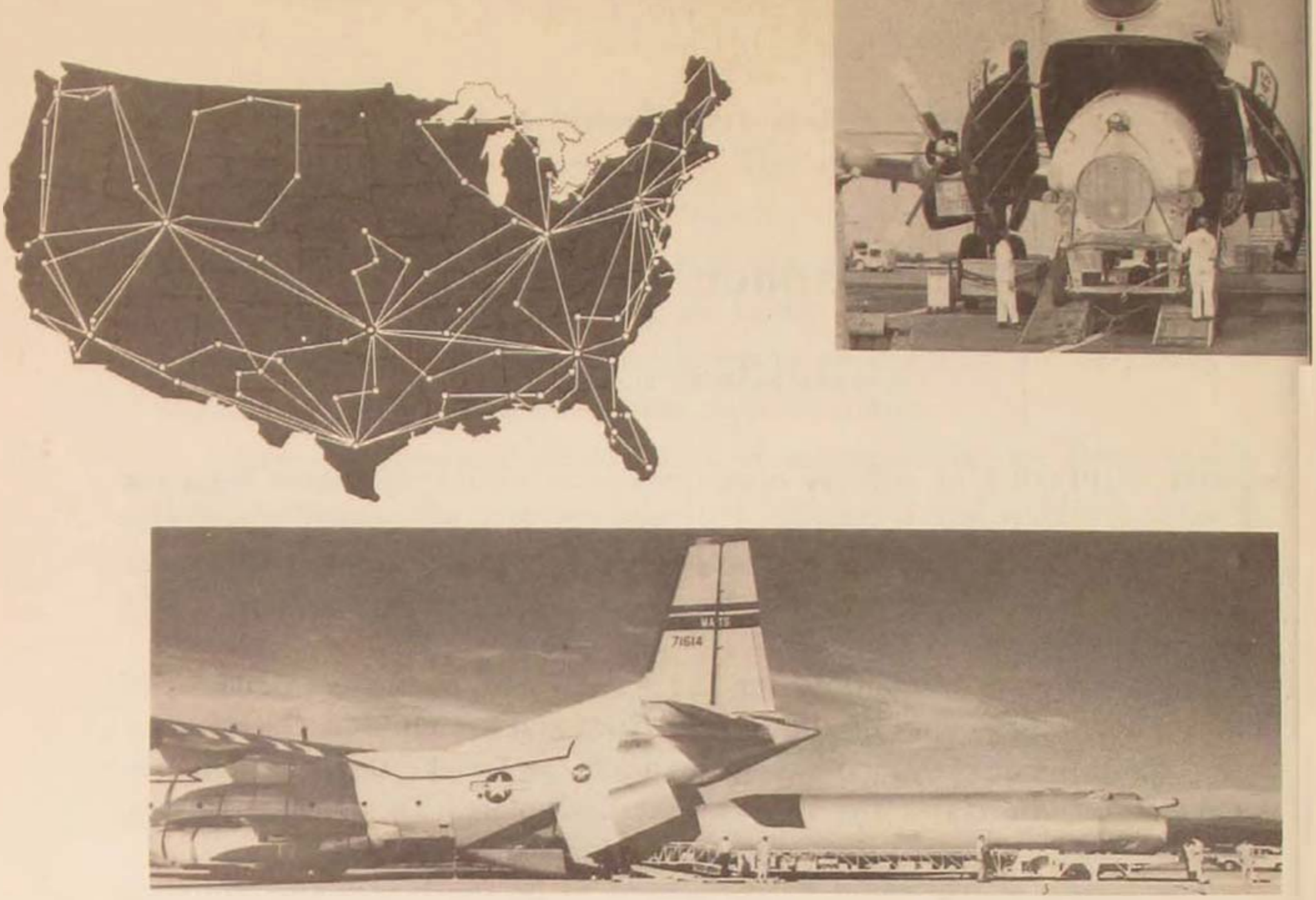
THE SUPPORT of military operations must ultimately derive from the Nation's economic resources. This support is not automatically forthcoming, nor does it automatically assume the required size, composition, or proportions. If it did, there would be no need for logisticians or a logistic system.

Logisticians are responsible for the effective support of military operations. They must determine the precise types and amounts of resources required for this support, obtain these resources, and make them available to the operational forces at the proper time and place. To do these things, they must design, construct, and operate the logistic system.

The logistic system could be considered to be the bridge that connects military operations with the national economy. It is the medium through which economic resources of all types are channeled, including personnel, services, and vital technical know-how as well as items of materiel, and from which they emerge as elements of effective support. This bridge must necessarily be constantly renovated as changes occur in weapons and concepts of warfare and in patterns of economic behavior. If the logistic system is to be kept up to date and capable of meeting the demands made upon it, logisticians must ceaselessly search out new techniques and concepts for logistic support.

This process of constant revision of the logistic system is not new, but it is more clearly discernible today because of the rapidity with which it is occurring. Measured by the more leisurely time scale of the past, centuries of change have been crowded into the few brief decades that separate the massed bomber fleets of World War II from the manned spacecraft of tomorrow. Today we stand between these two milestones of aerospace power. It is a unique position. Never before has it been possible to encompass so much technological change in weaponry with such short looks into the immediate future, and thus to convey so much insight into the way the logistic system changes through time.

We will examine the changes in the logistic system during the era dominated by the massive manned air forces of the 1940's and 1950's, the era just ending. We will then look to the era just beginning: the logistic system being designed for the support of mixed aerospace forces. Finally, we will note some of the major characteristics of the logistic system of the future, the era of manned aerospace forces.



In support of Air Force constant combat readiness, AFLC's Logistics Air Transport Operation (Logair, shown on map) flies high-priority and high-cost items to air units around the world. Promptness of supply with minimum number of items in pipeline is particularly necessary for ballistic missiles. Thus a Thor IRBM (top right) is loaded into a C-124 at a ZI depot for delivery in England. And the Atlas ICBM (above) goes into a C-133 at the depot, Norton AFB, for airlift to a SAC launching base, Francis E. Warren AFB.

Evolution of the Air Logistic System

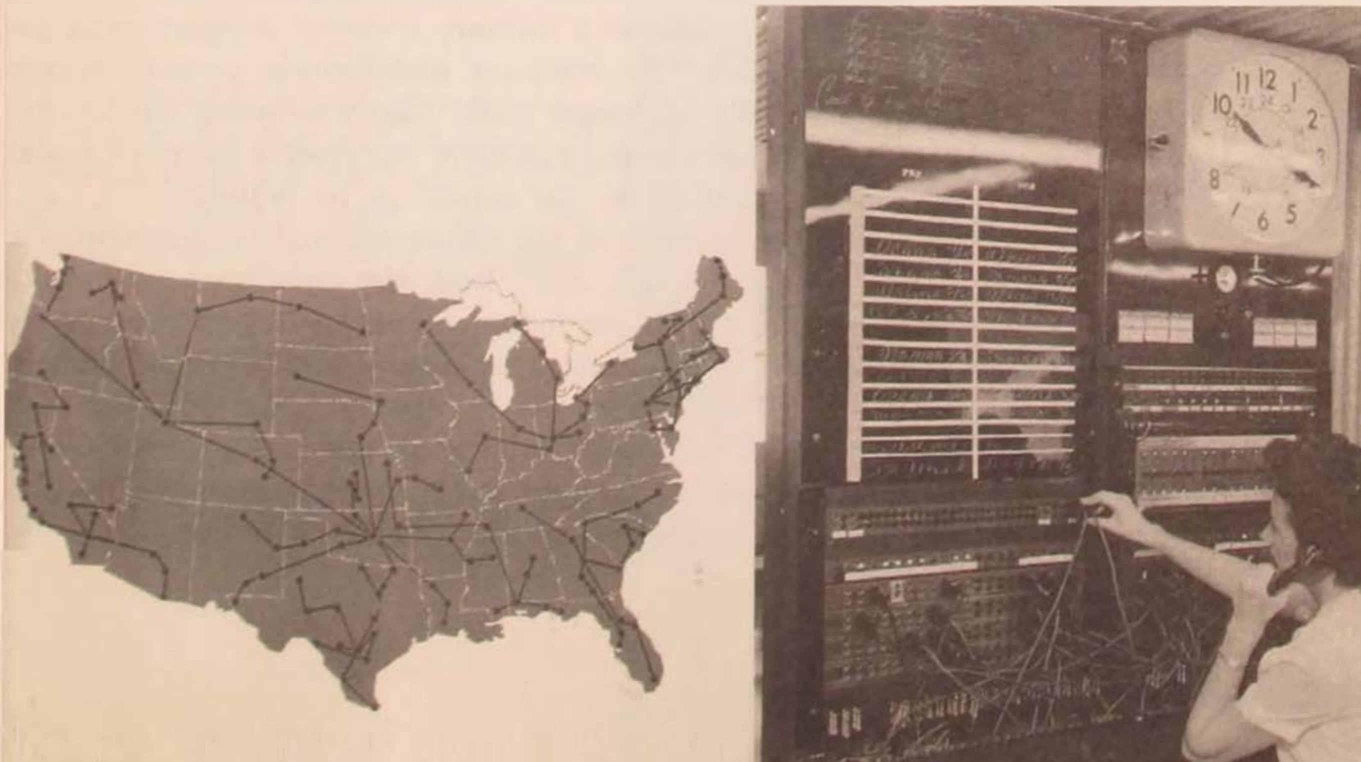
Air logistics, like air power itself, came of age during the Second World War. In that conflict the combination of tremendously large forces, rather complex equipments, great distances, relatively slow transport, manual record-keeping and requisitioning, and voice and teletype communications resulted in the creation of a logistic system capable of dealing with great quantities of materiel. Key elements in this system were the huge repair facilities and massive stores of stocks deployed all over the world. The structure had to be massive to support the large fleets of aircraft characteristic of that stage of warfare. It was condemned to slowness by the transportation and communication limitations of the time.

Yet it served us well, for in that war massiveness of action rather than quickness of response held the key to victory.

The years since the end of the war have seen this emphasis on mass logistics disappear as the tremendous destructive potential of modern air power brought about significant reductions in numbers of aircraft. Especially in the years following the Korean War the Air Force made rapid progress in developing a more precise, specialized logistic system, tailored to the individual needs of the costly, complex, and constantly changing weapon systems that began to enter the inventory. Faster transportation and communication, high-speed electronic data processing, and highly sophisticated statistical methods of computing requirements all were tools that logisticians used in creating this new system. The results were gratifying. It now became possible to eliminate most overseas depots by supporting operational forces direct from installations within the zone of interior. Significant decreases also were made in depot facilities at home, as we substituted more precisely controlled support for inventory bulk. One of the most significant developments was the "Hi-Valu" concept, through which striking reductions in materiel costs were achieved by providing special management attention and high-speed communication and transportation for expensive inventory items, thus sharply reducing the total number of these items.

During its early years the logistic system had been strongly mobilization-oriented. This is not surprising, for the mobilization concept is deeply rooted in our national consciousness. Always in the past, even after war started, we were assured of enough time to bring our tremendously productive industrial structure into support of our military forces. Past wars were won not with forces in existence when the conflict began but with forces mobilized and equipped during its early stages. Several years ago it became obvious that the decisive blows in any future general war would be struck by the forces in existence at the outset and that mobilization as we had known it in the past probably was no longer possible.

Transceiver circuits of AFLC's Logistics Communications Network (Logcomnet, shown on map) speed logistic support by bringing bases and depots in two-way contact. Switchboard ties in any transceiver in the Tulsa control station with circuits covering the U.S. (including Hawaii) and England.



In contrast to garage-like maintenance of World War II, thirteen of SAC's B-52 jet bombers can be overhauled simultaneously in mammoth hangar of SAAMA at Kelly AFB, Texas. Largest of its type ever built, the hangar is 2000 by 300 feet, the adjoining shops add 412,000 square feet, and the combined structure measures a mile around.

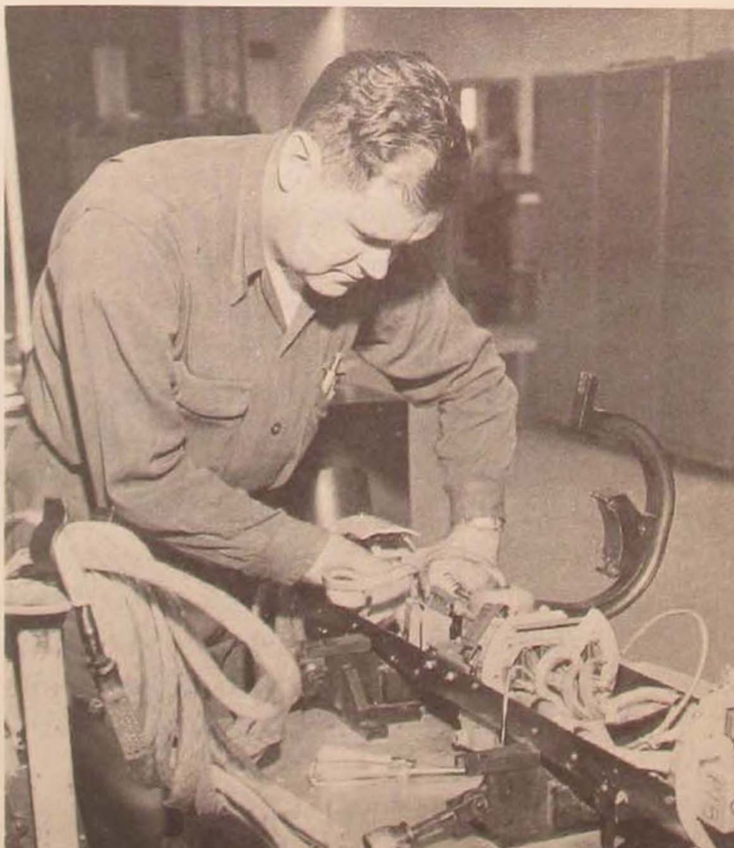
This recognition caused another major change in the logistic system. In terms of maintenance capability, our depot complex had been designed for maximum expansion to absorb the increased workloads of the expected post-D-day mobilization. Our supply policies were similarly designed to a main objective of having on hand at the beginning of the war adequate stocks to sustain the combat forces until a rapidly mobilized industrial structure could convert to war production. As we began to realize that we no longer could depend upon time as a military resource, support concepts and capabilities oriented toward an extensive mobilization period became more and more unrealistic. We no longer could justify devoting any sizable portion of our resources to maintaining extensive war-reserve stores of materiel or expansion capability either in our depots or in industry.

This was especially true in view of the unprecedented requirement for instant readiness implicit in the shift away from the mobilization concept. Since the war would be fought with the forces already in being, they had to be kept at peaks of maximum peacetime readiness never before attempted. For the logistician, the traditional distinction between peace and war had disappeared. He had now to treat each minute as though it were H-hour minus one, for what he had not done when the war began he might not be able to do at all. Supply policies were changed to have peacetime stocks, insofar as possible, in the hands of the operational commands rather than in depots, with additional backup in the form of immediately responsive depot support. In maintenance similar stress was placed upon maximum self-sufficiency by increasing base repair capabilities and by realigning depot capability to hard-core, sustained, flexible maintenance of vital, first-line weapons at maximum peacetime readiness levels. These changes represented a major readjustment in the character of logistic support. A new sense of urgency had been injected into the logistic system.

Still another major development was the adoption of the weapon system concept as a principle of logistics management. The primary management orientation of the logistic system during the early part of this period was that of commodities or items. The reason is not difficult to find. Compared with present aerospace vehicles, the aircraft of World War II and before were relatively simple. A high degree of standardization was possible in power plants, instruments, and armament, as well as in the equipment, skills, facilities, and services necessary to support them. This standardization permitted a maximum of interchangeability; that is, a considerable number of the parts and equipments were common to more than one aircraft. Because of this high degree of commonness or interchangeability, we found it advantageous to organize the logistic system in terms of what it did (supply, maintenance, transportation, etc.) and to manage in terms of the items of materiel it handled (generators, landing gear, instruments, etc.). The logistic system we created resembled a vast network of automotive-type repair shops and parts-supply houses capable of servicing all makes and models. Its functional organization and commodity management orientation gave it stability and flexibility and enabled it to cope with new situations without major internal adjustments.

But significant changes were under way in the nature of the aircraft

In contrast to World War II maintenance, the test and overhaul of Falcon missiles at Air Materiel Area Depot, Olmsted AFB, typify today's delicate, bench-type repair.



supported. Individual weapons were increasing in complexity and diversity. The introduction of intricately designed propulsion, navigation, fire-control, and bombing subsystems caused much of the interchangeability at component and subsystem level to disappear. Problems first began to appear during the development of these new weapons. A technique was needed to ensure that everything necessary for the final operational use of a new weapon—including the highly specialized ground support and handling equipment—would be completely compatible and fully developed by the operational date of the new weapon. Management by total "weapon system" was required.

To meet this need, a system project office was set up for each new weapon system under development. It was made up of representatives of the then Air Research and Development Command, the Air Materiel Command, and the using combat command. This office became the focal point for all problems associated with a particular weapon during its development and production phases. It performed the management function of total system integration. On 1 April 1961 the Air Research and Development Command was renamed Air Force Systems Command, and the Air Materiel Command is now called Air Force Logistics Command. With this reorganization the system project offices become the entire responsibility of the Air Force Systems Command. These system project offices are grouped together into three locations where the old Air Materiel Command already had appropriate centers: the Aeronautical Systems Center at Wright-Patterson Air Force Base in Ohio, the Ballistic Missiles Center near Los Angeles, and the Electronic Systems Center in Massachusetts.

But problems peculiar to a weapon system do not cease to exist the day that weapon becomes operational. Support problems associated with modern, complex weapons also need to be considered within a total "weapon system management" framework. A logistic support manager was therefore appointed for each weapon system. These managers are located in the nine air materiel area depots. They have world-wide responsibility for the support of their assigned weapon system throughout its operational life, including supplying it, maintaining it, and modifying it as necessary. They also serve as the point of contact between industry as the source and the combat commands as the users of the weapons. Air Force weapons now are "system managed" from their earliest conception, through their development, production, and operational lives, to final disposal. This is weapon system management.

Of course the logistic system cannot operate entirely by weapon system. It must buy, modify, repair, and distribute by item. Item management continues to be essential because weapon system support provided by logistic support managers is based upon the response they in turn receive from item managers. Weapon system management does not replace item management within logistics. It does provide logistics with a new and vital management orientation.

To sum up this first period, significant changes were being made in the logistic system even before the advent of some of the more advanced weapons now making their appearance. During this period logisticians made considerable headway in installing responsiveness and preciseness as cardi-

The increasing complexity and diversity of modern weapon systems—such as the Atlas ICBM and the SAC B-52 bomber—have required AFLC to shift to logistics management by each total weapon system.

al logistic principles; they shifted logistics from a mobilization concept to ne of instant readiness; and they incorporated into its structure the concept f management by weapon system. Each of these developments was in response o the changing support requirements of the times. Each helped significantly o prepare the logistic system for the support problems that lay ahead.

The Mixed Aerospace Force Logistic System

THE intercontinental ballistic missile has ushered in the era of mixed aerospace forces. We must maintain a capability in both missiles and manned ircraft, with missiles increasing in relative importance as they become more ully developed. Significant changes are now being made in the logistic ystem in preparation for the support of this mixed force.

In many respects each new weapon provides an opportunity for a logis-ics "fresh start." Once the support pattern for a weapon is crystallized, he advantages of major change are usually outweighed by the disadvantages n terms of cost and possible disruption of support. For this reason few ma-or changes in the logistic system developed for the support of manned air-raft are likely to be made, at least in the immediate future. Changes will ccur, but probably somewhat later as more-advanced manned aircraft enter he operational inventory. The more significant immediate changes in logistics are associated with the support of the ballistic missile portion of this mixed force.

The most important single factor that shapes the nature of ballistic missile logistics is of course the fact that the missile is unmanned. We must forever be compensating for the man who is not there—the human mind and judgment left behind on the ground. In manned aircraft we were conscious of the problems involved in protecting the frail human organism in flight. Now we see the other side of the picture: the mass of complex equipment needed to substitute for that superb but highly vulnerable human mechanism. Because there is no flying program to call attention to actual or potential malfunctions, an elaborate checkout procedure must be developed to uncover them through periodic "exercising" of the missile. Because there is no human hand at the controls, ground support equipment must be developed to launch the missile and start it on its initial course. Finally, because there is no one to compensate for even minor functional failures, reliability becomes an extremely critical factor.

When we consider that these requirements must be met while maintaining the missile in a state of instant readiness, we begin to appreciate the magnitude of the logistics problem involved. And it should be emphasized that it is a *logistics* problem. Ballistic missiles are not "fought" in the classic sense. They are only "maintained" and then "launched"—and maintenance is a logistics function.

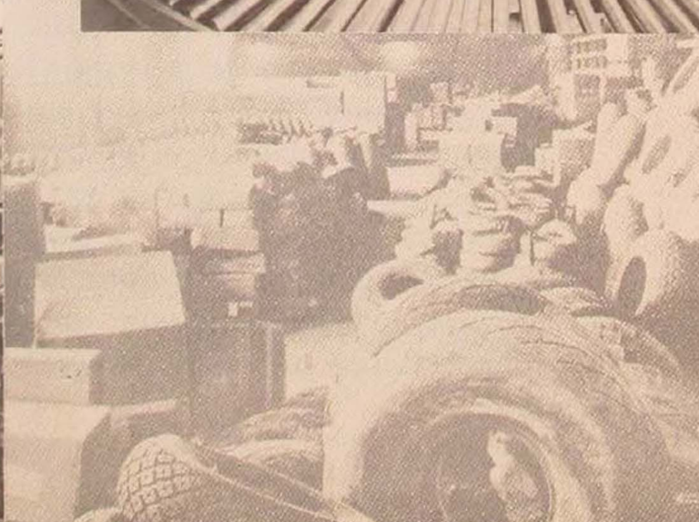
The operating status of SAGE electronic equipment is shown on the SAGE computer maintenance console (right), manned by IBM field engineers. At Hq AFLC, a UNIVAC computer (below) is engaged in actuarial studies on engine management to gain better planning figures for procurement of new engines.

The nature of this logistics problem was perceived very early during the development of the first generation of ballistic missiles. It was also recognized that recent developments in logistic tools would enable logisticians to cope with the problem in a way never before possible. That the ballistic missiles represented a completely new family of weapons was in many respects a distinct advantage—there were no old logistic support systems to be revised or discarded. We set about designing a completely new system to provide the required logistic support.

The principal advancements which made this new approach possible were in the areas of electronic data processing and systems design. The Air Force has long occupied a position of leadership in both these fields. It underwrote some of the earliest research and development in data processing and at a very early date began utilizing the new computers in its existing logistic activities. It also made extensive use of techniques of system analysis and design in developing some of its advanced weapon systems and their associated early-warning and command-and-control networks. These investments in new techniques have paid handsome dividends in that they made possible a new approach to logistic support.

The new system which was created differs from its predecessors in two important respects. First, it identifies and describes the materiel assets and actions necessary to support a specific weapon system and establishes the pattern of sequential relationships which must prevail. This in itself is a

Since World War II, global logistics has been quickened not only by electronics but by mechanization of materials-handling in depots. Time and manpower saved by conveyor machinery multiply the number of orders that can be filled promptly and accurately.



monumental task—one that system-analysis techniques only recently have made possible. Second, it accumulates in one location all the information needed to manage the entire system effectively, an accomplishment now possible because of recent advances in electronic data processing.

The advantages of this new system are clearly evident. It provides central knowledge of all materiel assets in support of a specific weapon system, whether they are in the hands of the operating command, the central depot supply system, or the contractor. It eliminates much burdensome paper work at the point of use. The user provides consumption data, and automatic resupply is forthcoming—the record-keeping is accomplished electronically at the central location. Most important of all, for the first time a significant segment of the total logistic system can be managed as a whole, regardless of where the items of materiel are located or the logistic actions are taking place. This system is now being used in supporting the Atlas, Titan, and Thor weapon systems. It is a significant step forward in the development of scientific management in logistics.

Another milestone in logistic-system design will be reached with the introduction of the Minuteman weapon system. The common complaint of all logisticians has long been that problems of logistic support usually are not considered until well along in the development of a new weapon—so far along that many times the main design characteristics of the new weapon are already crystallized and can no longer be influenced toward easier supportability. Of course in some cases state-of-the-art limitations leave the logistician no choice but to accept the weapon as it is and support it as best he can. The first generation of ballistic missiles illustrates this point. Atlas, Titan, and Thor are extremely difficult to support. They are expensive systems primarily because of the logistics costs involved. The liquid oxygen used as an oxidizing agent must be kept at several hundred degrees below zero and is subject to constant boil-off. For this reason these missiles cannot be maintained in a ready-to-fire condition but must be fueled shortly before firing. A tremendous ground complex is required to accomplish the last-minute fueling and checkouts, all within the extreme time limitations imposed by the modern warfare requirement for instant response. Clearly a simpler system was required.

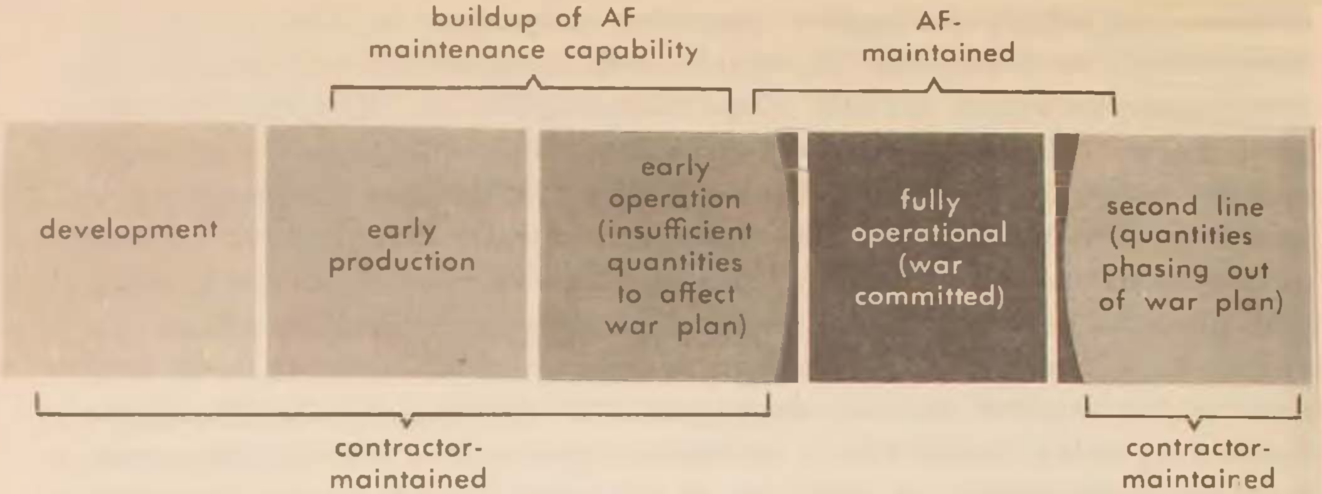
The Minuteman is such a system. It is designed to overcome the logistic difficulties inherent in maintaining missiles such as Atlas, Titan, and Thor in an adequate state of operational readiness. The Minuteman's solid-fuel propulsion system enables it to be maintained in a ready-to-fire condition over long periods of time. Its checkouts are for the purpose of locating malfunctions and can be performed at periodic intervals, free from the split-second timing of last-minute countdowns. Because it can be prepared for firing long in advance, Minuteman requires only a fraction of the personnel and equipment per site required by Atlas, Titan, and Thor. Few major weapon systems have been so greatly influenced in their basic design by logistic support considerations. Because of the increasing importance and costs of specialized logistic ground support complexes, this precedent of designing supportability into advanced weapon systems seems likely to continue.

Working within the logistic framework established by these design criteria, the Air Force Logistics Command is well along in the establishment of a logistic support system for the Minuteman. Ogden Air Materiel Area was given logistic support management responsibilities shortly after the assembly and test contractor had been chosen. Much of the detailed planning is now completed. Construction will begin soon on a facility that represents a new concept both in logistic support and in Air Force–industry relationships. This plant, to be used for final test and assembly of the missile, will be Air Force owned, a part of Hill Air Force Base, but will be operated under contract by the assembly and test contractor. This provides the Air Force the support capability essential for a first-line weapon system with the important operational role of the Minuteman. At the same time it best employs the contractor's experience gained in the course of the development program and utilizes his wealth of management, production, and maintenance skills. Other buildings at Hill Air Force Base are being modified to adapt them for the specialized support required by the Minuteman. When the first production missile is accepted by the Strategic Air Command, we will have in-being in the Ogden Air Materiel Area the most complete Air Force support capability developed to date for a first-line missile weapon system.

In many respects the problem of supporting a mixed force is not significantly different from the challenge always facing the logistician. Even while he is bringing the most highly developed techniques of his art to bear on designing and operating support systems for missiles and other advanced systems, he must be maintaining the forces in-being in a condition of instant readiness. The logistic system that he constructs must therefore be made up of many specialized support systems. At any point in time some of these are supporting the force in-being, others are being readied for advanced weapons in the process of development, and still others are being phased out as the weapons they support become no longer essential. For the immediate future, the manned aircraft will remain the backbone of the operational force. Nothing must be allowed to compromise its support. As ballistic missiles in turn assume a more dominant role in the forces in-being, supported by the systems now being designed, planning attention will turn to the design of support systems for the still newer weapons which at that time will lie just ahead.

The Logistic System of the Future

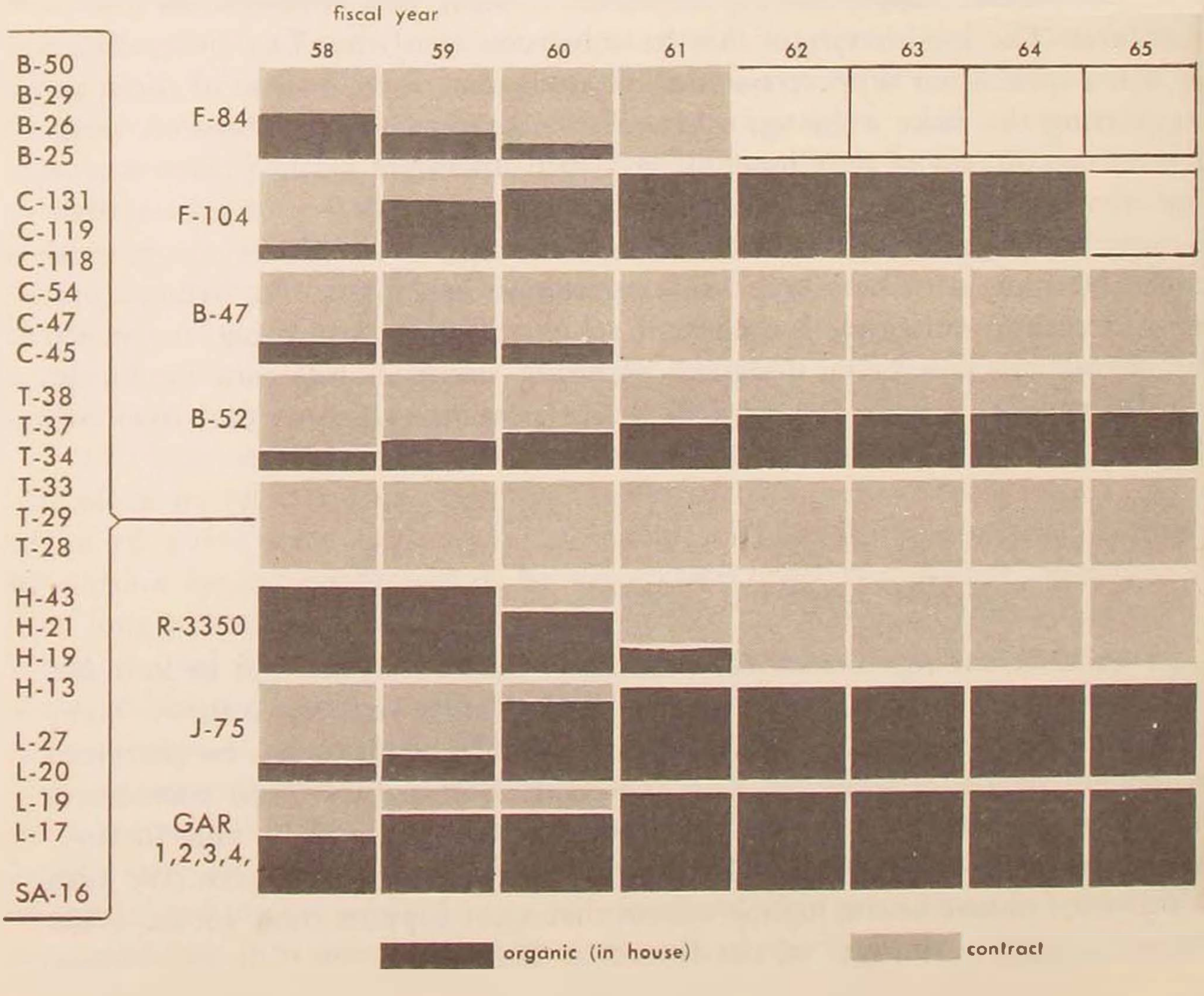
As we shift our sights from the immediate future and attempt to look farther ahead, the picture necessarily becomes somewhat less distinct. Many of the details must remain obscure, but the main outlines can be perceived with some degree of accuracy. True spacecraft, both manned and unmanned, will have entered the inventory and operational forces will be able to function throughout all significant levels and regions of the aerospace. We turn now to the nature of the logistic system that must support these forces. What will the logistics "bridge" of the future be like?



a

The close Air Force–industry logistical relationship is indicated by these charts on weapon system maintenance. Chart "a" shows the approximate division of maintenance responsibilities between the Air Force and contractors during five stages in the life of a weapon system. Chart "b" shows the percentage of maintenance manhours in house and by contract for a number of weapon systems from 1958 to 1965.

b



Many of the trends that will shape the future logistic system are already at work. The increasing importance of logistics as a primary factor influencing the basic design of weapon systems is an excellent example of a trend that is likely to grow. In the Minuteman weapon system the tremendous cost and complexity of the ground checkout and launch complex of earlier systems composed the logistic problem which the design engineers were attempting to solve. The goal was to develop a missile that could be easily launched and that would function correctly for a flight of approximately one half hour.

Contrast this with flight times of weeks, months, or even years for space systems now on the horizon. Tremendous additional improvements in reliability must be achieved before flights such as these will become feasible. The cost of unreliability, both in human lives and in the failure of the mission, will justify almost any actions taken to achieve these higher reliability levels.

But perfection can never be obtained; some maintenance will always be required. In many cases it will be either impossible or uneconomical to return the vehicle to its home station for maintenance, and the malfunction will have to be corrected in flight. It is obvious, therefore, that the logistic considerations of reliability and ease of in-flight maintenance will play a far more dominant role in the design of space vehicles than they have in past weapon systems.

Other problems will be relatively new. The movement of supplies, for instance, will involve problems of transportation never faced before. In the past, commercial transportation systems were available which logistics could utilize or duplicate. Such will not be the case in space logistics. The logistic transport will have to be developed, as will also the design of whatever space-logistics supply sites will be required. Tremendous ground complexes, dwarfing the present one at Cape Canaveral, will be required to launch both operational and logistic vehicles. Some may be geographically located so as to achieve equatorial orbits more easily; others may have to be at sea to facilitate the recovery and re-use of the mammoth first-stage boosters now on the drawing boards.

As in the past, improvements in logistic tools and techniques will be a prime factor in meeting these support requirements. Many of these improvements already are under way. A completely integrated transportation and materials-handling system, embracing not only the transport function but the loading and warehousing functions as well, is now under development. The purpose is to minimize the packaging and handling now associated with the storage and movement of materiel by designing a single, integrated system rather than utilizing separate systems for warehousing, handling, and transportation as in the past. The techniques that result from this total-systems approach to the physical aspects of supply and transportation should provide the framework for an extension of the same technique of analysis to space-logistics supply and transportation problems. We also are taking advantage of the latest research in solid-state physics to improve communications reliability and stability so that the logistic command-and-control network will be as effective as those of the operational forces it supports. Our data-processing equipments and techniques also are being continually improved, and these improvements make new techniques of management available to us.

But perhaps the most important improvement concerns not a physical tool but a management technique—the technique of control. The logistic system as a whole is so large, is made up of so many individual support systems, and has so many intricate interrelationships that effective control is extremely difficult. But each new weapon-support system we design is more clearly defined than those that came before. Systems analysis and electronic data processing are enabling us to identify and keep track of essential relationships within and between support systems, relationships which in many cases existed informally if at all. As we study these systems more closely, especially in the process of applying electronic data processing to them, we discover numerous cases where essential information was being obtained through informal personal relationships rather than through the formal information channels. Unless these informal relationships are identified and formalized when the formal channels are mechanized, the system cannot operate effectively. Accurate systems analysis is enabling us to do this.

The first systems that have been thoroughly defined and brought under this new management control are those directly supporting the vital weapon systems of our strategic strike force. But this type of system analysis is not limited to individual weapon-support systems. It is equally applicable to commodity- or item-oriented systems and to the many other individual systems that make up the totality of logistic support. As each one of these systems is brought under this new type of analysis and control, we draw closer to our goal of a completely integrated and thoroughly responsive total logistic system.

Increased responsiveness and control are essential because the logistics management job is constantly expanding in complexity and in scope. The requirements of modern weapons are such that they depend upon many different organizations and activities for their support. Although logistics is a military function, its roots extend deep into the industrial segment of the economy. Regardless of who provides it, the essence of effective logistic support is responsiveness to the needs of the operating commands. The entire logistic structure, its industrial as well as its military components, must meet this requirement. Effective systems analysis and design can enable it to do so by integrating each vital logistic function—whether performed by the operating command, the logistic command, or the industrial contractor—into the total logistic system at the appropriate time and place, thus making the entire system responsive to the military logistics commander.

At the beginning of this analysis the logistic system was described as the bridge between the economy and military operations. We have seen how the nature of this bridge changes through the years. The bridge of the past was made up of vast stores of supplies and equipment obtained from the economy and held on hand until required by the combat commands. The bridge of the future will be a managerial one, integrating both military and industrial logistic actions to achieve effective support based upon preciseness and quickness of response rather than on massiveness of stocks. The logistician must continue to perfect the techniques that enable him to integrate and coordinate the vast number of individual actions which go to make up logistics. Only in this way can he accomplish his objective, the effective support of military operations.

Headquarters Air Force Logistics Command

Basing the Aerospace Force

Major General Augustus M. Minton

WHEN General H. H. Arnold was Chief of Staff of the Army Air Corps, he wisely observed that air power was supported by three pillars—men, planes, and bases. The passing years have seen each pillar undergo changes in context and configuration to mirror the evolutionary effects of the dynamics of technology and world events. The texture of each pillar now is extremely complex, with the strength of the whole structure inextricably related to and dependent upon the capabilities of component parts. Each must support its share of the load, which constantly shifts to reflect technological advances and potential threats of enemy forces and weapons. Our aerospace power is dependent upon the maintenance of a delicate level of balance among its three remodeled pillars—men, aerospace vehicles, and bases.

Too often when we think of bases we think only of the facilities necessary for the operation of aircraft, such as runways, hangars, communication systems, and maintenance shops. As we enter the aerospace age our concept of bases must change. We must think of vastly complex facilities that are conceived and designed almost as a subsystem of the weapon itself. Certain of these facilities would have been considered impractical of construction a few years ago, as at the radar sites now being constructed on the icecap in Greenland. Not only must bases in support of aerospace forces include the comparatively crude facilities necessary to house, maintain, and launch our earlier missiles such as Matador, Snark, Thor, and Jupiter, but they must provide the fantastically complex facilities for the ICBM's and the space vehicles of the future.

aerospace construction requirements

Although in the past it was necessary to design runways, hangars, and ramps to conform to the aircraft that were to use them, the degree of tolerance was great. It was possible to construct these facilities with a fair degree of certainty that the weapons could be deployed on them with no difficulty. We could budget, design, and construct them with a minimum of coordination with the developer of the airplane or air weapon system. We talked in terms of length, width, and strength of pavements, square feet of maintenance facilities, and number of refueling pits. If the civil engineer followed these very simple criteria, the results were satisfactory.

The same practices are not applicable to the bases for our more advanced weapon systems, such as the liquid-fueled missiles, the Minuteman, and the more exotic space vehicles. The building or structure that accommodates the missile or the radar is a small part of the facility constructed by the civil engineer. It is the outer garment that shelters and protects the complex of equipment essential to the weapon's capability. The environmental control system, the supporting power system, the fueling system—all are designed and constructed by the civil engineer as an integral part of the weapon system. The requirement for "concurrency" in the development of weapon systems is in fact becoming ever greater as new and more complicated systems are conceived, in that all elements or subsystems must be developed concurrently to ensure the timely and satisfactory operation of the system. The necessity to include facilities as a subsystem or element is unquestionable.

Sophistication. In this trend of weapon development, the one factor that stands out as most important in the field of civil engineering is the constantly increasing degree of sophistication built into the newer weapon systems. Although among our airborne weapon systems there is little resemblance between the B-17 and B-52, their basic principles involved primarily a refinement of similar techniques and knowledge. On the contrary, the ICBM goes far beyond any degree of sophistication that existed in our most complicated airborne weapon system. The ICBM gives rise to requirements for environmental controls such as air conditioning, heating, dust control, and power that were never dreamed of a few years ago. For instance, the very close tolerances in power requirements for our radar systems have generated entirely new concepts of engineering design and equipment production.

Reliability. Hand in hand with increased sophistication has been the increase in reliability required for each of these new weapon systems. The number of B-17's and B-52's flown with one or two engines out of commission, with various flight instruments not operating properly, or with other assorted maladjustments is legion. With missiles, each one of the literally hundreds of thousands of parts must function perfectly if the missile is to perform its mission. Not only must each of the engines function; it must function with a very small tolerance in thrust—another criterion inconceivable in our design practices a few years ago. To provide this degree of reliability requires facilities for supporting equipment that are virtually an integral part of the missile.

As we plan, budget, and construct our bases in the future, we also must always keep in mind that their requirements have become twofold: First, they have the conventional base function of supporting the weapon system. Second, and perhaps more important, many bases must be engineered to survive an all-out nuclear attack and still remain operationally effective. They must protect the weapon system.

Increased personnel facilities. The support aspects of our bases will continue to be quite prosaic, although increasing dramatically in scope as we add more family housing and better places for people to live, work, and play. In the past few years our base facilities of the more or less conventional types have increased at the rate of about $1 billion a year to a total at the present time of approximately $11 billion. All this property must be maintained and operated. In size alone, such support will present some very interesting problems of engineering management in the aerospace age. The Air Force has been a leader in striving for better facilities for its personnel, in the sure knowledge that the profit in terms of better personnel and greater operational capability would far more than offset the initial capital outlay for these facilities. Our high re-enlistment rate, based on a very selective policy, is reflected in the capability of our offensive and defensive forces. It is sure testimony to the soundness of this purpose.

Building for survival. In the survival aspects of our base facilities we enter into a new era of construction, maintenance, and operations in the Air Force. Actually the survival problem can be broken down into two parts. We have the necessity of maintaining and operating some of the most complicated facilities that man can devise, under the most difficult climatic and logistic conditions existing on earth. We are well along on the construction of these facilities—such as the Ballistic Missile Early Warning System (BMEWS) and the icecap stations—yet we have not begun to cope with the maintenance and operation problems that climatic and logistic conditions will present. These installations were designed and built to a very high degree of reliability and sophistication at great cost; the Thule BMEWS installation cost a total of $500 million, of which amount $100 million was for construction. We can expect comparable expenditures for maintenance and operation of these facilities if we are to attain the capabilities to which they were designed and constructed.

Of much greater importance is the requirement that our facilities must be designed to survive nuclear attack. Since our national policy dictates that this country will never be an aggressor, we must provide our weapon systems with facilities ensuring their survivability for reasonable periods of time in nuclear war. This we do by hardening them, to the maximum extent that is economically and technically practical, and by dispersing them. This means a vastly more complex weapon system and more difficult problems of construction.

We think of survivability in terms of resistance to destruction by overpressures and shock. A term commonly used, although not truly descriptive of the problem, is pounds per square inch (psi). A good, substantial roof on a commercial building can be considered as about ⅓ psi construction, meaning that each square foot of roof can support and resist forces of approximately 50 pounds. Our present construction practices for ICBM's provide protection of 100 pounds per square inch or 14,400 pounds per square foot. This strength is roughly 300 times that of a normal structure. A 100-psi overpressure on average soil will produce vertical and horizontal movements of 8.6 and 2.9 inches, which attenuate very little—to 8 and 2.1 inches—at 100-foot depth. The shock will be in the order of 37.5 g, a magnitude that may be envisioned in terms of the 7.3 g which a supersonic fighter and its equipment are designed to withstand. Already we are planning facilities several times stronger than the nominal 100 psi.

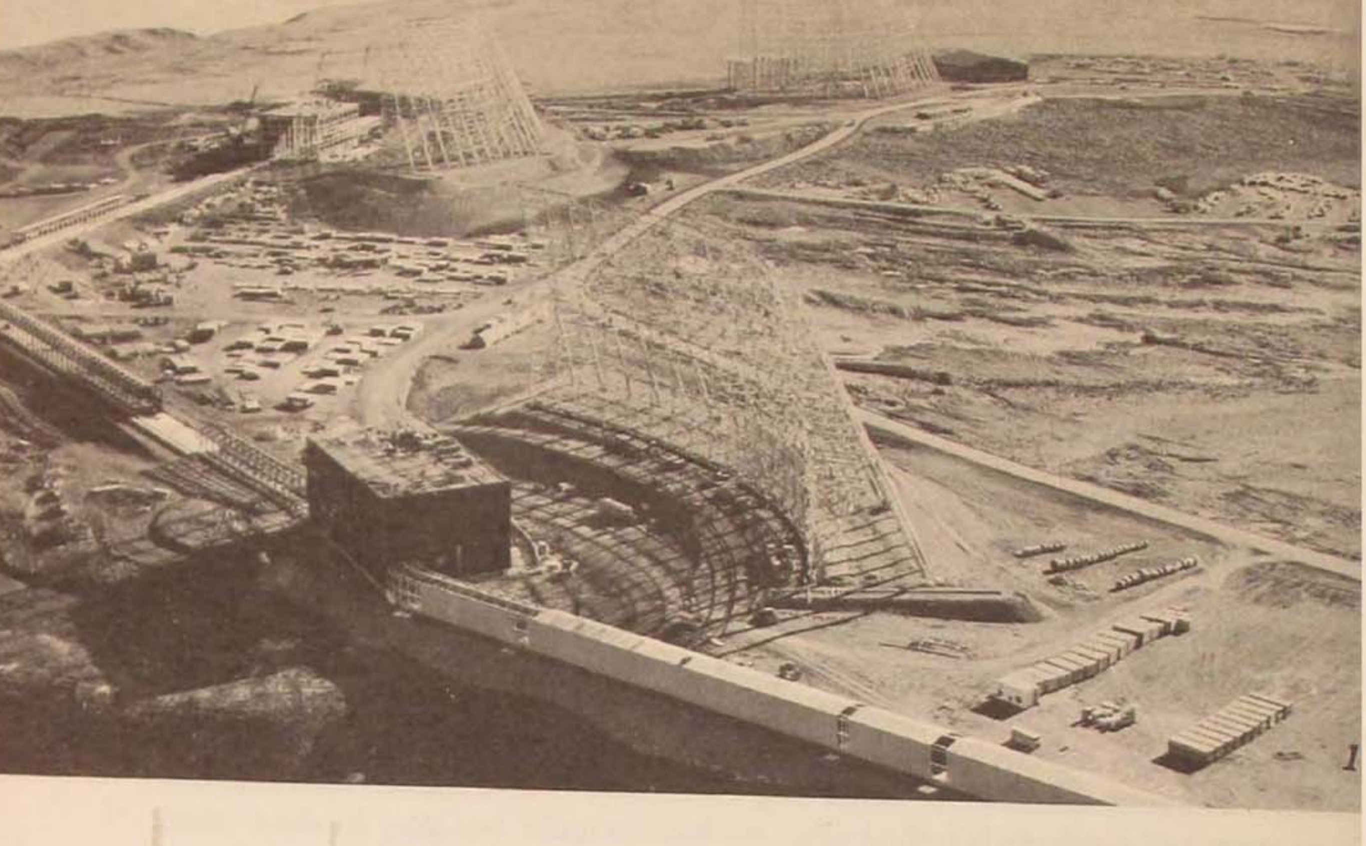
The twin purposes of protection in terms of psi and shock, considering the very delicate equipment that must be protected, pose unique problems for the engineering profession. This problem is complicated by the fact that there is no known way to test these structures to determine the adequacy of design. We have means of subjecting bridges, ordinary buildings, and other conventional structures to tests to determine how nearly they meet their requirements. But it is not feasible to simulate the mountain-crushing blow of a multimegaton bomb on a facility that houses one of the most complicated masses of equipment ever devised and assembled by man. The only real test will come after these facilities have been subjected to the shock of an attack: Will they then be able to respond to the push of the red button? Until that test, we must rely upon the highest degree of professional knowledge and integrity available.

However, if there is any aspect of the development of our new weapon systems that has been underestimated, it is the ability of the engineer to design and construct facilities suitable for protection. Not over two or three years ago it was felt that construction with a nominal 100-psi capability was about the best we could hope for. Now we feel that several times that degree of hardness is technically and economically feasible. As the enemy threat develops or changes, we will be able to devise means of meeting it by increasing hardness, by dispersal, and by concealment of our prime offensive weapons.

maintenance of facilities

In the consideration of facilities necessary to support aerospace power, we must always be aware that they are only as good as our ability to maintain and operate them. In the past there has been a clear line of demarcation between maintenance of facilities and operation of weapon systems. A B-52 could be refueled from conventional refueling units and take off from a substandard runway without undue difficulty if emergency dictated. The great problem was that of maintaining and operating the weapon system itself for the many flights necessary to attain and hold a high degree of proficiency in the crew and the weapon system. The maintenance of supporting facilities was accomplished for convenience.

The missile requires an entirely different concept. It does not wear out engines, accessories, or subassemblies. It never makes training flights. It sits and waits. During this period of waiting the only requirement is constant check, recheck, and further recheck of the subsystems having a bearing on the capability of the missile to perform on its one-time flight. This checking must include the external air-conditioning, heating, compressed-air, and fueling systems, as well as the guidance system and the components that are a part of the missile itself. Every one of these elements, whether the power generator that keeps the inertial-guidance system warm or a pump in the liquid-oxygen system itself, must be in perfect shape at all times. In the aerospace age maintenance and operation are synonymous.



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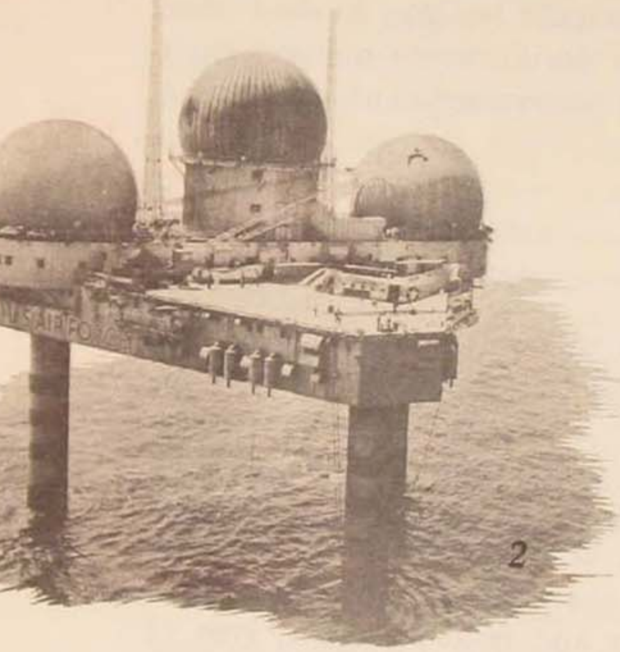

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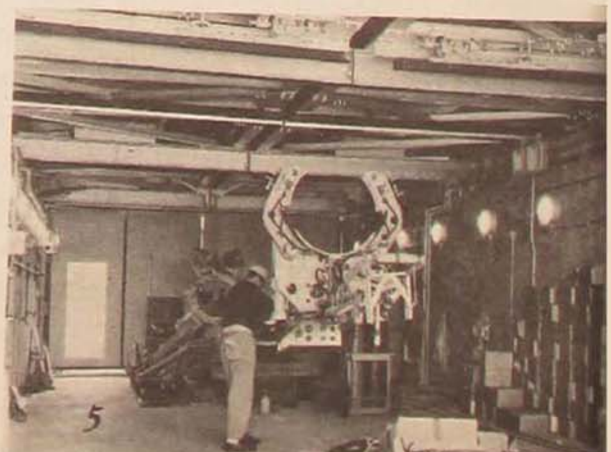

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Defense

Construction of defensive outposts often must accommodate unusual environmental conditions or rapidly evolving weapon systems. The result may be structurally unique. 1. At Thule, Greenland, BMEWS radar antennas 160 feet high and 420 feet long are built to withstand 150-knot winds when covered with a solid coat of ice. 2. Texas Tower radar stations must endure winds up to 125 mph and breaking waves up to 35 feet high. 3. An eastern-extension Dew Line station, 350 miles across the Greenland icecap from the nearest air base, could only be constructed during limited work periods because of logistic and weather problems. 4. A composite building in the Dew Line eastern extension was constructed with built-in jacks that can recover its 3-foot annual sinkage into the Greenland icecap. 5. A Bomarc launching building near Suffolk County AFB, New York, illustrates the trend in weapon systems for maintenance and operation to be under one roof.

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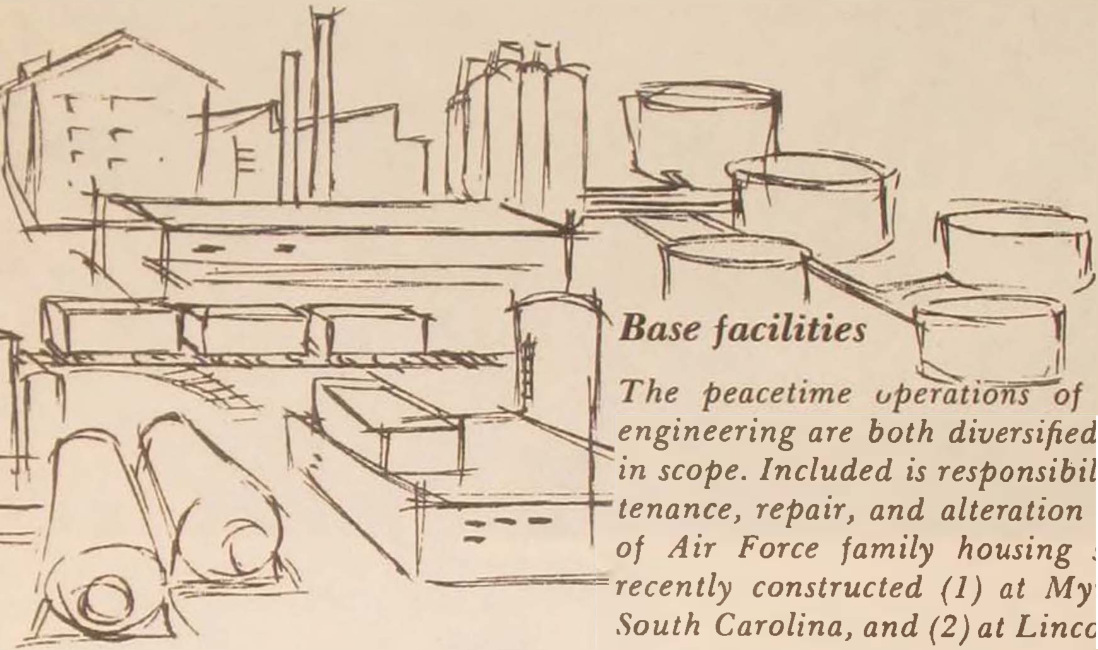


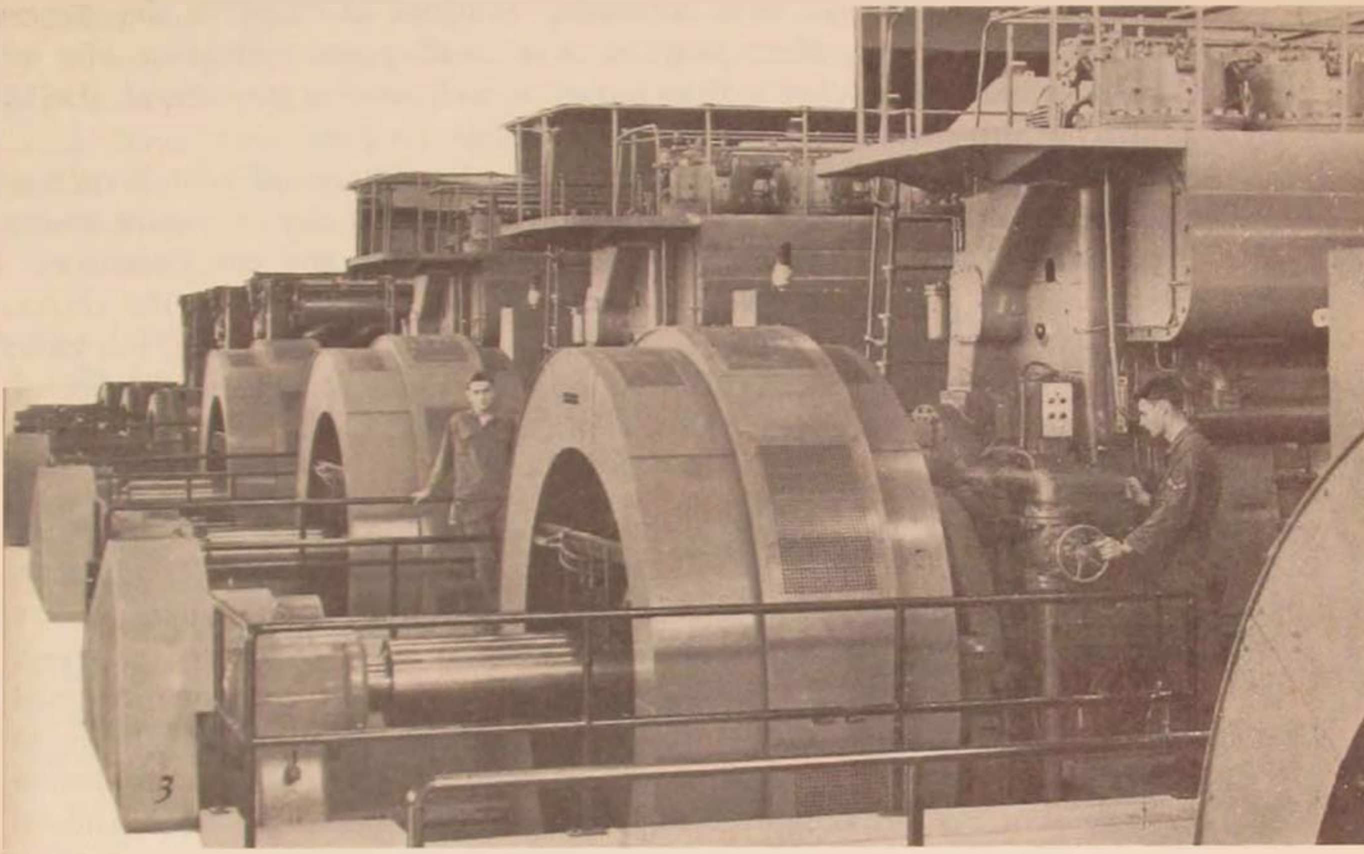
Base facilities

The peacetime operations of Air Force civil engineering are both diversified and world-wide in scope. Included is responsibility for the maintenance, repair, and alteration of 157,277 units of Air Force family housing similar to those recently constructed (1) at Myrtle Beach AFB, South Carolina, and (2) at Lincoln AFB, Nebraska. This program now has an inventory valued in excess of one billion dollars. Electrical power requirements for operational facilities, such as these 2500-kilowatt units (3) at Loring AFB, Maine, place a heavy demand on the civil engineer for maintenance and operation. At operating locations throughout the world the Air Force has 1767 fixed diesel generators supplying a total of 592,623 kilowatts.

problems of aerospace facilities

Certain problems arise in our transition from air force to aerospace force.

Budgeting. Perhaps the most important problem is our budgetary procedure. At present we are geared to a system developed in the era of the 300-mile-per-hour bomber and the one- or two-thousand-pound conventional bomb. This procedure envisioned a period of approximately 36 months from the time the requirement for a facility is established to the date it can support the weapon system. There is compelling need to revamp this system to provide unified budgetary support for the weapon system. Perhaps budgets should carry a single line item for a weapon system, to include all



the costs of providing the system. At present we have different line items for procurement of the missile, direct-support equipment, construction, development, training, and operation. These line items are separated in the "functional" budget. Thus construction, for example, is part of the over-all construction budget, and procurement is part of the over-all procurement budget. Different staff sections justify and defend the various parts of the functional budget before Department of Defense, Bureau of the Budget, and Congressional committees.

We should have a procedure whereby all the costs of an aerospace weapon system are combined in one budget program and presented as a package through all levels of review. With a reasonable degree of flexibility to offset unexpected higher costs, for example in the communications area, and to reprogram savings achieved, as in the construction area, such a procedure appears essential if we are to proceed with timely and effective development of the sophisticated aerospace weapon systems of the future.

Programing. A second problem area is that of better long-range programing. We have an increasing number of monuments built throughout the United States and in overseas areas that attest to the twin problems of inadequate funds and incomplete programing. Possibly we may stop in the middle of construction of an airfield, at a cost of a few million dollars. But if we attempt to change programs halfway through the development of weapon systems such as Navaho, Goose, and others, the cost enters another order of magnitude. We have increasing evidence of "foot in the door" technique—the selling of a program with inadequate evaluation of the manpower and dollars that will be required, and, more important, of ability to deliver an operational item on the schedule proposed.

As our aerospace systems become infinitely more complex, it is certain that their cost will increase proportionately. The necessity to ensure sound programing, based on the best possible accumulation and consideration of facts, becomes paramount. We may consider our monuments to the changing program as evidence of the dynamic nature of the aerospace age; but those who are inclined to be critical of us may see them as patent evidence of our inadequate programing and of the need for closer scrutiny of our proposals.

Impact of weapon sophistication. A third problem is the degree of sophistication we are inclined to gear into our weapon systems development, and how this reflects upon the facilities requirement. Too often we are tempted to try the 100-yard dash when we have not yet learned to crawl. Although the general criteria given the civil engineer for environmental controls, fuel systems, and power are within his technical capability to satisfy, the costs of their fulfillment are sometimes far out of proportion to the results that are obtained. This is particularly important for consideration in view of the fact that our construction requirements in the civil engineering area are several times larger than the funds made available.

Design and construction methods. A fourth problem area is the adequacy in the aerospace age of our present design and construction methods. Facilities to support the weapon systems are programed, budgeted, designed, and constructed by agencies that have comparatively little connection with the contractor who is responsible for producing all other elements of the weapon system. This separation was not productive of especial difficulty when we were building pavements for aircraft. The difficulty increases as the supporting facilities become more and more an integral part of the weapon system itself. A step in the right direction has been taken in that the far greater part of civil-engineering design on new weapon systems and research facilities is now done by the Air Force. However, in every case the subsequent construction passes to an agency which is not a part of the team of the prime contractor. Although this separate approach to support facilities during the design and construction period is a matter that has been discussed throughout the history of the Air Force, it takes on renewed emphasis as the furnishing of adequate facilities for the aerospace age becomes more difficult. Considering all the factors involved, the answer is not readily apparent, but it continues to present a problem.

Personnel. There is one last problem that is most critical as we enter the aerospace age. Personnel requirements in the civil-engineering field are most acute. We cannot expect to design, construct, and maintain the sophisticated facilities of this age unless our personnel procurement, education, and training programs are also geared to the aerospace age. The day when the base handy-man, skilled in maintaining concrete runways and wooden buildings, was adequate is rapidly vanishing. He must be replaced by a man with a background of education, experience, and specialized training tailored to the aerospace age. As in most other problem areas of this difficult transitional time, the right man is the key. If we can establish an adequate source of properly trained personnel, the rest of the program will be comparatively simple.

At no time in the history of this country has the requirement for appraisal of the future been quite so urgent. We stand at the threshold of a gigantic breakthrough in technological development. We cannot take full advantage of the opportunity if we cling to planning, programing, procedures, and thinking geared to the airplane, the carrier, and the tank. To complicate the problem, time is the essence of the requirement, and it is most difficult to change long-established procedures quickly.

Our methods of producing the men, vehicles, and bases for the aerospace age must be responsive to the unique requirements of an entirely different problem. The only element moving constantly and inexorably forward is time.

Headquarters United States Air Force

Training the Aerospace Force

Lieutenant General James E. Briggs

THE DECADE of the Sixties will be one of great scientific and technological advances. It will be one of great strides in military weapon systems. All this may lead to speculation about the part that man—or more properly in the case of the Air Force, the airman—will play in the future Aerospace Force. Developments in the Aerospace Force during the next ten years will more than ever highlight the importance of man in the weapon system complex. As present and future weapon systems develop, larger numbers of high-quality manpower trained in advanced skills will be needed.

As developments and changes take place in weapon systems, progressing from the air-breathing vehicles to the space systems, from mechanical to electronic operations, from gasoline to exotic fuels, training programs to prepare the man for the Aerospace Force will have to be updated and evolve with the change. This will be a matter of evolution rather than revolution.

Over the past 40 years training has transitioned from early systems of the Twenties and Thirties (P-1, B-2), through the more complicated systems of the Forties (P-51, B-29), into the complex and what we call sophisticated aircraft and missiles of the Fifties (B-52, F-104, Atlas, Titan). Throughout these years, because of the increasing complexity of new systems, the question has recurrently been raised whether the military training organization could effect unaided the training and upkeep required for the operational force. The Air Force has proved that, with the necessary wherewithal, it could do it in the past, and we see nothing to preclude this accomplishment in the future.

During the next ten-year period, training for the aerospace force will divide into (a) continued updating of training programs to keep abreast of new developments and (b) concurrent development and implementation of space-system training programs.

developments in training

The evolution of the aerospace force training concept is dictated by the foreseeable needs of future systems requirements. The training program must have flexibility to meet changing needs. It must provide the right man for the right job and provide the training that will convert individual potential into valuable activity. It must achieve this mission in the most economical manner practicable.

During the next decade four general areas of development in personnel training can be identified as necessary to support the aerospace force:

(1) Continuation of programs for officer training, Officer Candidate School, military training, rated officer training, and technical training.

(2) Identifying and planning technical training programs that will require updating of their contents to correspond with changing system requirements. These programs are normally system-oriented or closely tied to new developments in existing equipment. Examples are the B-70, second- and third-generation missiles, new types of radar, reconnaissance, and communications equipment. Replacement training of operators and maintenance personnel for the mixed force will undergo continual change and become more complex as required by new follow-on missiles, aircraft, electronic systems, and space systems and modifications of existing systems, including support equipment and facilities and systems hardware. This training will be conducted at resident schools and at field training detachments. The complexity of the new systems and modifications will call for more than one-for-one replacement to satisfy the need for more people of a higher skill level. Thus the training problem becomes more difficult. Nevertheless it is considered that technical training can be accomplished under present training concepts. Organizationally we will continue to have training centers that are responsible for training on specific weapon systems as well as training in specific functional areas.

(3) Flying training programs for both pilots and navigators must be continually advanced so that the students train from the very beginning in vehicles with flight characteristics and performance as close as possible to operational vehicles. This method will minimize the problems of transitioning to the higher-performance operational aircraft such as the B-52, B-58, B-70, F-105, F-106, and early spacecraft. The T-33 will phase out. The more advanced supersonic T-38 will become the basic jet trainer, following initial jet training in the T-37.

(4) Concurrently new training capabilities will have to be developed, including training programs for operators and maintenance personnel for new type ICBM's, B-70's, and satellites; for manned space systems; for electronic command and control systems; and for subsystems such as nuclear propulsion and data processing.

recruiting and selection

As the aerospace force develops and its systems become more complex, the need for higher-quality manpower will increase in direct ratio. Thus during the next decade there will be an increasing need for selective recruiting to locate and procure men for the aerospace force with as broad a base of prior knowledge as possible. The larger their base of knowledge, the shorter can be their training time, particularly if their prior knowledge is related to the fields in which training is conducted.

It will be increasingly important for personnel classification and assignment systems to be refined to locate the right type of man to be trained for the present career areas as well as for the many ones that will open up. Once the technicians, pilots, and navigators are trained, they must be positively identified so that they may be utilized in their most productive capacity.

Having selected the best man and trained him, it will become imperative to keep him, since training is costlier, more complex, and more time-consuming than ever. The aerospace force will, by its very nature, demand well-trained, experienced, qualified, and dedicated men. It cannot afford to operate with a constant turnover of this valuable component of the weapon system. Careers will have to be made as attractive as possible, and at least competitive with private industry, to retain these men.

Pilots and navigators will continue to be selected as under current programs. Reduced pilot production will permit increased emphasis on selection of more highly qualified individuals. All students in pilot training will be commissioned officers. The majority will be Air Force Academy graduates, ROTC-commissioned, or specially selected college graduates who have been through the officer training program.

The Officer Training School will play an increasingly important role as a source of officers with a broad base of prior knowledge needed for particular aerospace force skills. Input to this precommissioning program will continue to be restricted to college graduates with degrees in specific technical areas where the need for additional officers has been determined to exist. Experience to date indicates that this course offers great potential, permitting selection of top-quality personnel.

A progressive need will be a better understanding among civilian educational institutions of the aerospace force and its requirement for a broad spectrum of knowledge.

training concepts and problems

Training Time. Today the high-school graduate has a greater chance for success in learning technical jobs and for succeeding in them than the non-high-school graduate. Similarly the college man succeeds better in the more complex jobs. After the right man has been found, training methods will have to be constantly improved to shorten the training time. Extensive training time will be prohibited by rising costs and by compression of time available because of rapid hardware development. Training will have to be constantly evaluated to be sure it meets the needs of the using agency as soon as possible, consistent with providing a quality-trained individual.

Instructors are the key to any successful training program. The instructors must continue to be given proper recognition, and they must become professional. They must be in on the early development of systems and be kept current on them. We must continue to secure the best instructors possible and train them in the latest developments in teaching techniques and training aids and devices.

Training Equipment. The quality of training is and will continue to be dependent upon the training equipment that is available at the start of the training, which means that it must be developed along with the development of the related weapon system. We must also progressively increase the fidelity, effectiveness, and utilization of our simulators, trainers, and training aids. In some instances it will be necessary to develop simple synthetic training devices incorporating fundamental principles reflected in new equipment, for use prior to or after the actual hardware is available. In other cases it may be necessary to build specially designed parts of greater ruggedness than the actual parts in the equipment. This is particularly true in missiles, where parts often are engineered for one-time use and may not stand up under repeated usage in training. The day of "paper and pencil" training is rapidly disappearing. In its place are training devices which will become more elaborate and more costly, with prices for some, like the operational equipment, running to six and seven figures.

Facilities at training bases presently in use will have to evolve to accommodate the new training missions and training equipment needed for new systems. As recent experience has shown, present structures may not be adaptable as to size, power, and environmental requirements. An example of a new type of training facility is Neel Kearby Hall, a classroom laboratory structure completed in late 1959 at Sheppard Air Force Base as part of a 3-million-dollar missile training complex. It has 210,000 square feet of floor space, 126 classrooms and laboratories, and a huge missile bay area in which several missiles can be placed at one time with enough room to conduct training on all simultaneously. This complex duplicates for the student the real facilities of his eventual environment. It provides facilities for training that could not be housed in presently available training buildings because of size (such as erect ICBM's) or other requirements.

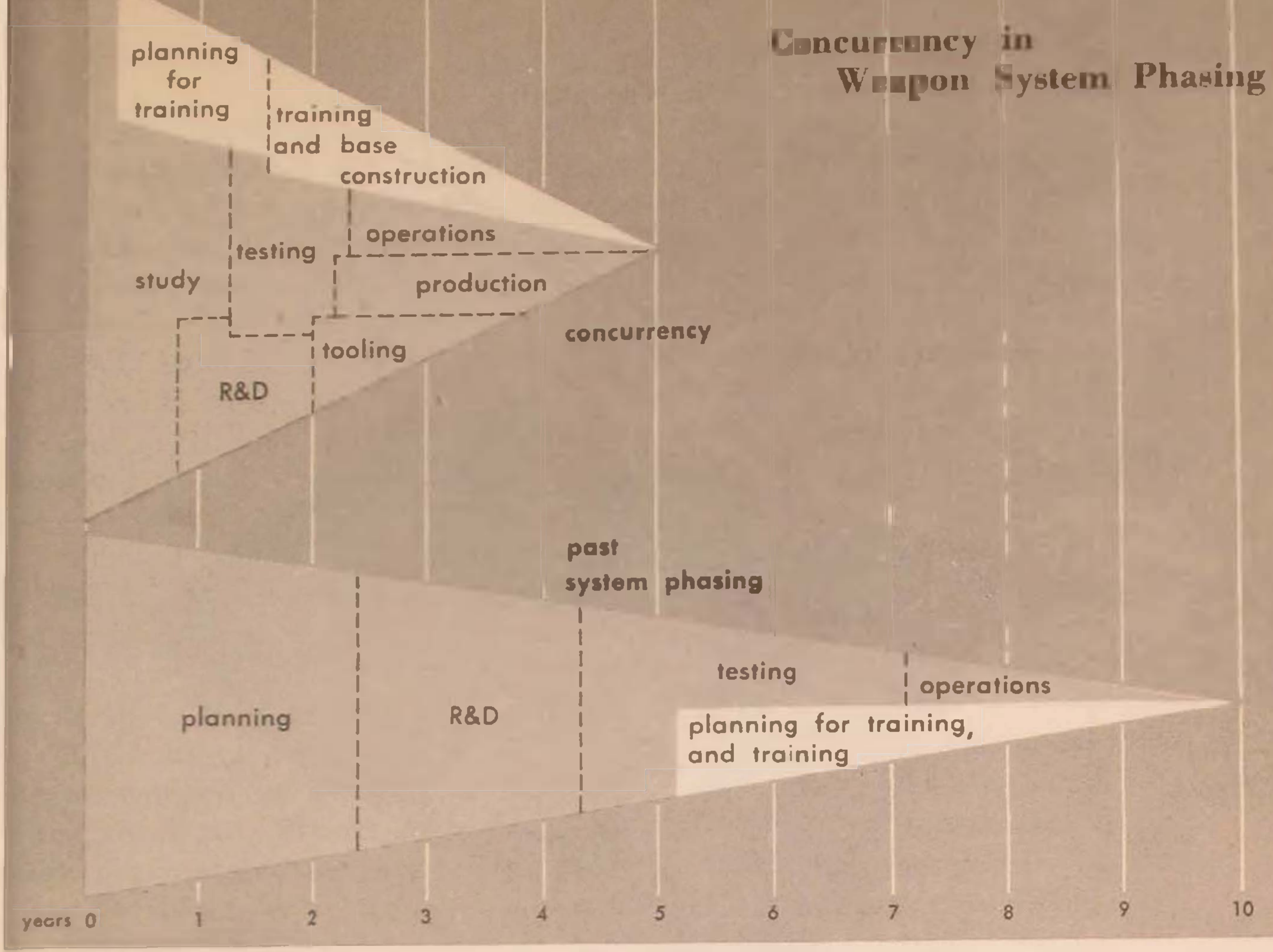
The "prime center" concept will continue to be used to support systems training requirements for the next decade. Under this concept one technical training center is assigned over-all responsibility for the individual-training program for a system. Supporting centers are assigned as necessary. To further establish this concept, the trend is to conduct as much system training as possible for a particular system at one training center.

Navigator training has a pressing requirement for a more advanced training aircraft than the present reciprocating-engine T-29. A high-speed jet navigator trainer with performance capabilities nearer those of the operational aircraft is needed to relieve the operational commands of transitioning the student to the higher-performance aircraft. The higher-performance, higher-altitude operational aircraft and space vehicles will also bring about the need for new techniques of navigation, on which the pilots and navigators must receive training. Navigators will be concerned with three-dimensional navigational techniques rather than two. They must also be trained to operate intelligently and to control the advanced equipment subsystems associated with Dyna-Soar and other future-generation manned missiles and spacecraft. New trainers employing a new technique of simulating land masses will be required. Navigator trainers utilizing the light-optic technique of simulation will replace present supersonic trainers.

New training methods and techniques will be needed to meet new aerospace training requirements. It is not anticipated that these techniques will be revolutionary in nature or that they will be generated primarily because of incoming space-system development or any one type of system, but they are inherent in an evolutionary training concept. When conceptual methods and techniques must be developed, they will be programed—as at present—into the research and development structure so that they can be applied to the training environment. Examples of these developments which are now in the program and which will see greater use in the next decade are closed-circuit TV, automated teaching devices utilizing computer techniques with programed questions and answers, and advanced simulators that can simulate a complete mission profile and total environment. The objectives of these and other such developments are to increase the rate of learning, increase retention factors, cut training costs and time, and produce better-qualified personnel.

Concurrency as applied to hardware development is well known, but its impact on training has not been so well understood. In the past, weapon systems have evolved in sequential, definite steps. This phasing provided lead time for planning and conducting training after the development cycle. The concurrency concept has resulted in an overlap in the development, testing, production, and operational cycles. The resulting compression of time means that planning for training and developing a training capability must start during the conceptual stage, if trained operating and maintenance personnel are to be ready as soon as the system becomes operational. Training under the concurrency concept presents a constant challenge. At the beginning of training it is necessary to use research data and to develop training aids that will depict principles and fundamentals. Often there are no guides, no textbooks, no past to draw on. The program must be built from bare beginnings and evolve with the developments in the system as it progresses from drawing board to reality. Thus training must reflect the changes that take place during the research, testing, production, and operational cycles, all of which may be overlapping. Training lead time in some cases, such as for skilled missile technicians, is now longer than the lead time required to develop new weapon systems. Two concepts are valid in this area: (1) a weapon system will not be operational nor will it function efficiently unless there has been adequate and timely training of operator and maintenance personnel, and (2) planning for the required training must be a part of the concurrency concept and must start at the conceptual stage.

Complexity of new and future systems entering the aerospace force inventory will require personnel with a better background in basic principles and fundamentals, in addition to specific equipment-oriented training in their career areas. This broad background will enable the individual to understand how and why he must accomplish specific functions and tasks and to develop his capacity to operate and maintain specific hardware. It


Concurrency in Weapon System Phasing

will provide a base on which to grow careerwise and flexibility for assignment to follow-on systems with minimum retraining.

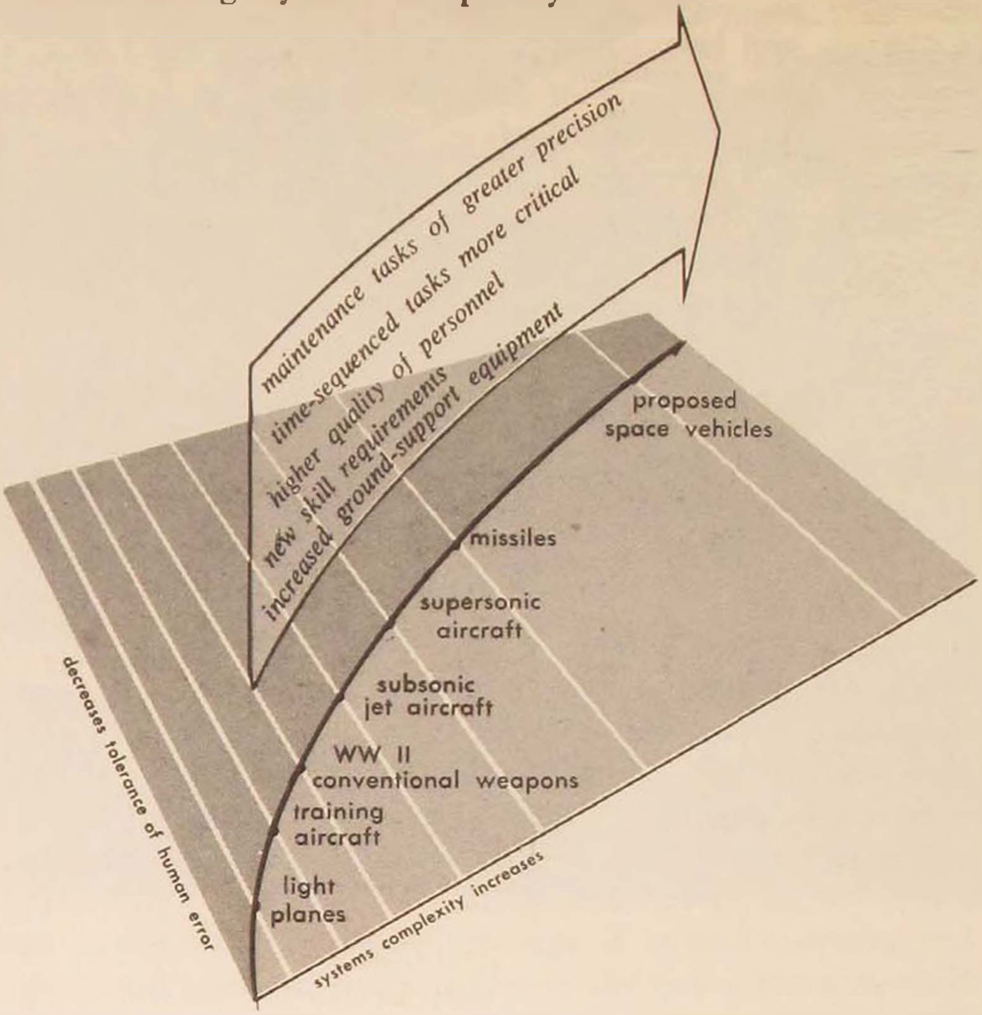
training for space systems

As the United States advances in its space efforts during the oncoming decade and as its aerospace forces begin to operate increasingly in what is commonly called space, training programs geared to space vehicles will have to be developed. At present many agencies are engaged in related research and operations. However, one U.S. agency should be responsible for the complete training of the personnel who will operate in space. This single agency will provide continuity, centralized control, efficiency, economy, and flexibility to meet all agencies' needs and will preclude interagency duplication.

Although manned operations in space have yet to materialize, the best efforts of Air Training Command to anticipate what will be required to prepare personnel for space have already produced some accepted concepts:

Manning for the space systems will be drawn from existing personnel resources. As systems in the inventory phase out and new systems phase in, no gross effect upon the total USAF manpower requirements is anticipated.

Effects of Increasing System Complexity



Personnel selected for the space systems will require application of expanded selection procedures, more simulated training, and actual "space" training. However, many of the jobs and positions required by the space systems will be partially or completely compatible with existing personnel qualifications at that time, e.g., launch personnel, communications, data processing, etc.

Training methods and techniques to satisfy the space-systems requirements will evolve from present training. Specific design of simulators and equipment will be peculiar to the manned space systems, but learning techniques and methods will not.

Instructors for the future space systems should be integrated as participants in the space-systems development programs presently existing. These instructors will provide an initial base of experience for future space systems.

Personnel for space systems will present new problems, but their solutions will be built upon past experience with personnel for the air age. Maintenance and support career areas currently in use are compatible with the requirements for space systems. We must update, as required, courses for missile mechanics, airframe repairmen, instrumentation technicians, aircraft and missile accessory specialists for life-support systems, etc. New career areas may evolve, as in nuclear propulsion.

Crews selected to man space systems will initially be retrained jet crew personnel. Personnel for existing X-15, Dyna-Soar, Mercury Project, and super-mach aircraft will have the basic qualifications to retrain into spacecrew functions. Eventually the selection of crews for manned space systems will involve the development of criteria for physical and mental capabilities heretofore unmatched except in the Mercury Astronaut selection program. Although the exact stresses to be placed on a spacecrewman are unknown at this time, the general stressful areas are well recognized. Weightlessness, sensory deprivation, accelerative forces, excessive heat, and isolation are all stresses which must be considered in any program of selection and training for spacecrews.

Physical examinations presently used for aircrew qualification will have to be supplemented by two other types of tests to adequately evaluate manned space-system crews. The first of these added tests will be the stress tests. They will encompass such aspects as physical fitness and tolerance to acceleration, heat, noise, and vibration.

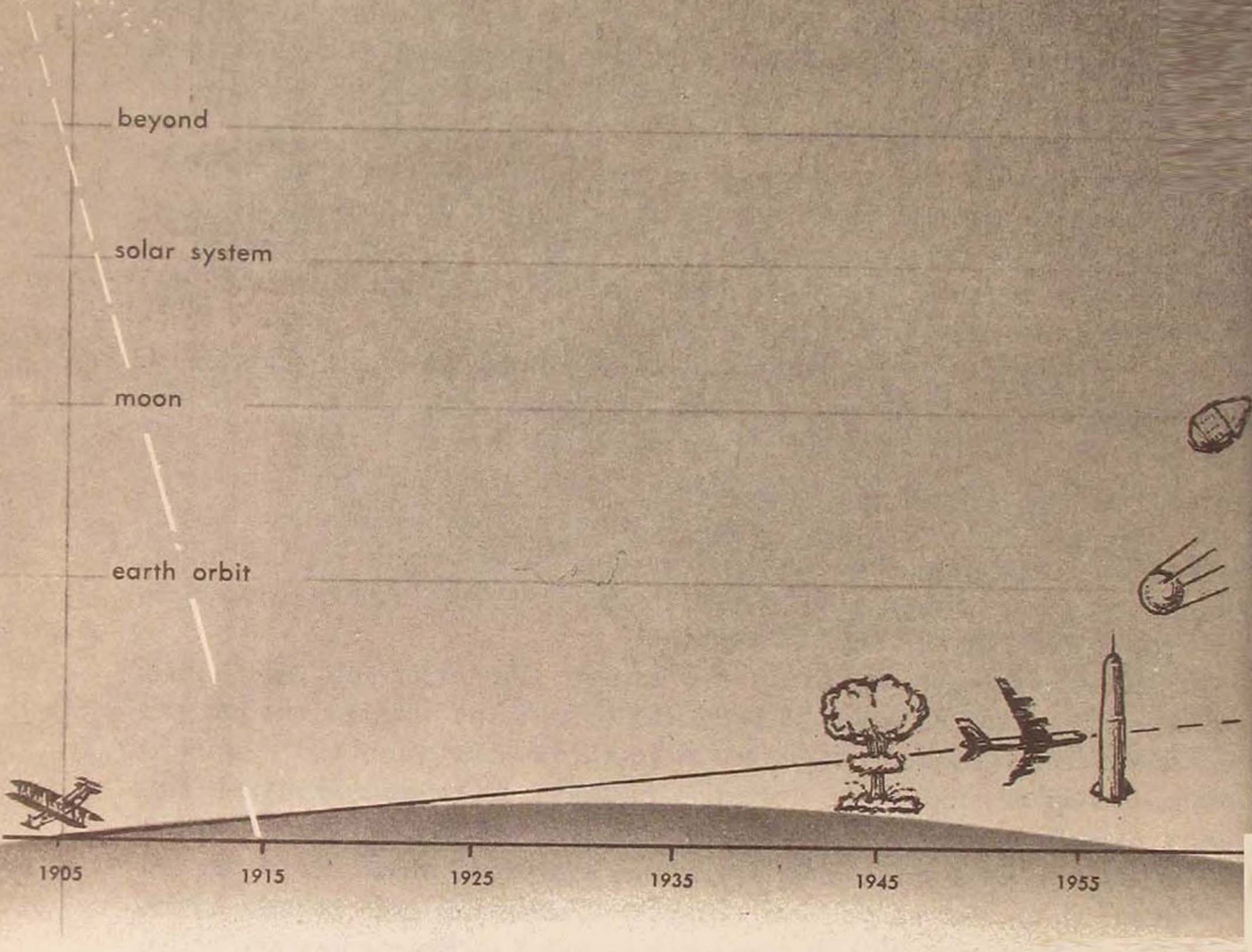
Psychological tests will be the second group of added tests and perhaps the most important. The spacecrewman will have to have a rare psychological make-up. He will have a high level of intelligence. He should be able to work as an integral member of a group and then suddenly accept extreme isolation. He should be able to respond to foreseeable situations in predictable manner and also to adapt rapidly to unanticipated and unfamiliar circumstances. The proper selection of spacecrews will be of great importance, and the responsibility for much of such a selection program will fall within the medical and paramedical fields.

Simulation devices of advanced sophistication will be needed to raise individuals to the required level of proficiency in the numerous aspects of space missions without the tremendous expenditure of effort, hardware, and facilities to give this required training in space. Examples of these are: (1) World-wide escape and survival procedures and equipment. (2) Operation and maintenance of various space vehicle subsystems in independent and integrated programs, such as vehicle control systems, reconnaissance subsystems, systems for communications, display, warning, life support, etc. (3) Complete mission profiles, to include preparation for launch, injection to orbit, orbiting, re-entry, and recovery.

Training vehicles will have to be developed to give individuals or crews training in actual space vehicles and actual space conditions. There are many areas that cannot be taught by simulators but only by actual flight. For manned space systems examples of these areas are (1) actual launching, (2) speed regimes up to and including orbital or near orbital speeds, (3) actual vehicle and subsystem mission performance in actual environment, and (4) psychological preparation for actual mission requirements. Psychological preparation will be most important, as it will prove to the individual that *he* can do it and that the equipment does work and perform. Crew confidence is thus developed. This is an important factor, since the mission performance will depend on the capability of the crew.

Training sites will eventually be needed to train crews for space flight.

Mid-century Performance Breakthrough



of ballistic missile technology, man was able to send his vehicles into outer space, to orbit the earth as artificial satellites or to escape the earth's gravitational field entirely. These developments have had profound effects on military strategy and thinking:

- The classical pattern of depending upon a big increase in weapon production after the beginning of hostilities has gone by the board, once and for all. Wars will be decided with the firepower and delivery systems in place at the beginning of hostilities.
- The entire world and the aerospace surrounding it have become the potential theater of war.
- The ability to apply hundreds of megatons of firepower halfway around the world in a matter of minutes has made irrevocable any decision to start a nuclear–missile war.

- The amount of time allowed to formulate this irrevocable decision has been severely compressed.
- The classical commander, with his binoculars and bugle, can no longer direct the battle in the old ways.
- New means are required to put the commander back into command, to allow him to use and control the new weapons that technology has created for him.
- The new weapons have also relieved the military of much of the chore connected with military operations, e.g., the arming and flying of thousands of air vehicles. This relief frees a larger segment of the military to exercise the more basic and decisive activities—strategy, command, and control.

Thus the overriding factors have become the compression of time, the expanded theater of operations, the increasing importance of decisions that are right the first time, and the lessening of the commander's ability to perceive and actively direct the battle. The machines of war have outstripped the control capability of their creators. We have to return control of the battle to the commander. This is the essence of what has come to be termed "command and control."

Fortunately we can turn to technology for answers to the very problems it has created. Concurrent with, and partially as a result of, the breakthroughs in warhead and delivery-system performance came data-processing machines (computers) that can process, store, and present vast masses of data at microsecond speeds. The notion was thus conceived that perhaps such machines, coupled with electronic information-gathering devices and electronic communications techniques, might put the reins of command back into the hands of the commander. Within the United States Air Force this notion first took the form of a semiautomatic interception system against air-breathing bombers. As time went on the notion caught hold in other mission areas.

nature of command and control

Today the commander has updated his binoculars and bugle. His "eyes" may be the giant radars of the Ballistic Missile Early Warning System (BMEWS), located far in the northern reaches, or in the near future they may be Midas, orbiting in space. His electronic "bugles" must send instantaneous orders to weapons soon to be positioned in silo farms and undersea launching platforms thousands of miles away. Each of his sensors and flexors employs complex data-processing machinery to accumulate, process, and distill war data.

How can the commander act quickly and decisively in so vast a battlefield, with his war resources scattered over the globe and into space? What crutches must he employ when his resources are so remote, his war staff so decentralized? In essence, this is the command and control problem: how much control, what kind, at what level?

There are two definitions of command and control—one functional, one technical—each having its place in this discussion.

Functional definition: Command includes methods, organizations, and techniques employed by commanders in their formulation of war decisions. Control denotes a command organization which clearly assigns responsibility, establishes commensurate authority, and ensures prompt transmission of war orders.

Technical definition: Command and control consists of those methods and systems comprising combinations of data collection, data transmission, data processing, and data display, to facilitate timely decisions. It also provides for information on which to base decisions at all levels of command.

To relate the command and control problem to the operational needs of the Air Force it is necessary to consider that, although aerospace is an operational continuum, technologically it breaks down into three main areas according to the types of vehicles operating in that continuum:

(1) Operations within the air ocean that surrounds the earth. Such operations are normally considered to be restricted to altitudes below 100,000 feet. The vehicles employ air-breathing engines and depend upon the atmosphere for lift and for directional control by means of airfoils.

(2) Operations in near space, just outside the air ocean, when the vehicle or satellite is no longer dependent on the atmosphere for propulsion or lift but is still acted upon by the earth's gravitational field.

(3) Operations in outer space, well beyond the earth's gravitational field, where extraordinary propulsion means must be utilized to position vehicles so as to permit their recapture by the earth's gravitational field.

The Air Force has been actively operating in the first of these areas for a long time. Its sensors, communications facilities, and control centers are globally deployed to perform the command and control function associated with it. Already its operational activity is being extended into the second area, through such oncoming satellite programs as Midas. Logic dictates that it will invade the third area as an inevitable and logical extension of its basic mission.

To meet its growing needs in these three operational areas, the Air Force is developing command and control elements in four main categories.

Control center elements. Most essential of the command and control elements are those immediately surrounding the commander and his active battle staff in a major command such as North American Air Defense Command or Strategic Air Command. The physical location is normally called the control center. Here is concentrated the highest level of command decision. From it execution orders are issued, replan and redeployment of the battle forces are directed, and, when the battle is won, surrender terms could well be enunciated. The physical design of a control center in the nuclear–ballistic age is most important, since it is here that the status and posture of the entire aerospace war machine are portrayed to the senior decision maker. Here masses of information meet in the mind of the commander. It is the knoll overlooking the classic battlefield of old.

Of primary importance in the control center is the graphic portrayal of the aerospace theater of operations, displaying the location and current status of forces wherever they may be in the great tridimensional theater of aerospace. Here the commander, with his intelligence and operations officers, evaluates and analyzes the vast amount of data concerning his battle area and formulates his strategy to employ effectively his diversified weapons of war. In the control center the climate, the physical arrangements, the portrayal of war situations must be such as to ease the heavy burden of judgment placed on the senior decision maker. Wrong assessments, misinterpretation of information, or lack of information as to battle elements can be the crucial hinge on which the tide of battle turns.

Alert and warning element. This is the element of command and control which globally deploys sensory devices in electronic fences, chains, or bastions to scan or guard our aerospace frontiers. It maintains intelligence and reconnaissance to ascertain locations and movements of enemy forces. Hostile electromagnetic radiations must be monitored likewise. These sensors are netted, through communications, to the homeland control center to provide intelligence and warning.

Aerospace-vehicle developments are demanding that sensors guard more and more aerospace volume, including both friendly and unfriendly orbital traffic. The sensors of this command and control element are basically designed to conform with the "distant air battle concept," and the various sensors are netted to provide a number of zone-of-interior (ZI) command posts with correlated data, since exact direction of attack can no longer be anticipated.

As newer research vehicles are created to probe space, the need arises for an experimental environment within which to track such probes—a task which encounters new difficulties caused by the rotation of the earth. Activity is under way to tie our world-wide tracking sensors to a central ZI control post for analysis, direction, and display. This experimental environment is an extension of our more sophisticated command and control elements already in place.

Air-vehicle control elements. Because the Air Force conducts its offense from hundreds of bases dispersed over the globe, an air-vehicle control element has been set up to report instantly on the posture and status of these vehicles no matter where deployed. Automation techniques bring these data to a central ZI command post for continuous display and analysis. From the information the Strategic Air Command commander can issue orders that will maintain a maximum strike posture consistent with manning, combat readiness, and economic factors. Should hostilities arise, the same air-vehicle control element directs the aerospace battle.

In defense against air-breathing bombers, where the theater is not as extensive geographically as for the offensive forces, similar control elements have been established for target detecting and identification, tracking, alert, launch, and intercept direction. A system not unlike its offensive counterpart has been established to ensure the readiness of the total defense force and to direct its portion of the air battle.

Support elements. Weather: For that portion of USAF operations conducted within the air ocean, an automatic weather observation and forecasting element is under development. This element monitors the conditions of the atmosphere on a global basis and permits constant and ready machine input of weather data for calculating optimum routes, refueling areas, and restrike operations.

Combat readiness: The need for high performance has made the air vehicle technically complex. To ensure a continuous high state of alert, a family of automatic machines is under development to ground-check the combat readiness of each vehicle. An umbilical cord connects the vehicle to the ground-check machine. Automatic programers check each subsystem of the vehicle for proper functioning and identify malfunctioning parts so they can quickly be replaced. The part can be automatically reordered from the original vendor electromagnetically. The degree and speed of reordering are presently under study.

Data transmission: Most important of the support elements is that which the USAF employs to interconnect all its command-control elements with a ZI command post for central management surveillance and decision making. Modernization of this communications net is constantly in progress. Of particular interest is the design concept: refurbishing of the network should serve primarily to improve transmission of data in the total command and control complex. Heretofore the traffic has been primarily concerned with the transmittal of "messages" per se. In transmitting data the requirement for accuracy is infinitely higher. Errors in word messages are quickly noted and corrected through extrapolation, while errors in mathematical data compound themselves and are relatively irretrievable.

Intelligence: Here data-processing techniques are used to screen the vast quantities of information available on a potential enemy's national posture, economic structure, research and development efforts, force deployment, etc. Tons of data are sorted and screened for indications of strategic intent or technological surprise and for changes in posture. This intelligence activity directly supports command decision at all levels. It is important to realize that such command control data are used, on an urgent basis, by the top civilian management of the country for comparison and correlation with diplomatic and other intelligence to determine if a state of hostility exists or may soon exist. The dual utility of these data, both as inputs for top civilian decision making and for military command and control functions, underscores their increasing importance as time goes on.

general design considerations

We have seen that there was a time when strategic command decisions were contained in the commander's mind and he exercised control through relatively primitive communications. There are some indeed who still hold to this parochial view, even while acknowledging the advances which technology has made in these areas. But modern weaponry, with its inherent complexity and limitless vistas, has enlarged the scope of command and control until it now encompasses the commander, the flow of essential war data, the war staff, and the entire organization and its resources.

To produce an effective command and control complex, its designer must have at the outset a concept of operation which encompasses national strategy, which takes into account the climate of decision at civilian and military decision-making levels, and which examines organization and assigned missions. He must take notice of war-planning operations and control of forces, of communications and doctrine, of deployment of sensors and data-collection inputs, of the nature, deployment, and use of the weapons, and of logistics and other military support operations. In other words, the designer must truly understand the organization for which he is attempting to design a system that will automate the flow of decision data and to build automated evaluation aids and intelligent machines.

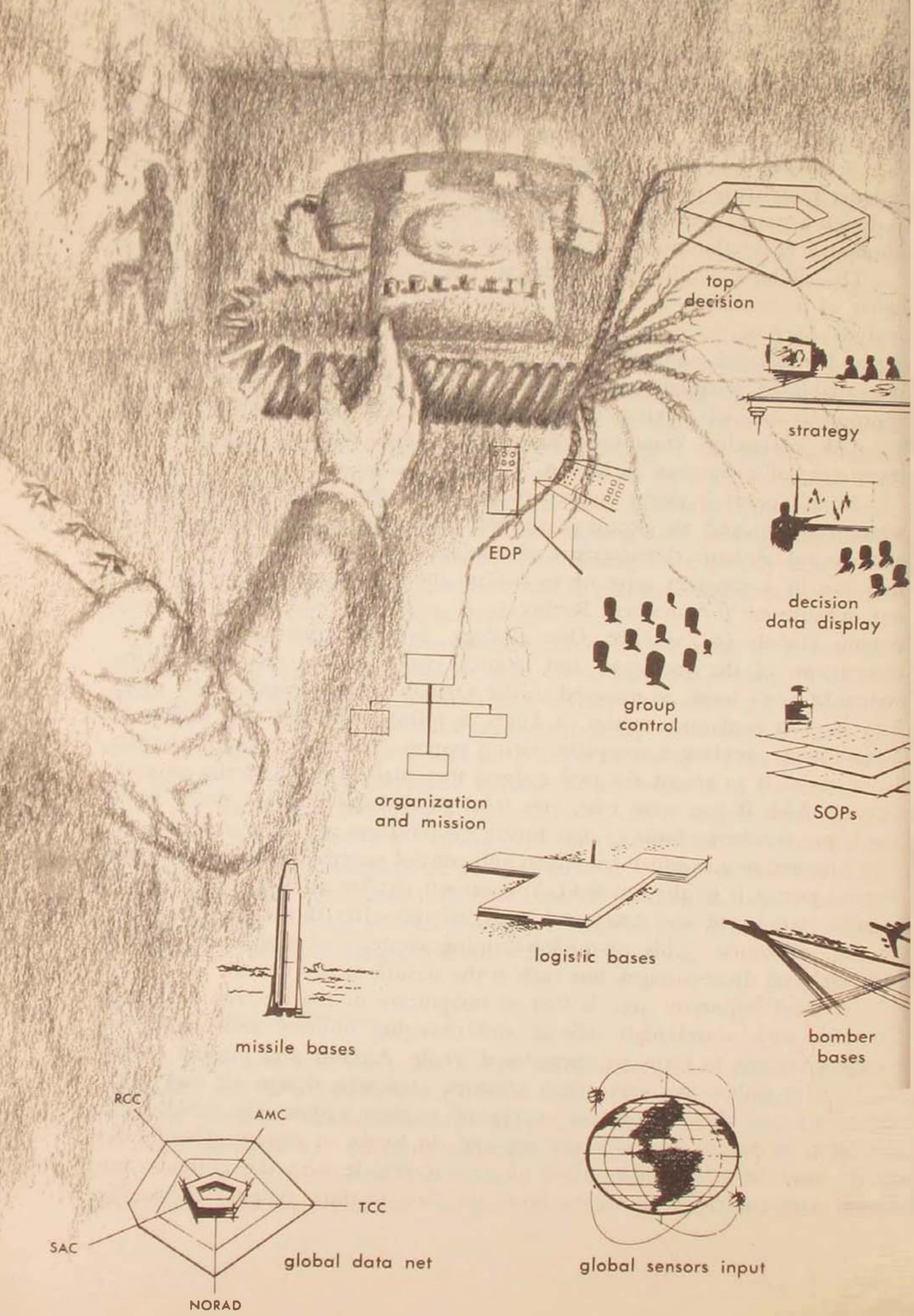
The following illustration depicts the considerations that the designer of a command and control system must embrace in his study and analysis. Each of the items depicted includes complex internal data processing and associated communications and decision displays. Thus the items are capable of interconnection to permit flow of essential information to appropriate decision-making centers. In the USAF alone this display complex for data processing, communications, sensor, and decision represents an investment of more than $5 billion.

At this point it might be well to point out the differences between a weapon system and an electronic support system in the field of command and control. A basic characteristic of command and control systems is that they are in a constant state of evolution and progression. One system is not substituted for another. Rather it is added to and integrated with systems already in existence. One analogy, perhaps oversimplified, is the comparison of the command and control system to the electrical wiring system in one's home, as opposed to the various electrical devices one plugs into it. You replace a toaster, a lamp, a refrigerator. But you never, or almost never, replace a complete wiring system. You add to it, modernize it, or revise it to accept the new gadgets that place a heavy drain on your circuits. And, if you were wise, you tried to anticipate future needs when the home was being built so that future modification would be minimized.

Another area in which command and control systems differ from weapon systems per se is in the test field. You cannot test-fire an electronic support system. It is tested and developed in actual use—after thorough component testing, of course. This on-the-job-training concept of test has both advantages and disadvantages, but such is the nature of the beast.

A third important area is that of integration of the electronic support complex with a well-nigh infinite and changing number and variety of weapon systems to form an operational whole. Aircraft and missiles are of little value unless they serve their creators. Men who design air and space vehicles expect them to be able to respond to their wishes. The vehicles are required to probe, survey, penetrate, and do battle in distant theaters. So there must be a total integration of the air vehicle with the ground command and control complex to form the "air warfare system." Thus the

Command and Control as a Single Concept



weapon system concept naturally evolved into a total concept, integrating the aerospace vehicle with the command and control complex to perform the military tasks expected of it by the commander.

The command and control elements that have been described have two things in common. All have been designed to aid man in control of the complex aerospace-vehicle force. In addition all are predominantly electronic in nature. Being electronic, they are inherently capable of data distribution through several successive elements. This interchange is accomplished by appropriate electrical interconnection of the elements. Interconnection permits data correlation to be a powerful tool. Decision centers can be shifted up or down echelon by means of the network to provide flexibility of operation and survival of command by redundancy.

specific design considerations

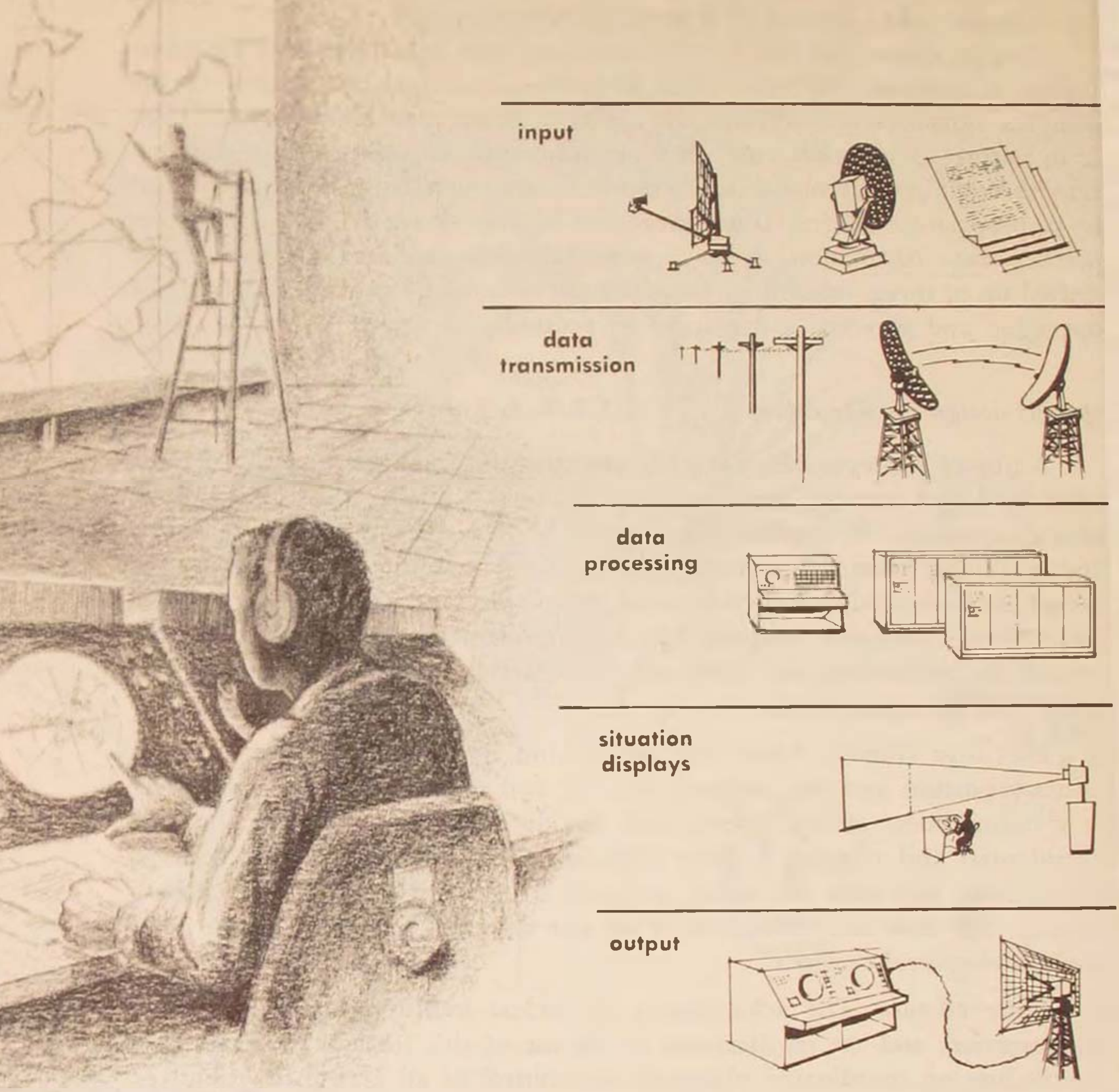
National strategy. The designer of the command and control complex must take into account the plans and national strategy which dictate our strategic posture. He should be aware of the required hardness and survivability of the command centers and associated communications links. His design must consider our strike-second philosophy and the effective employment of our aerospace weapons. He must implement the general plans for arming and defending our allies and the strategic plans for integrating the global and aerospace forces.

Executive climate. There is a curious but important interplay between military posture and our national security and diplomatic activities. There is a commonness of intelligence and the decision data used by both the Presidential and the top military decision makers. More and more critical information and data are being gathered by our far-flung global military sensors. The flow and utilization of all war data are important to the command and control designer.

Force climate. The achievement of nuclear–ballistic capabilities in all three services and the implications of the use of this force in warfare place a premium on coordinated planning and control of all U.S. force resources. The designer of a command and control system must understand the roles of all services and the interplay between them in war planning, particularly with respect to targeting and replanning. The "decision to go to war" under an "attack-second" policy has important plan and replan overtones, particularly in the matter of survival of command.

Control of forces. The decision to employ force, the degree to which it will be limited, the reliable communications to a dispersed thermonuclear-armed force, and the transmittal of last-minute executive decisions are important considerations. It may be that the side capable of regrouping intelligently for the second wave will win the historian's nod. The weapons, their performance, and their integration must be understood by the system designer.

Typical Subsystems of a Command and Control Element



Combat readiness. In the nuclear age, logistics has translated itself into the problem of keeping the in-being force at razor-sharp combat readiness. The entire war machine must be poised. The command and control system and the weapons must be cocked but not accident-prone. This is a design problem of no mean magnitude.

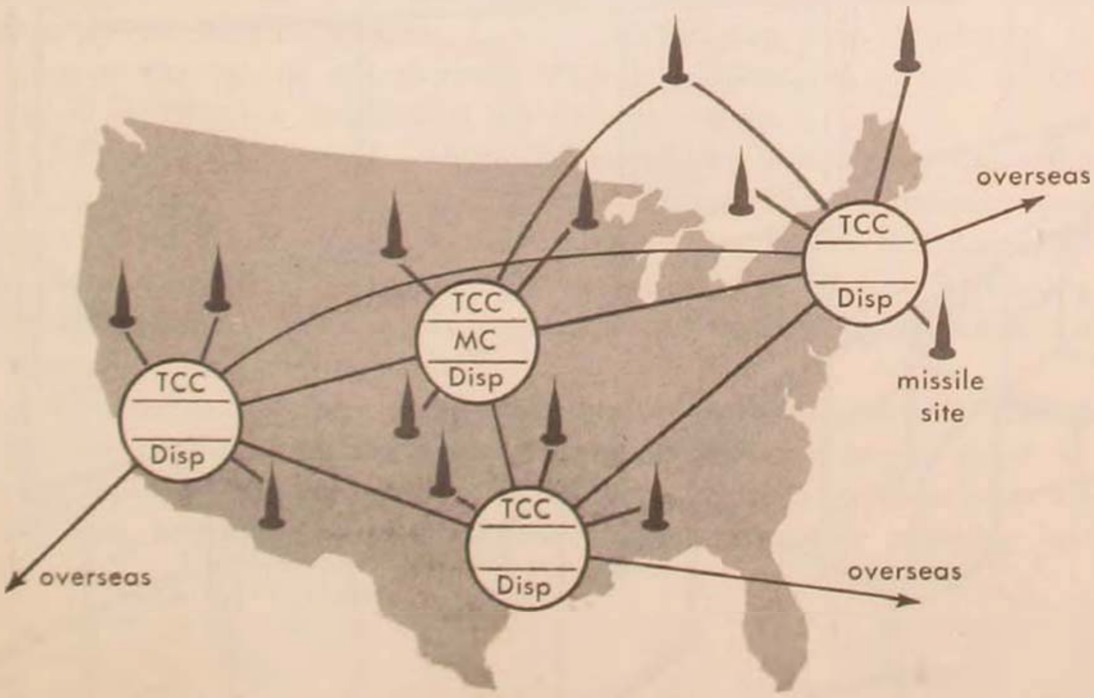
command and control in the air ocean

The USAF has planned or under way at the moment some twelve elements which comprise its command and control complex. Before discussing a specific command and control element, however, it is necessary to explain the systems relationship between the command and control elements.

The elements are usually composed of similar subsystems. These subsystems are (1) a form of an input, (2) a data-transmission means, (3) a data-processing complex, and (4) a situation display. Each element contains these subsystems, but they vary as to form, complexity, and nature. Each element is capable of interconnection with another element, and a number of elements form the whole complex. Finally there is a "system rhythm" about the complex. The best way to explain it is that a system is something one order larger than the component item or element immediately under scrutiny. To the bolt manufacturer the nut-and-bolt assembly is a system. To the nut-and-bolt manufacturer the system may be the wheel assembly or what have you. A similar system relationship applies to each and every element of the USAF command and control complex. In size these subsystems of command and control elements may range from something like the Washington Central to the McGuire Sector of the Eastern Air Defense Force or to a net spanning the entire globe.

SAC *Control System* (SACCS). One of the twelve major elements in the projected USAF command and control complex is the Strategic Air Command Control System (SACCS). This system is to be utilized by the Commander in Chief, Strategic Air Command, as a tool for positive control of his force. To fulfill the SAC mission, CINCSAC must have continuous, total, positive, and instantaneous control of his forces deployed at bases around the world. This can be achieved only if he has complete real-time knowledge of the status and capability of these forces. "Real time," in this context, means that data collection, transmission, processing, and military reaction take place within the time element of the military problem—that decision making and reaction take place in time to effectively commit and employ the military force and complete the mission for which it was designed. This requirement dictates the need for a highly automated command and control system, such

SAC Control System Organization

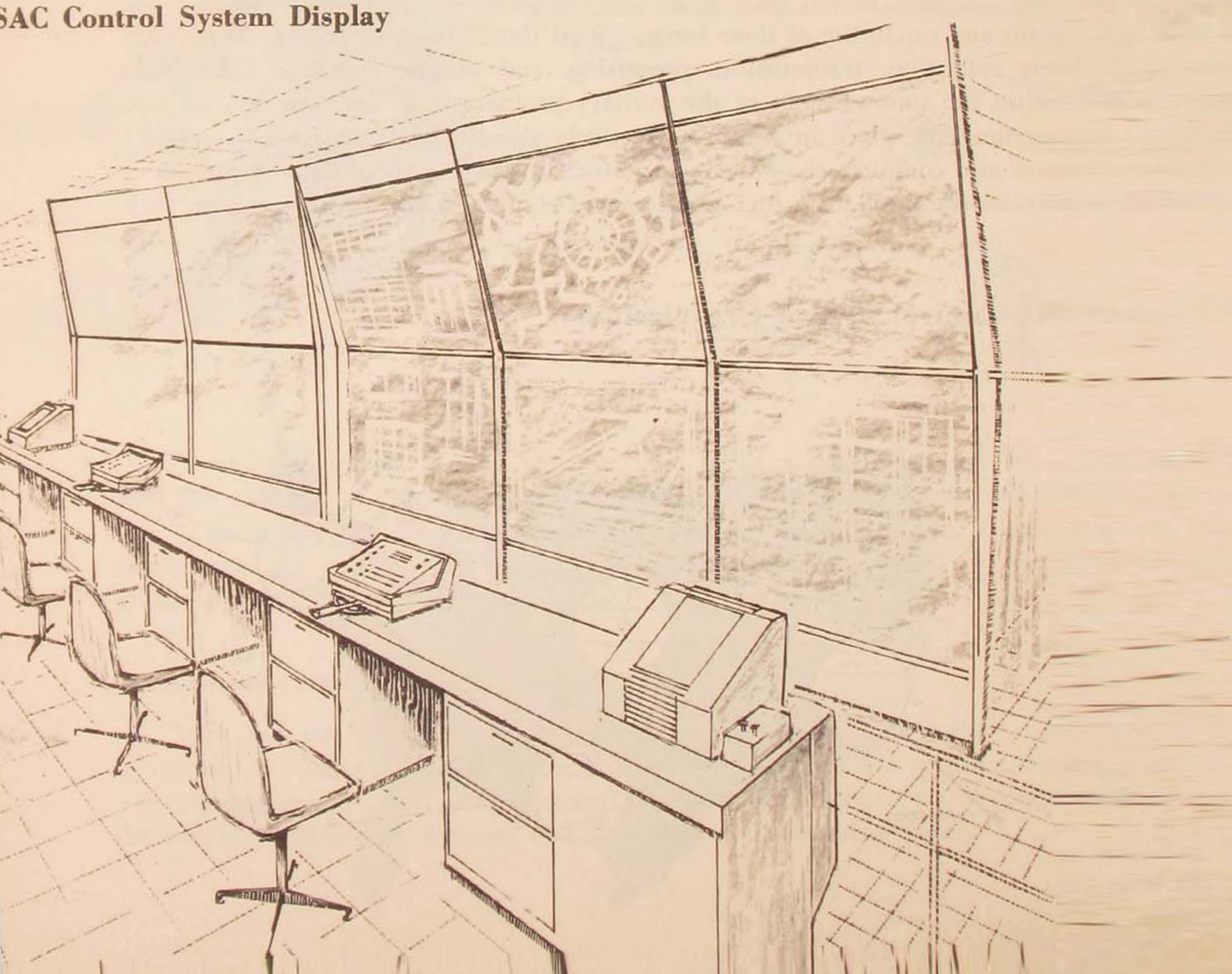


as the one currently under development by the Air Force as System 465L—SACCS.

SACCS is a high-speed data-transmission, data-processing, and data-display system to provide CINCSAC with information required to plan, direct, and control the world-wide operations of Strategic Air Command. In addition to displaying information for decision-making activities, the system will also aid in war planning, training exercises, flight-path planning, missile employment, war gaming, and bomb damage assessment. The SAC Control System provides the following features: a high-speed data-transmission network with automatic routing and error-detection–correction capabilities; high-speed, large-volume, random-access storage and computing capabilities, with cross-telling of information; and automatic display of complex information in a form suitable for decision making. These features are indicative of the SACCS subsystems, i.e., data-transmission subsystem, data-processing subsystem, and data-presentation subsystem.

Data and messages pertaining to each base or missile site are transmitted via a remote communications complex (RCC) to an electronic data traffic control center (EDTCC). Here they are routed to their proper destination. The data are normally routed to a high-speed digital electronic computer,

AC Control System Display



which operates on the raw data in accordance with predetermined programs. The finished data are stored in perforated pages available for display to the SAC commander and his staff either by an automatic or request chain. The commander and his staff evaluate the displayed information, formulate the decisions necessary to control the force, and transmit commands to the SAC units via the electronic data traffic control center into the remote communications complex. This entire process can be accomplished in a matter of a few minutes, most of which are required for the normal input at base level and for the decision-making processes. These few minutes between events and resultant commands will enable the CINCSAC to constantly control his forces under rapidly changing conditions with the effectiveness required for instantaneous deterrent reaction.

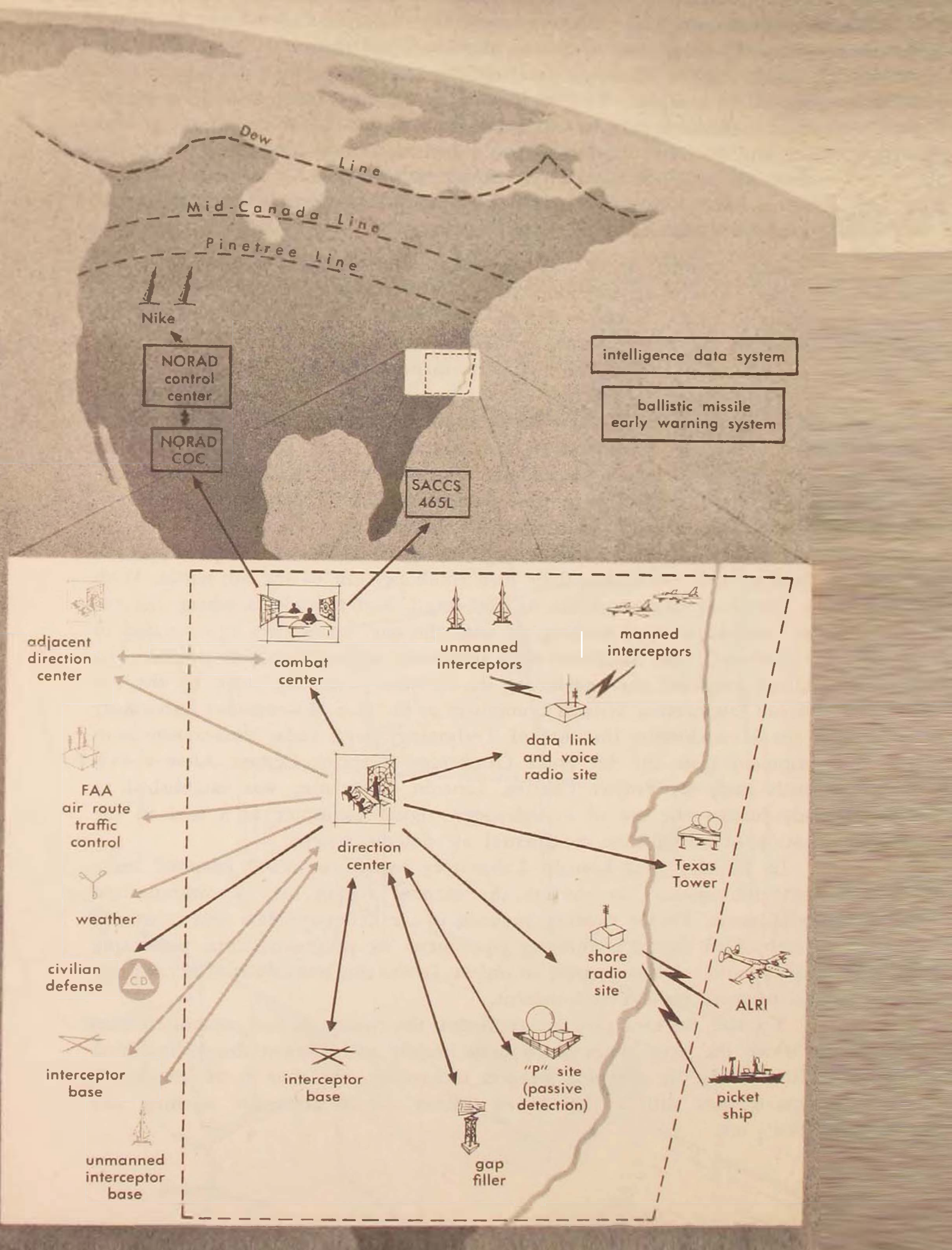
SAGE. Another major USAF command and control system is the semiautomatic ground environment (SAGE). This system is utilized by the Commander in Chief, North American Air Defense Command, in directing the defense of the North American heartland. SAGE was primarily engineered and designed to combat the high-performance manned bomber.

The technical significance of SAGE as a precursor in USAF command and control effort warrants a few words about its history. At the end of World War II the Air Force had in operation a manual "lash-up" air defense system composed largely of outdated World War II radars and communications equipment. Small geographic areas in the United States were established, and each was assigned a manual direction center or ground-control intercept (GCI) station. The air defense facilities operated almost independently in following and conducting their own small portion of the air battle. With the advent of large numbers of high-speed, high-altitude bombers, the system was incapable of keeping up with the amount of data that needed to be processed. The Air Force then instituted an improvement program. Its findings proposed the continuing of the data-processing work by the Air Defense Engineering Systems Committee at the Digital Computer Laboratory of the Massachusetts Institute of Technology, with radar data-transmission equipment from the Air Force Cambridge Research Center. After a five-month study by Project Charles, Lincoln Laboratory was established to study further the use of a high-speed digital computer as a tool in the creation of an effective continental air defense system.

In January 1953 Lincoln Laboratory issued an initial proposal on a "transition system" to convert the manual system into a computerized environment. To the existing network of air defense radars this transition system added digital computing equipment for processing data, presenting displays, and calculating weapon orders. It was this system which became the semiautomatic ground environment.

To date, the SAGE program represents the command and control element in which the USAF has invested most heavily and is most deeply involved. With the rapidly changing weapon technology, the USAF is at present reassessing SAGE with a view to its further use in aerospace warning and surveillance.

Sage System in Relation to Air Defense Mission



command and control in near space

In the operational area of near space, the USAF is responsible for keeping track—for defensive surveillance purposes—of all objects orbiting the earth. The Air Defense Command is operating its SPADATS (Space Detection and Tracking System) Center at Colorado Springs, with the SPADATS Research and Development Facility (formerly the National Space Surveillance Control Center) acting as backup and technical support.

Mission of SPADATS is to detect all satellites and space vehicles, to catalog and identify them, and to predict their future position. This mission is accomplished by a detection loop consisting of sensors tied to a computer, with a feedback line from the computer to the sensors that furnish initial acquisition data. Outputs from the system present users with data on each satellite in a form compatible with their needs.

The sensors presently in use are of three types: optical, radio ranging, and radar. Optical sensors are the most accurate because the satellite's position can be determined by measuring the angle between the satellite and the known position of fixed stars. When the aperture of the optical system is increased, very sensitive devices can provide surveillance at extreme altitudes. Since cloudiness or daylight can prevent visual observations, these devices are restricted to part-time operation. Radio ranging devices, using both direction-finding and Doppler techniques, are employed when the orbiting satellite transmits a signal or when a deep-space probe radiates signals back to earth. These signals can be used to determine the present position of the object and to predict its future location. Radar is capable of continuous coverage in any weather conditions, although its range is limited by the present state of the art to approximately 2000–3000 miles for a one-square-meter target. Even significant increases in the power output of the radar transmitters will not enable the detection of satellites much more than a few thousand miles from the earth.

These sensors transmit data which are processed in Philco 2000 computers at the SPADATS Center and the R&D Facility. Computer programs have been written that will provide "look angles" to the sensors for future satellite passes, using the data transmitted to the sensors from SPADATS on earlier satellite passes. Also the sighting information is used to compute the "space-track bulletin" issued on each satellite. This gives the users the information necessary to determine a satellite's position at any time.

The first major space-track activity of the former National Space Surveillance Control Center was tracking the decay of the carrier rocket of the first sputnik, which occurred only some 48 hours after the project was organized. Despite a crash-basis operation, the activity was able to make significant contributions in coordinating the activities of the radars at Jodrell Bank, at Millstone Hill, and in the vicinity of the Stanford Research Institute in California. NSSCC worked closely with the Smithsonian Astrophysical Observatory during the last revolutions of the satellite.

By April of 1958 NSSCC was performing routine computations on the motions of the only remaining Soviet earth satellite, Sputnik II, as well as participating in the countdown and launch of all U.S. satellites. Ephemerides of Sputnik II were being dispatched by teletype and cable to interested scientists and observations returned by the same means, which allowed rapid reaction to the rather unpredictable motion of the decaying satellite. Full exchange of unclassified data had been initiated with the Smithsonian Astrophysical Observatory and has been continued ever since. Because of the rapid response made possible by the use of teletype and telephone, up-to-date predictions for Sputnik II enabled visual observation of its decay over the Caribbean early on the morning of 14 April 1958. Both land observers and ships at sea reported seeing the flaming object as it passed over the eastern United States and down across the Caribbean. This was the first and so far the only time that the final decay of a U.S.S.R. satellite has actually been observed.

By July 1958 NSSCC had graduated to its first fully-owned electronic computer—IBM 610, which was used in conjunction with a Cambridge Research Center IBM 650. These two computers and a modest increase in military and civilian personnel enabled NSSCC to issue its first routine predictions on a U.S. satellite. Regular bulletins for Explorer IV were started just prior to the famous Argus experiments of September 1958. Gradually other U.S. satellites were added to the list, and soon NSSCC was maintaining a catalog on all satellites. In December 1958 the Advanced Research Projects Agency provided funds for the present SPADATS R&D Facility, which was dedicated in February 1960 as the National Space Surveillance Control Center. Since then, NSSCC has been the prime source of information on all orbiting objects—whether satellite, rocket body, or odd piece of space "junk" cast off in satellite launch or decay—providing a current catalog on all satellites and predicting the position and motion of all artificial earth satellites. Such information is now being used by the scientific and intelligence community to solve some of the complex problems facing the Department of Defense as the Nation moves further toward the goal of an automatic warning system.

In 1960 the Air Defense Command began training its own people to man the nation's satellite surveillance center, by having them in on-the-job training at the National Space Surveillance Control Center. These are the personnel who are now operating the SPADATS Center at Colorado Springs, reporting this vital information to NORAD.

command and control in deep space

While it is far too early to outline in detail the nature of the command and control system needed for deep-space operations, some of the problems to be faced are highlighted by the Pioneer V vehicle, which is to pass within several million miles of Venus, and at which time the United States would like to be capable of exercising full control. This statement depicts the rudimentary state of our command and control capability in deep space as of this date. It is the achievement of progressive, increasing space command and control that we earnestly seek and toward which the national effort must be pointed.

We have seen that a high degree of commonness exists between the command and control elements which the United States Air Force employs for vehicle and air-weapon control in the air ocean and that which will be employed in near- and deep-space activity. Only through determined pursuit of a policy of commonness in the use of its command and control resources, from both a functional and an operational sense, can the Nation hope to achieve full utilization of these resources and more positive control of aerospace-vehicle activity. On basis of the progression of command and control elements thus far, as discussed here, it is logical that the USAF should continue to apply its experience and operational know-how to near space and deep space to achieve a single, integrated control capability.

A survey of the automation-communications efforts within the United States Air Force has revealed that a plurality of separate organizations was responsible for only partial implementation of command and control subsystems. Most of these organizations were basically "black box" orientated. It was evident that if systems problems of the magnitude outlined were to be successfully solved a development organization had to be created solely for the management design, development, and implementation of integrated command and control systems.

To accomplish the over-all command and control development mission, a recent reorganization of the Air Force has established the Electronic Systems Division (ESD) as one of the major divisions of the Air Force Systems Command. In effect ESD is a lineal descendant of the old Air Defense Systems Integration Division (ADSID). ADSID was set up to ensure that all air defense weapons and the electronic systems that controlled them were compatible, one with the other. Hence the important word "integration" in the title. Germane to the problem also was the need for positive control of the entire air battle, offensive as well as defensive. ESD will continue the ADSID job, expanded to include all USAF command and control systems.

An automated ground environment or sophisticated command and control system is now a requirement for the control of any weapon or force. Intersystem integration has been demonstrated as essential for air defense and will be required for aerospace activities. Systems must be meshed to perform a functional mission, such as aerospace offense. Some systems are common to several mission areas, e.g., the weather data-handling system. Data transfer, common language, multipurpose computers, joint use of facilities, redundance for reliability, and dispersal for survivability are all indicators leading toward a common aerospace control environment.

The USAF is rapidly extending command and control systems that were originally conceived for employment in the air ocean to control operations in near and deep space. The extension of operations to these new theaters outside the air ocean comes naturally to the Air Force and capitalizes on prior efforts and experience. Command and control systems are heavily steeped in the electronic and automation technology and have evolved basically from the electronics, automation, and communications plant which the Air Force has operated globally for more than a decade and a half.

Continued emphasis on command and control systems is essential if new generations of aerospace weapons are to be employed in an optimum manner in the national interest, whether in peacetime, cold war, strategic offense, or defense.

Electronic Systems Division, AFSC

Requirements for Aerospace Weapon Systems

MAJOR GENERAL BRUCE K. HOLLOWAY

SIMPLY stated, the function of requirements planning is to determine first what operational capabilities will be needed in the future and then the specific weapon systems to establish those capabilities. Required capabilities stem from the tasks and responsibilities assigned the Air Force. They are responsive to our national objectives. They must be in consonance with general military policy and established aerospace doctrine. Requirements for the ensuing necessary individual weapon systems must be defined as specifically and quickly as possible. The systems must be the best that can be made available, but their cost must not be prohibitive.

Proceeding from these broad fundamentals, this examination of requirements planning will highlight what we believe to be its course during the next 10 to 15 years, as determined by the evolutionary character of future requirements. The discussion will include basic considerations from which requirements must derive and many of the limiting influences that must be weighed. Some attention will be devoted to the manner in which requirements administration/documentation has already been revised for the future. Finally, a number of the reasons will be considered why the Air Force must continue to define its own requirements.

During the next decade requirements planning must be vastly more dynamic than in the past. Undoubtedly the acceleration of change will furnish the most significant impact on requirements. Traditionally wars have been started with weapons developed during the later phase of a previous conflict. In peacetime the requirements function in staff planning was then relatively static. Its emphasis was on slow improvement in hardware needed to support an already tested operational concept. The same is not true today. Since World War II the rate of technological growth has been phenomenal. It is obvious that another major conflict would not be fought with weapons in the same class as those of World War II or even Korea. Operational concepts would be radically different.

Future technological growth will continue to accelerate at an exponential rate. This condition makes it imperative that those engaged in satisfying the requirements function in staff planning be more imaginative and look deeper into the future than ever before. Their outlook must be increasingly sensitive to changing situations and to new potentials as they become available to ourselves or the enemy. Requirements will have to be quickly modified or reoriented so that we take prompt advantage of technical possibilities which occur. At the same time the perimeters of science have become so broad that it is not possible to attack them all simultaneously. The major efforts will have to be directed toward the approaches which offer the best chance for successfully developing capabilities or systems urgently needed. As never before, the requirements plan must "lead" basic research and advanced development. Careful guidance will ensure that the effort is profitably directed.

evolutionary nature of requirements

Desired future operational capabilities are often called "long-range" requirements; individual weapon systems to give that capability are called "short-range" requirements. These are convenient terms, but they imply a sharper line of demarcation than actually exists, since both designate parts of the same evolutionary process. Requirements initially try to look far into the future, but the effort is based on very meager information. Nevertheless the required general capability is estimated. As time progresses and more facts become available, the estimates assume greater validity, and the nature of the exact capability needed becomes more self-evident. Finally it becomes possible to describe in detail the individual systems which, as a family, will give us the desired capability.

Long-range requirements, usually written seven to fifteen years in advance, are principally to guide basic research and advanced-system studies. It should be emphasized that these are our best estimates and that they must inevitably be modified and changed with time. Intelligence data for such time periods obviously are less valid than for the near future. Estimates of technical feasibility are based more on possibility than on probability, more on probability than on certainty. For those reasons long-range requirements are written in comparatively broad terms that describe only the general capabilities required. These are first expressed in such terms as "operate in near space" or "sustain an aircrew for an indefinite period." Later the desired capability can be described by individual mission areas and in somewhat more specific terms. It should be possible, for example, to specify in a general way the speeds, altitudes, and flight regimes needed. Long-range requirements must be broadly conceived for two reasons. First, we are only estimating our technological capability for the required time period. Secondly, a reasonable degree of latitude should be allowed for basic research and advanced study. Exploration of all the most feasible possibilities is desirable so that the best specific approach can be taken. Long-range requirements point the way to the areas where technological advance is needed. They furnish the signposts to basic research. Based on improved information, long-range requirements must be constantly reviewed and updated. Above all, they must be flexible enough to allow rapid exploitation of technical breakthroughs.

Short-range requirements are written in terms of individual weapon systems, usually three to five years in advance. They are based on better information and a clearer understanding of immediate responsibilities. Above all, short-range requirements are based on what is known to be technically feasible within the time period. For these reasons, and as an aid to weapon systems developers, short-range requirements can be and should be written in terms that are comparatively specific. For example, in considering a manned interceptor, short-range requirements describe exact speeds, altitudes, duration, and crew. As more decisions are needed during the preliminary development study phase, short-range requirements may be modified to include even more detail, such as the type and number of engines.

All this is not intended to stifle in any way an imaginative developmental approach. On the contrary, it is the guidance the builder wants. To illustrate, the written requirement for a transport aircraft may not specify a load capacity of "between 75 and 90 thousand pounds," as this characteristic would probably describe not one but two different aircraft. One designed against the lighter load could be faster and of longer range than one designed against the heavier load, but the former would probably cost less to operate. The builder needs to know which of these two aircraft we want the most. Short-range requirements written in specific terms ensure that the developed weapon system will be exactly tailored to the part it is expected to play in our total capability.

fundamental considerations

Requirements established for either a future capability or a specific system must be based on careful consideration of the tasks to be accomplished, the threat we face, and a technical estimate of what is feasible within the state of the art.

Air Force tasks grow out of the national objectives and policies emanating from the President and the National Security Council. Specific responsibilities are placed on the Air Force through the Joint Chiefs of Staff and the Department of Defense. A clear understanding of exactly what is expected, both immediately and for the future, must prevail before valid requirements can be properly defined. In establishing programs for specific weapon systems, requirements must be highly responsive to the stated needs of unified or major air commands. Systems selected must be those which enable our tactical forces to accomplish their mission as easily and effectively as possible.

Evaluation of enemy capabilities and intentions will be a major influence in establishing requirements. Intelligence information is constantly being changed and updated as new facts become known. The requirements function will have to be flexible enough to allow for rapid modification or even complete reorientation of our own objectives. Of even greater significance is the fact that the threat itself does not remain constant. The enemy is constantly re-evaluating, redefining, and replanning. The threat is therefore constantly changing. During the next decade it will be difficult to keep our own requirements secret from the enemy. His evaluation of their impact and of the threat posed to him will directly affect the requirements he establishes. His intent will change, and his new intentions in turn will furnish a major input for reassessment of our own objectives and requirements. To carry this one step further, before establishing requirements we must consider in advance what the probable impact will be on enemy plans and capabilities. This is a real "chicken or egg" process. Requirements planning will have to constantly re-evaluate not only intelligence concerning the threat but the potentials which the enemy may employ against us.

A careful and honest evaluation of technical feasibility is the third basic input to be considered in establishing requirements. For example, it would not be practical to require an operational capability for manned landings on Mars in the 1968–1970 time period. It would not be feasible to require that a manned interceptor system, capable of speeds of mach 20, be operational by 1965. As to future capabilities, the requirements function must yield two results: First, it must point to the direction in which study is needed, guiding research into avenues which show the greatest promise for developing weapon systems that will give a decisive military advantage. Secondly, it must be exercised imaginatively so as to stimulate technologic breakthroughs. In plain language, we in the Directorate of Requirements try to push the state of the art as hard as possible. On the other hand, requirements for specific weapon systems are established only when it is clearly indicated that such systems are technically possible. For example, we know that it is feasible to produce a transport aircraft with speeds of mach 3 by 1968. A specific requirement for it can be written if such a system is actually needed as a part of our 1968 capability.

limiting considerations

The requirements task would be comparatively easy if it were restricted to description of need based purely on evaluation of tasks, the threat, and feasibility. From a practical viewpoint, however, the Air Force will undoubtedly not be able—as it is not now able—to procure all the systems we think would be useful. We must presume that we will not be able to buy in the quantities that would give us overwhelming superiority. A great many expediency considerations will limit the things we can do. There will be restrictions in available money, manpower, and material resources. There will be political impacts, both national and international, which will affect decisions. Based on our desired capability as modified by these practical considerations, the first requirements function will be to determine the best composition of aerospace forces to give that capability. Then we will select the best mix of specific weapon systems to establish this force composition. To determine the necessary trade-offs, the prime yardstick will be cost effectiveness—how to get the most for our dollar. Cost is measured not only in money but also in time, manpower, and material resources. Effectiveness is the qualitative measure of one system against another, related to the total capability desired.

Budgetary ceilings are perhaps our most obvious limitation. During recent years money appropriated to the Air Force has been considerably less than was needed to completely fund all desired programs. Based on rapidly increasing costs of advanced systems, there can be no doubt that this situation will continue. Probably it will become even more serious during the next decade. Thus one of the prime functions of the Requirements staff will be to discriminate between "must have" and "want to have." Our hard-core requirements—those most urgently needed—will have to be carefully identified by priority so that they get the higher funding out of the money available. At the same time basic research must be adequately financed, for it is the best insurance we can buy to guarantee that succeeding generations of weapon systems will continue to be qualitatively superior.

Related to budget-ceiling limitations will be the problem of advanced budget planning. This problem would be considerably less complex if it were possible to plan ahead for several years with some degree of confidence that money for the plan would be available when needed. Unfortunately funds are appropriated on a year-to-year basis. It is not possible to forecast at long range either budget ceilings or limitations imposed on individual programs as a result of annual reviews. Consequently our programing often must be conducted on a "hand to mouth" basis, which is of course wasteful and inefficient. Constant budgetary defense, rejustification, and resultant program reorientations are very time-consuming and take considerable effort. Although solution of this problem falls outside the purview of the Air Force, it is a real problem and one with which we have to live.

Another extremely serious money problem is accurate estimation of advanced program costs. Too frequently the actual cost of a major program has been two or three times that estimated only months before. Rarely has cost been overestimated. The Air Force does not have a contingency fund to cover these unexpected increases. When the cost of a program rises to any significant extent, either that program must be cut back or another robbed to make up the difference. This has a seriously adverse effect on our operational capability. Since "fat" has already been trimmed, the cut must come from "muscle." For several years this problem has been of grave concern, but it has not been solved. Each overrun causes an agonizing reappraisal of the weapon system concerned and of the relative priority of all other systems. Something has to be sacrificed. It will not be possible to do meaningful planning for selection of required systems until a way can be devised to estimate future costs with reasonable accuracy. This problem does fall within Air Force purview, and it is one we must solve in the near future.

Manpower ceilings will be another restriction to consider throughout the foreseeable future. The Nation's ultimate limiting resource is probably manpower rather than economic capacity. Both long- and short-range requirements must therefore be based on careful evaluation of their manpower connotations. Those selected must not be too costly in numbers of people needed for system operation or maintenance. Also related to this factor will be the complexity of advanced systems. We have always had difficulty in retaining very highly trained and skilled technical people. It is time to face the fact that we probably never will be able to keep such individuals in large numbers. The systems we select must therefore be ones which can be operated and maintained within the skill levels we will have, and simple enough, on a practical basis, to sustain a high "in-commission" rate and combat-readiness status.

Many other considerations will limit the things we can do, and most will relate also in some way to money and manpower. Geographic considerations, for example, might imply that a particular system must operate under very adverse weather conditions. Other considerations might be those of serviceability, maintainability, or expected useful service life. Certainly the extent of our technological know-how will be an important material limitation. The development of a manned vehicle traveling at ultrahigh speeds might be technically feasible but only at extreme cost in both money and manpower. Then with a decisive breakthrough in metallurgy or propulsion, such a system might suddenly become possible at an attractive price. Limitations in material resources usually will be such that we have little or no control over them. Still they will be highly important when deciding which trade-offs should be made to get the best weapon.

Outside of purely military considerations, there are and will be political effects upon requirements planning. Political factors are constantly in flux, changing rapidly at times. They concern, for example, our political relationships with and obligations to both friendly and neutral countries. Even the internal politics of other nations sometimes affect our own requirements. Certainly the political and foreign policies of an enemy have a profound impact upon them. This impact may be distinct or different only in degree from the impact of an enemy's military potential. Formal NATO and SEATO commitments directly affect our desired future operational capabilities and our requirements for specific systems.

These several areas encompass the major limitations that must be factored in determining best possible trade-offs to give us maximum capability at minimum cost.

requirements decisions

Part of the requirements function is to define a desired composition of forces. This definition must be derived from consideration of the operational tasks to be performed, the threat to be countered, and the technical possibilities, with due regard for the limitations listed. Its formulation will be concerned primarily with necessary trade-offs between mission areas. The relative importance of various subtasks will have to be weighed. The comparative need for and value of offense versus defense will have to be judged. We must evaluate the need to support general-war versus limited-war capability, including the degree to which the one effort could support the other in emergency. We must examine the need to support tactical forces with, for example, airlift and training.

Once the desired composition of forces is defined, the next function of the requirements process is the selection of specific systems to achieve this force structure. Such considerations hinge about quality versus cost, or cost effectiveness. Obviously a system will be highly desirable if it promises markedly superior performance at small price increase. Conversely, a system will not be worthwhile if it costs significantly more but offers only a small improvement in performance. Unfortunately our choice seldom lies between alternatives permitting a "black or white" decision. Care has to be exercised so that improved effectiveness is well worth the cost involved, particularly for improvements during production or for modification during service life. To reduce the time from decision to operational availability, development and test programs are often conducted simultaneously. While this procedure is necessary, it does prevent some possible improvements from being incorporated into early production articles. Also modifications of in-service equipment are so costly in money, manpower, and operational readiness that all proposed changes must be closely scrutinized from a cost-effectiveness point of view. On the one hand we want to take advantage of possible improvements, but on the other hand it is desirable to freeze design as early as possible. One duty of the requirements function is to choose between these alternatives.

From the foregoing it should be apparent that in establishing both long- and short-range requirements a vastly complicated interrelationship between many factors must be considered. All these factors bear to varying degrees on the problem. All must be carefully weighed. The impact of possible trade-offs must be carefully evaluated before the best decision can be reached. Judgment of the most mature type is needed throughout the entire Air Force structure. The problem is further complicated because the requirements function must in no way impede the development process. It must be consistent enough to preclude confusion, yet fluid enough to adapt to new situations. Requirements changes must be accomplished in such a way that orderly study of advanced system potentials and system development is facilitated. We cannot go "chasing butterflies in the meadow," but neither can we remain married to concepts or systems which are no longer defensible in cost effectiveness.

requirements administration

A requirements administrative/documentation system is needed which is in consonance with this approach and which is clearly understandable. Such a system, covering both long-range and short-range requirements, will serve as a check list to ensure that desired actions are not omitted and that they take place on schedule. With this purpose in mind, the Air Force requirements administrative/documentation system was recently revised.*

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*Description of the system and related documents is contained in Air Force Regulation 80-2.

Long-range requirements will be documented as required operational capabilities (ROC). These will be the basis for research and development objectives (RDO) and for system development requirements (SDR). They will give detailed guidance to basic research and advanced development. Advanced development system studies (ADSS) will determine and recommend general approaches and specific systems best suited to meet required future capabilities. Based on results of these studies and on qualitative operational requirements (QOR) submitted from the field, specific operational requirements (SOR) for individual systems will be established.

As we gain experience during the coming years, the present administrative/documentation system undoubtedly will need to be further modified, improved, and streamlined. We believe nevertheless that changes will still adhere to the same basic philosophies and principles. The system must be highly flexible and responsive. It must be geared to give the earliest possible requirements decisions. Above all, it must facilitate rapid and orderly development of weapon systems.

During the next 10 to 15 years other services and Government agencies may also have interest in and responsibility for aerospace systems. For reasons of national economy and considering Air Force budgetary limitations, the Air Force must and will strive to prevent needless duplication and waste. Nevertheless our prime concern must be with the military tasks assigned to us, since they are vital to national survival. Compromises that might seriously degrade our military capability will not be acceptable, either to the Air Force or to the Nation.

In broad terms, we have seen something of the nature of the requirements function, now and for the next decade. Greatly increased emphasis will have to be placed on careful delineation of our long-range needs. Requirements planning will have to be cast further ahead with keener vision than ever before. It must take the lead, pointing out the path we want to travel. As time progresses, requirements planning will have to be alertly receptive to new ideas, new situations, new possibilities. It must not be afraid of change when change is indicated, but at the same time it must work with care and wisdom to preclude vacillation, confusion, and wasted effort. Solving this dilemma will take mature judgment of the highest order. Individual weapon systems will have to be selected earlier. They will have to be described in more careful detail than ever before.

The requirements function in Air Force planning, like the Air Force and the Nation itself, faces a challenge ahead that is without parallel. The mushrooming rate of technological growth will give a new perspective to the element of time. Progress that might formerly have taken a generation will now be possible in several short years. To the Directorate of Requirements, this means that evaluations must be completed and decisions rendered within radically compressed time spans. At the same time the complexity of advanced systems will be coupled with a vastly increased number of alternatives from which we must choose. The evaluation process will therefore be more complicated and must be more comprehensive than ever before. The decisions we reach will be more vital to national survival. This, then, is the real challenge requirements planners must meet: Can we carefully consider, fully evaluate, and then decide at a pace to match our science? We are confident that we can and will.

Headquarters United States Air Force

Budgeting for the Aerospace Force

MAJOR GENERAL ROBERT J. FRIEDMAN

THE interested reader of this publication devoted to aerospace force in concept and in being might well be excused for asking before this point, "When are you going to get to the all-important question of buying the aerospace force?" His impatience may reflect a cynicism stemming from personal knowledge of the impact of budgetary decisions on military programs.

It would be naive to deny the importance of funds in the attainment of military objectives. Yet the late positioning of the subject in the order of this publication is not accidental. Rather it is intended to emphasize the fact that the budget is one of the final considerations in the process of conceiving, planning, and programing the aerospace force. I realize this is directly contrary to the idea which has been nurtured, particularly by the events of recent years, that the budget comes first and rules all and that everything else must be made to conform to the rigid framework it establishes. But a moment's reflection upon a few fundamental truths will, I believe, bear out the premise.

The budget makers cannot put a price tag on mirages or on concepts. They must deal in tangibles—in men, machines, facilities, goods, and services. In a word, theirs is the finishing touch. First come the men of vision who can foresee the force of tomorrow and can communicate their thoughts and concepts tangibly to those who will bring them to fruition. Next, obviously, are the efforts of those whom, for want of a better label, we might call the more practical people, although with no intent to belittle those whose priceless gift of vision, forethought—or prescience, if you will—is so vital to achieving the aerospace force of the future. They must translate ideas into new items of hardware and plan the utilization of forces which will be equipped with the new hardware. This practical planning includes all components of the weapon or support systems involved, including material, manning, logistics, operations, bases and installations, communications, etc. Finally we must program the "bits and pieces" according to realistically attainable increments, quantitywise, qualitywise, and timewise. Only then can we fashion a budget, solidly grounded in all that has gone before.

Having gone through this sequence and arrived at the point where we must express all our dreams, aspirations, plans, and programs in the cold dollars-and-cents terms of the Federal budget, what now are our chances of success in "buying the aerospace force"? True, there are constraints; but there is also the relentless force of progress.

When we talk about buying the aerospace force of the future, we must consider that, to the extent it is bought, it will be paid for by taxpaying, earthbound United States citizens. These citizens will have a number of things on their minds besides space, and many other demands upon their resources. One has only to reflect upon his own personal budget to get the full import of this fact. As for new types of defense programs in space, to many people an understanding of the need to be there at all is as "far out" as space itself. One thing is crystal clear: space programs will be extremely costly. This is especially pertinent if military requirements also continue to exist for the more conventional weapons. It is predictable, therefore, that the question of how much military strength is enough will be encountered with increasing regularity.

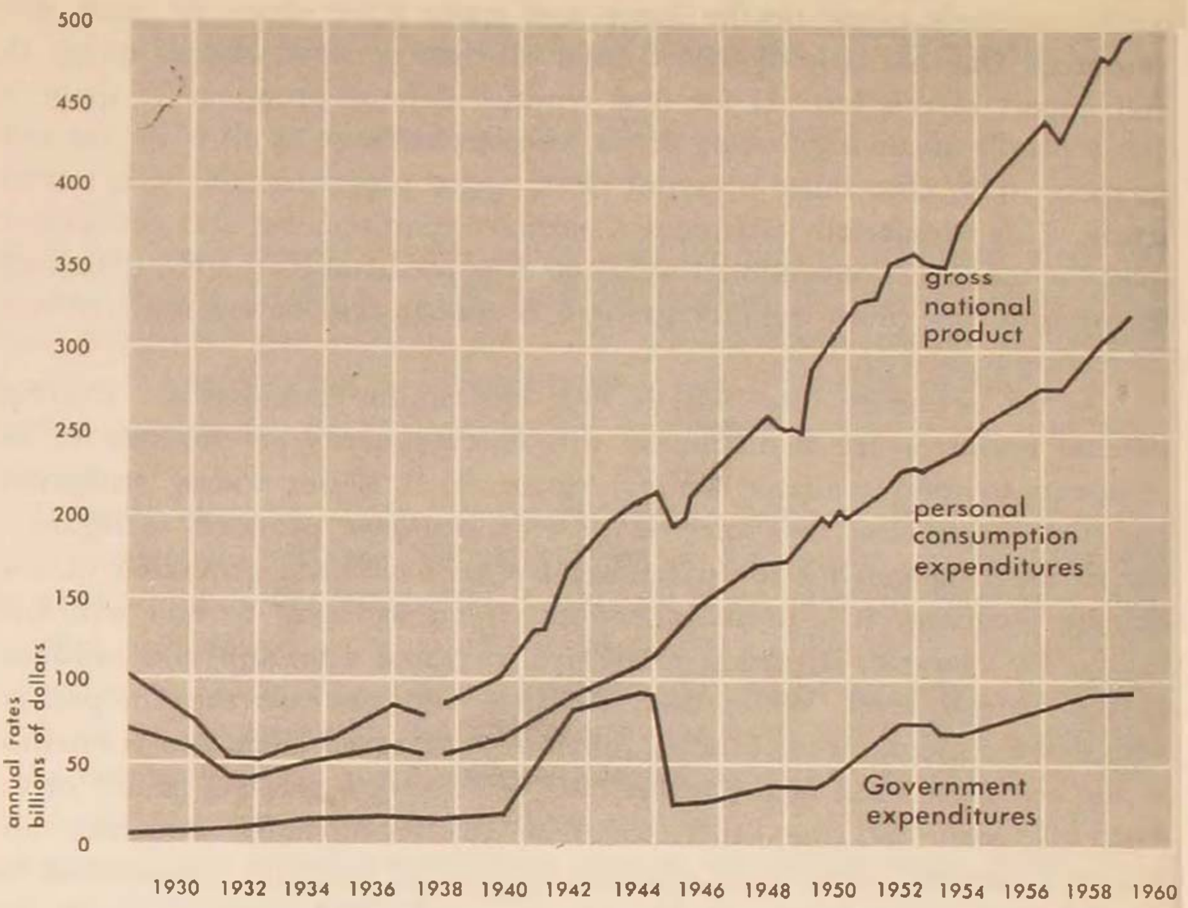
As the aerospace force will be but one of the claimants for whatever defense resources are available, so will defense needs be but one of the claimants to total available Federal resources. It is not widely recognized, but true nevertheless, that some of the most explosive pressures in regard to the national budgets for the past several years have been generated in nondefense programs. It is unlikely that this trend will now be reversed. Education, for example, is certain to receive increased attention and assistance at the Federal level. While this assistance will increase the competition with defense programs for funding, obviously improved education is essential to the aerospace force of the future. We must have a growing source of the men of vision and the other scientists, mathematicians, specialists, and leaders to conceive, plan, build, operate, and control the force of tomorrow. Increased emphasis on education complements, rather than competes with, the defense program.

Increased pressures on the national budget will also develop from other programs, in such areas as increased assistance to the aged and the impoverished, relief of depressed areas, or increased public works. While perhaps not directly, defense does nevertheless reap an advantage from these programs in that they maintain or enhance the vigor of the national economy and contribute to its growth. For it is upon increased economic growth or increased rate of taxation, or both, that we must rely for the ability to buy the aerospace force that we will need.

As a frame of reference for discussion of the interrelated elements of gross national product, economic growth, taxation, personal consumption, and Government expenditures, the accompanying chart which is taken from Department of Commerce estimates graphically compares gross national product, personal consumption expenditures, and Government expenditures for the period 1930 to 1960.

First, as to increased taxation, the chart clearly indicates that Government expenditures have not risen in proportion to the rise in gross national product and personal consumption expenditures. Even in the war years 1941–1945 Government spending did not reach the level of personal spending. It is apparent that a higher proportion of the national resources can be devoted to Government expenditure if required for attainment of the aerospace

The Relative Cost of Government



force. What is not indicated by the chart is the high degree of courage that will be required if increased taxation is necessary. If to the abstract nature of space in the minds of men is added the normal antipathy of taxpayers toward increased Government spending, one may appreciate the political courage that will be required to levy new taxes or increase existing rates.

The chart, however, also suggests that perhaps the sacrifice on the part of the taxpayers need not be great to provide dramatic increases in resources available for Government and defense spending. Government spending is no higher today than at the peak hit in 1944, yet since that time personal spending has climbed from approximately $120 billion to $330 billion—a 275 per cent increase. As the 1944 Government spending represented World War II expenditures, the period 1952–1960 may provide a fairer comparison. During this period Government expenditures rose approximately $20 billion, from $80 billion to $100 billion, or 25 per cent, while personal consumption expenditures rose approximately $100 billion, from $230 billion to $330 billion, or 43 per cent. Viewed another way, at the end 1959 point a reduction of only 5 per cent in personal consumption expenditures would have provided an increase of some 16½ per cent in total Government spending, or an increase of some 40 per cent in defense spending if applied solely to defense programs.* Although it may appear that some measure of sacrifice is warranted, sober consideration must be given to the limits beyond which increased taxation would stifle further growth and thus retard one of the bases upon which we must depend for financing the aerospace force.

Much has been said recently on the subject of financing increased programs by economic growth. Increased growth, unaccompanied by inflation, will result in greater revenues and therefore will make possible some measure of increased Government spending without increase in rate of taxation. Economists differ as to the rate of growth, but it is generally accepted that without increase in rate of taxes the relative distribution between personal spending and Government spending will remain substantially the same. Consequently when the pattern of distribution does not change and aggregate totals increase, each segment benefits. For instance, a net increase in gross national product provides a net increase in tax yields and an increase in private consumption. For every dollar devoted to Government spending, there will be $3.30 applied to personal expenditures. Although this rate can make a significant contribution to total Government financing, it is problematical whether this factor alone will finance the aerospace force requirements.

Thus far in this discussion I have pointed up the obstacles in buying the aerospace force. The military can not be complacently content to design forces, make plans, estimate the costs, and then rely upon the Biblical injunction, "Ask and ye shall receive." The "aerospace" label on any program will not be a magic word which will cause an automatic flow of funds. Despite the problems which I have posed, however, my outlook as to the future remains sanguine.

Maintenance of military strength has become an accepted part of national policy. Our country now takes a more stable, consistent view of the requirement for military forces, which makes possible better planning and management in the defense establishment. An informed public is a keystone to buying the aerospace force of the future. If it understands the necessity for such forces, the public will support programs that are demonstrably necessary, as a logical extension and projection of today's forces.

Under these circumstances, what sort of aerospace force can we afford? As to the near term, the financing of the force has already been approximately fixed. Because of the lead time required to move from concept to drawing board, to production, to training and equipping the force, we have already made that determination. The aerospace force for the near future will include much that is now in being, some new systems that are now in production, and a few others on which research and development work is about complete.

The problem will arise in the transition from the short-term to the

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*Comparisons are given in current dollars. It is recognized that this does not include distortion resulting from inflation. The principle to be illustrated, however, is valid.

long-term implementation of the aerospace force. Our national policy must resist the temptation either to judge prematurely a system's effectiveness or belatedly to substitute funds for time. Of one thing I am certain—we cannot buy the aerospace force as though by turning a spigot on and off.

The Air Force can contribute to the amount and kind of aerospace force we can afford to buy by the quality of its management. Obviously the more economically our day-to-day operations can be run, the larger will be the amounts that can be applied to the development and production of new systems and equipment. It will continue to be essential to concentrate on the elimination of unnecessary costs in the design of systems. Selectivity of systems will become more and more important. Management concepts such as "concurrency"—i.e., the simultaneous expenditure of effort and resources on development, on production, and on base facilities—must be further developed and judiciously applied. The Air Force must continue to stand ready to do its share.

In summary, the buying of the aerospace force will require a fine, close balance among many complex factors, calling for all the foresight, wisdom, experience, sacrifice, and courage that can be brought to bear on the problem. Beware the charlatan who offers a panacea as a substitute.

It is my conviction that while the problem of meeting the cost of the required aerospace force is not one susceptible of speedy, facile solution, from the standpoint either of the National Administration or the Air Force, nevertheless the difficulty is not insuperable.

Headquarters United States Air Force

PART IV

Development and the Aerospace Force

A scientific technology has become more and more the pacesetter of the aerospace force. On systematic and farsighted exploitation of scores of scientific fields will depend the rate of progress of complementing and reinforcing weapon systems as well as in the command and control systems and communication networks demanded by the burgeoning ranges, spatial heights, and incredible speeds of the aerospace age.

The decade of the 1950's brought military technology into a long-term, substantial program of research in basic as well as applied science. The decade of the 1960's now opens with a similarly determined attack on the complete cycle of science and technology for the purpose of accelerating their application to military purposes. In part this effort will advance a systematic and thoughtful search for new principles and new ideas. Though in their original context the findings may be far removed from military problems, by ingenious application they may offer new approaches to solutions.

Part IV presents the vital relationship of research and development to the continuing establishment of superior aerospace forces, together with associated examination of the mechanics of the technical breakthrough, the significance of the concurrency philosophy, the probable mix of manned and unmanned systems in the aerospace force, the contribution of the spacecrew to spacecraft operations, and the Air Force program in that fundamental area, propulsion.

The Operational Urgency of R&D

Lieutenant General Bernard A. Schriever

IN THE 15 years since the close of World War II we have seen a productive increase in science and engineering on such an unprecedented scale that it is sometimes referred to as a "technological explosion." Major discoveries in these areas used to occur once or twice in a generation. Now they come along every few months, significantly changing the environment in which men live and conduct their activities.

In aerospace research and development one of the most striking effects of this stepping-up in the pace of technology is the compression which it has brought about in our previous concepts of time. The same compression can be found at work in the operations for which the systems are conceived, in the rapidity with which important technical advances occur, and in the rate of progress introduced into the development cycle itself.

The most familiar aspect of time compression is the operational one. It is basic to all our military thinking today. As recently as 20 years ago, during the early stages of World War II, the Germans referred to their mobile warfare as *Blitzkrieg* or "lightning war." By this they meant that fast-moving, motorized columns might penetrate, envelop, and obtain a decision in a few days or a few weeks, depending on the depth of territory to be secured and the forces defending it. In the present era a well-coordinated attack by ballistic missiles might obtain a decision in less than an hour —or in several hours if the outcome waited for follow-up strikes and counter-assaults by missiles and aircraft. Depth of territory is a factor of no consequence to the intercontinental missile. Since the distance traveled is governed by cutoff velocity and angle, time in flight is nearly the same, whether the missile covers 5000 miles or 9000 miles or more.

Increasing the speed of an ICBM by any significant amount would simply accelerate it to orbital or escape velocity. So it may be said that with this weapon we have apparently arrived at the ultimate in speed of attack and decision. If the term has any meaning, this kind of combat should be known as "lightning war." Without one having yet been fired in anger, the ICBM has already revolutionized our ideas of strategy and tactics. In fact, it has changed our outlook on the purpose and consequences of war. This fact is so important to the outcome of any large-scale military operations that it must be borne in mind constantly in the design of future weapon systems.

The contraction in time that is characteristic of missiles applies not only to operations but also to supporting functions—research and development, training, logistics, maintenance, and communications. In all these areas time has become a vital element. Just as a nation's speed of reaction to attack has come to be the most essential quality in its actual defense, so the rapidity with which it takes advantage of technological advances may determine whether it will be called upon to defend itself or not.

technological war

It may be said that warfare has acquired a new phase—technological war. In the past, research and development were only preparation for the final and decisive testing of new systems in battle. Today the kind and quality of systems which a nation develops can decide the battle in advance and make the final conflict a mere formality—or can bypass conflict altogether.

There can be little doubt that we are now engaged in a technological war. The opponents in this war represent the two most highly developed plans for the organization of human society—one by total absorption into the state, the other by free association between groups and persons. The side that first achieves unquestioned superiority in technical capability as well as numerical strength may well prevail over the other without any overt test in battle.

For this reason the mastery of time in research and development is a factor of the utmost importance to our survival as a free nation. The achievement of a greatly extended aerospace capability is essential. To achieve it first is even more essential.

Until the present quickening in the pace of technology, military research and development was carried on at a rather leisurely rate. The reasons were various. For one, future operational needs usually crystallized out of the experience of the most recent war and pointed toward the next one, which was generally assumed to be at least some years away. By contrast, the systems we are now developing have sprung largely out of possibilities revealed by the expanding horizon of technology itself. It is no longer possible to foresee when another war might become imminent—events move too quickly, the international situation has become too fluid, and one of the most probable features of a future war would be its sudden onset in an attempt to achieve surprise.

In the past, too, it was considered necessary to conceive, build, test, assemble, and deploy new weapons and components in a cautious, one-step-at-a-time progression that would minimize the risk—and the cost—of failure. Mobilization of industrial resources—on which modern warfare mainly depends—used to be deferred to the last moment, so that the peacetime economy would be disturbed as little as possible.

The inadequacy of that time-honored approach was clearly recognized when in 1954 a committee headed by the late Dr. John von Neumann advised the Air Force to proceed with intensive development of the intercontinental ballistic missile. The Von Neumann Committee recommended and the Air Force implemented three specific innovations in management policy, which were aimed at compressing normal lead time in weapon system development to a minimum:

- Unprecedented authority was granted to the Western Development Division (later named the Air Force Ballistic Missile Division) of the Air Research and Development Command, in carrying out its assignment. As a semiautonomous agency, AFBMD was given full responsibility for day-to-day supervision of ballistic missile projects. The object was to bypass many of the inevitable delays that occur in an active development program when the decision-making machinery is entirely concentrated in a central, remote headquarters. In effect, on local problems in development AFBMD was permitted to exercise the independent judgment of a tactical commander in the field.
- A novel management system was established in which private research laboratories and industrial firms participated jointly with the Air Force in the conduct of development projects. This team concept had several advantages, two of which were decisive at that time. First, it brought to bear on missile problems a pool of highly gifted technical talent, supplementing the Air Force's own capable scientists and engineers. Second, it gave civilian science and industry a direct stake in efficient management of the program—a stake reflected by the substantial investments they have made in missile research, test, and operational facilities. This partnership could be compared to the integration of technology and production with the armed forces in a wartime mobilization. It recognizes that these civilian activities now are more closely allied than ever before with peacetime planning for national security.
- A radical technique of concurrent scheduling was adopted, replacing the old step-by-step approach. Under this method of concurrency different phases of the development program, including design, production, testing, assembly of the various components, and preparation of operating facilities, were undertaken simultaneously rather than in sequence. If the method involved some risk in case the ultimate performance of the weapon system fell short of expectations, it paid handsome dividends in the currency of greatest value to us then and now—time.

Thanks to these innovations recommended by the Von Neumann Committee and particularly to the one for concurrent scheduling, the development period for our first operational ballistic missiles, Atlas and Thor, was cut to half that normally required for a modern weapon system of comparable complexity. In fact, the goals set by AFBMD itself were exceeded.

The compression of lead time, made possible by these new techniques of management, had as its immediate aim the closing of the gap in missile development between the United States and the Soviet Union—a gap which had occurred when the U.S.S.R. made impressive progress after starting on an ICBM program some years earlier than the United States. In this aim the policy has been an unqualified success. These two ranking nations are now nearly equal in the state of their ballistic missile development programs.

technological surprise

Another interesting aspect of lead time has emerged from our strategic thinking in recent years. The ballistic missile is, above all, a weapon of surprise. Conversely, the most important defensive measure associated with it is protection from surprise. Any major improvement in the performance of the missile or its supporting elements may contribute to the total effect of surprise, while countermeasures against it are largely occupied with preventing surprise.

A parallel situation prevails in the technological war, a war which anticipates the circumstances of an overt conflict. Any important advance achieved by one side or the other is likely to have a strategic impact far beyond the tactical advantage which it confers for the time being. Hence in modern war we find a new element raised to a level of highly organized effort for the first time: the element of technological surprise. It is the effect secured by putting into use, before the adversary does, a significant technical achievement that makes him temporarily more vulnerable. Surprise in technology, as in operations, is the result of time compression.

In this respect aerospace development might be likened to the present-day automobile industry, where the company which senses a new trend in design early enough to beat the others in putting an improved model on the market harvests a competitive advantage. In military research and development, however, much more is at stake than in business competition. The reward for technological surprise may very well be survival. For that reason it is no longer permissible to follow the leisurely development practices of the past. Today time is of the essence.

Since the beginning of World War II we have seen a revolution in technology, accompanied by an extraordinary quickening in the pace of research. The development of nuclear energy and rocket propulsion has touched off the revolution, but it is not confined to these fields. Breakthroughs occur in many related areas of science with much greater frequency than in the past. In electronics, in structural materials, in fuel chemistry, and in medicine these discoveries have been particularly notable. Large industries that scarcely existed ten years ago have grown up to exploit the breakthroughs.

Consequently it is no longer possible for a military organization—dependent as it is today on technology—to lag behind the forward movement in science and engineering without inviting disaster. Before World War II a nation might create a large and seemingly adequate military force and keep it in being with minor refinements until it was called upon to meet a war emergency. This policy is no longer a safe one. Development must be on a continuing basis and pursued intensively simply to hold our position with respect to the constant progress of a determined adversary. It has to be all the more active and alert if we wish to stay ahead of him.

A two-year study of systems management requirements to meet today's military situation, and the assignment of the space development mission to the Air Force, resulted in the organization of a new command. Elements of the former ARDC and the Air Materiel Command were combined. The whole cycle of acquisition of a new system—from initial applied research to the final operational status—was placed under a single manager, the Air Force Systems Command (AFSC).

AFSC was organized to attain four objectives:

(1) to provide rapid decisions and accelerated actions on all designated system programs;

(2) to ensure efficient, responsive management of the space development responsibility assigned to the Air Force by the Department of Defense;

(3) to provide for the close integration and participation of the Army Corps of Engineers in the ballistic missile site activation task; and

(4) to provide for effective liaison and active participation by Army, Navy, and NASA on projects being developed for these agencies by the Air Force.

Primary responsibility for attaining these objectives rests with AFSC's four divisions. Two of the divisions, the Ballistic Systems Division (BSD) and the Space Systems Division (SSD), are located at Inglewood, California. The Ballistic Systems Division is responsible for the intercontinental ballistic missile programs assigned to the Air Force. The Deputy Commander for Site Activation in the BSD will be responsible for facility design, construction, and staff supervision over the conduct of all site activities in the field. By agreement with the Department of the Army, the U.S. Army Corps of Engineers' Ballistic Missile Construction Office and its subordinate elements are placed under the operational control of the Ballistic Systems Division commander.

The Space Systems Division is responsible for military space programs assigned to the USAF and for certain development projects in support of Army, Navy, and NASA.

The BSD and SSD report to a Deputy Commander for Aerospace Systems (DCAS), colocated with them to ensure on-the-spot decisions and rapid management responsiveness to any problems that may arise. In addition, the DCAS maintains liaison with the Army, Navy, and NASA and with Air Force commands to provide effective coordination and planning for systems development.

The Aeronautical Systems Division (ASD), located at Wright-Patterson Air Force Base, Ohio, is responsible for advanced aeronautical systems and aerodynamic aspects of recoverable space systems. Examples are the B-70 bomber prototype, the Skybolt air-launched ballistic missile, the new C-141 jet transport, and the Dyna-Soar boost-glide re-entry vehicle.

The Electronic Systems Division (ESD), at Laurence G. Hanscom Field, Massachusetts, is responsible for electronic and other systems for communication, observation, and command and, in general, the functions of tracking, surveillance, data reduction, and weapon control. The acquisition of the Ballistic Missile Early Warning System (BMEWS) and of the NORAD Air Defense Control System is included in the division's responsibilities.

This new reorganization places more project responsibility in the field. At the same time, it confers another benefit by removing the divisions from under the close and detailed technical supervision of AFSC Headquarters.

Staff personnel at AFSC Headquarters thus are left with greater freedom from administrative duties, so they can concentrate on plans and policies for the future.

It may seem paradoxical, at first glance, that greater compression of time in military research and development calls for more long-range planning. Nevertheless this is the case. The basic reason is that R&D no longer serves merely as a supply function, furnishing weapons and support systems to meet specifications adopted by the operational forces. More and more, R&D is called upon to participate in strategic discussions, from which emerges the need for new weapons and new methods of using them.

At no time in history have plans for the security of a nation in war depended so directly on the technical capabilities of weapons as they do today. The ballistic missile and the novel systems associated with it have not merely added vastly to the flexibility of the firepower that can be brought to bear on an enemy in conventional ways. Through their remarkable characteristics and the environment in which they operate, they dictate the actual nature and course of operations. From the inherent performance of these weapons a new philosophy of war has in fact evolved.

What are some of the considerations that have caused this new philosophy? For one thing, the weapons are extremely complex. Also they have never yet been tried in combat. Apart from the very limited experience of the Germans with the V-2 at short range in World War II, there has been no occasion whatever to explore the potentialities of ballistic missiles in actual use under the conditions of present-day warfare. Our concepts of the proper way to employ them are necessarily theoretical, arising from our knowledge of what they can do.

Besides, in a technological war of the kind we are now waging the laboratory, the assembly line, and the test range comprise the combat theater. Research and development has become almost an operational function, inseparable from the strategic performance of the systems which it produces. This functional change reflects the total nature of modern war, in which all the elements of a nation's capability to resist aggression—including its technological and industrial resources—are units of the over-all operational force.

That is why it has become a necessity for AFSC, at the command level, to concentrate largely on planning. Even with the most efficient management of projects under active development, it now takes at least three years to bring a major weapon system of a new type to full operational readiness. A prime objective of the planning staff is to devise methods of reducing this lead time. Compressing time, by every means possible, is an integral part of the R&D function. One way to save time is by exercising keen vision, balanced by sound judgment, in the original concept and design of a system. The more clearly its use and effects can be foreseen by the agency charged with its creation, the more quickly it can be embodied in tangible hardware. This is the aim of Headquarters AFSC under the current reorganization.

new weapons for deterrence

The most urgent phase of our national aerospace development effort was concluded successfully in the late summer of 1959, when the first operational units of Atlas were delivered to the Strategic Air Command. Together with our long-range jet bombers, Atlas gives us an intercontinental striking force as the foundation for a powerful aerospace deterrent. But our deterrent force cannot be a static one, regardless of its strength. Simply adding numerically to our missile inventory will not, by itself, bring security. The new field of space operations is marked, above all, by the dynamic nature of the forces that operate in it. We must be constantly on the alert for novel programs and original techniques that will take full advantage of this dynamic character.

At present our effort is concentrated on increasing the power of our weapons and on making them more secure against attack. Primarily this objective is being met in three ways. First, we are extending the capability of Atlas and adding to it another ICBM with somewhat more advanced features, the Titan. Second, we are bringing a new and highly versatile ICBM to operational readiness in the second-generation missile Minuteman. Third, we are developing satellite systems that will add materially to the warning time available to our missile forces.

As to the first of these goals, technical refinements in rocketry already have enabled us to extend the range, accuracy, and yield of Atlas well beyond the specifications originally established for it. In effect we are now building into our first-generation ICBM much of the performance we had expected to achieve only in a second-generation system. These improvements also will increase the capability of Titan.

The solid-propellant Minuteman will mark a significant advance in both the offensive strength and the security of our missile force. Because of its compactness and simplicity, Minuteman will be very much more economical to build as well as to operate. Hence it will become feasible to maintain a considerably larger number of units in readiness for instant firing. This reversal of the trend toward higher costs in weapon systems, achieved for the first time with Minuteman, is itself an important product of development planning.

From the defensive aspect Minuteman will inaugurate a similar reversal of the recent trend toward larger and more cumbersome weapon systems requiring elaborate ground facilities to launch them. Hard, fixed sites for Minuteman will be notably smaller and less complex than those for Atlas and Titan. It will also be possible to disperse Minuteman about the countryside, mounted on railway cars traveling constantly over the Nation's vast network of tracks. In this way the ICBM will acquire some of the speed and elusiveness on the ground that it now has in the air and in space.

Finally, the warning time available to our forces in case of an enemy attack will be considerably extended by satellite systems, which will provide instantaneous information on the dispatch of a hostile force against us. The Midas warning system will flash the earliest possible notice that enemy missiles are on their way, while the hostile salvo still is rising out of the atmosphere. Communication and command satellites will follow. They will round out the present phase of our aerospace program, which is largely one of consolidation, designed to strengthen and complete our deterrent posture. While our basic air and missile forces are becoming as nearly invulnerable as we can make them, more imaginative concepts are in the planning stage.

AFSC already is looking well beyond the current buildup in ground-launched rocket systems toward the true space vehicles of tomorrow. These advanced systems—characterized increasingly by direct control by human flyers—may begin to make their appearance sooner than is generally realized. Missile forces of the types under development today, both in our own country and abroad, should be well established in the next few years. Already the tendency is to reach out farther into space for an operational advantage. Among the military systems that may be expected early in this space age, two stand out with particular distinctness, each being a logical outgrowth of an existing automatic system or experimental project:

- Manned satellites for tracking, surveillance, communication, guidance, and command. The superiority of manned vehicles over the merely instrumented vehicles in these areas arises from the unique human faculties of intelligent observation, interpretation, and judgment in making decisions. At this time it is difficult to conceive of electronic circuits that can be made to perform these functions with the same acuteness and reliability.
- Maneuverable spacecraft in satellite orbits, growing out of the experimental Dyna-Soar boost-glide vehicle now in development.

In one way or another the element of time is vital to all the projects now envisioned for the new theater of space. It is particularly vital in the sense that space confronts us with an unfamiliar field of strategy and tactics, in which man has acquired a rapidly increasing capability and virtually no experience. It is impossible to foresee the full extent of the advantage that will accrue to the nation which first explores—and exploits—the military opportunities in space. They may very well turn out to be more revolutionary than the effects of the ballistic missile.

Headquarters Air Force Systems Command

Concurrency

MAJOR GENERAL OSMOND J. RITLAND

AT VANDENBERG Air Force Base in California, on the wind-swept plains surrounding Francis E. Warren AFB, Wyoming, and near Offutt AFB, Nebraska, Atlas intercontinental ballistic missiles are deployed in operational readiness. These are the first of a new breed of weapon, for a new kind of defense in a new and startling age.

In bringing the ballistic missile weapon systems from concept to reality, we in the Air Force have been preoccupied primarily with the exacting demands of time and technology, and with the interaction of these two factors, in the molding of an effective and up-to-date national deterrent. The extent to which we have succeeded in compressing time and expanding technology is—essentially—a study in "concurrency."

For those accustomed to thinking of military development procedures in traditional terms, the idea of concurrency may not be new, but the employment of concurrency concepts throughout a total development program might indeed seem to border on the radical. New weapons, even in our modern day and age, have been brought to fulfillment gradually, nurtured systematically step by step through the phases that mark a normal development cycle. The sequential growth pattern was as logical as it was customary. Military budgets in peacetime could be conservative. Risks in expenditures, either of funds or efforts, were minimized, since progress was measured in increments. The intervals between steps provided time for thoughtful evaluation and analysis of results.

Such a system was methodically productive, but it was also voracious in terms of time. To achieve a savings in development time, Air Force research and development leaders in recent years began to look to a limited concurrency; that is, the extent to which production of any weapon system, such as a new aircraft, can be committed before the development and test phases of the program are completed. Weapon requirements are based on anticipated needs, and the most enlightened human foresight is not infallible; but with due regard for this inhibiting fact, the Air Force has progressed steadily in compression of the development cycle. The policy of "considered caution"—of postponing initiation of a total development program until all the components and subsystems are "on the shelf"—is now passé. Simultaneous progress in certain aspects of any weapon system program has been a growing characteristic of Air Force procedures in the years since World War II, but the maximum expression of this concept was not demonstrated until the birth of the ballistic missile program.

Any military development program embodies individual stages that must be carried out before a workable product can be attained. First, there must be an appraisal of the need. This stage involves evaluation of requirements and costs, the preliminary sketching of designs, and an understanding of the problems. Second, there is the research stage, with all the diverse investigative activities that research requires. Third comes the building of a prototype. The fourth major step is flight test, a highly important phase and one demanding considerable time and care. Flight-test results usually dictate modifications and improvements necessary before the fifth phase, production. After production comes deployment with all its attendant problems, including construction of facilities, building of ground support equipment, and training of personnel.

The application of concurrency does not eliminate the performance of any of these functions but subjects them to a new time perspective. It calls for an overlapping of the development functions so that, for instance, flight test can proceed coincident with production, construction can get under way while flight test is in progress, and training can be initiated concurrently with testing and production.

To be completely successful, concurrency must be practiced "across the board." Efforts to achieve accelerated development schedules by limited modifications in the time-honored development system, without overhauling the system itself, have not yielded substantial savings in time. The B-36 was produced before sufficient ground-environment support equipment was available in the quantities needed to make the new plane immediately useful. In the development of the B-47 the Air Force trained men and then saw their enlistments run out before the operational aircraft were delivered to the Strategic Air Command. The B-52 took about nine and a half years from blueprint to "blue yonder."

Yet the system was not bad. There were factors which made the circumspect approach to weaponry appropriate. These were the factors of economy, technical capability, and need. We could usually depend on having ample time to bring our weapons through natural growing pains into natural maturity. American industrial leadership and the protective factors of time and distance were guarantees permitting the United States freedom to progress at a self-determined pace.

the origin of concurrency

Two major advances occurring in the latter years of World War II not only altered drastically long-accepted doctrines of military strategy but tempered severely our national self-assurance. In so doing they pointed straight to the need for a better, swifter weapon-development process. Those advances were the invention of the nuclear bomb and improvements of rocket-propulsion technology.

Harnessing the energy of the atom has meant that destructive forces of unparalleled power can be unleashed. The potentials of practical rocket-propulsion systems have opened the way to tremendously fast delivery capabilities. When it became painfully apparent that the Soviet Union had embarked wholeheartedly on exploitation of these two capabilities, a heightened responsibility for the security of the democratic world was laid squarely at America's doorstep.

In the early Fifties, when we recognized the threat inherent in Soviet ambition and Soviet ability, we took stock of our situation and responded to the double challenge with a comprehensive program dedicated specifically toward "beating the clock." Time and distance, those once protective dimensions, had suddenly become threatening dimensions. To meet the revolutions in technology that were reshaping ideas of offense and defense, we were compelled to accelerate our own technological progress and to instigate a revolution in development and management as well. Our Air Force ballistic missiles today have been built in time to beat time.

In the earlier days of this century American industry revolutionized fundamental work standards by introducing mass production. The result was more quality products, in faster time, at lower unit cost. At the midpoint in the twentieth century we began to realize that our overriding need was not faster production but faster introduction. It was obvious that time was no longer a luxury we could afford. Military superiority had to be demonstrated as a deterrent to war, not as the determining factor of war. And the rapid advancements in technologies set ever higher goals, while the complexities of the weapon systems posed challenging obstacles to our development timetables.

There was only one answer, but that answer had multiple implications. Technical competence had to be attained and sustained. Furthermore this technical pre-eminence had to be complemented by an enlightened management competence, and efforts in both directions had to be tailored to an uncompromising sense of urgency. Comparatively speaking, it was almost as though we had been rambling along complacently in the horse-and-buggy era and had suddenly been faced with the necessity of developing a modern automotive transportation system. Under such a circumstance not only would we lack the vehicle itself. We would lack the production facilities to build it, the people skilled in the maintenance and operation of it, the highway system to accommodate it, and the garages, service stations, and distribution systems to support it.

To our credit we did have, in 1953 and early 1954, two aviation companies under contract who had done some investigative work for the Air Force in ballistic missile design and propulsion. Again in terms of our analogy, it was something akin to the situation we might have faced if our total efforts in the direction of the automobile had been confined to the crudest internal-combustion engine and Henry Ford's original design for a horseless carriage.

If we failed to see the vital significance in trimming lead time (the time between conception of a new weapon and the operational deployment of that weapon), the Soviets did not, as is evidenced by a statement made early in 1958 by Anatoly Blagonravov, a prominent member of the U.S.S.R. Academy of Sciences: "It is easy to see that the time element is precisely the decisive factor which should be grasped in the competition with the capitalist countries in the field of technology."

Fortunately the Air Force did not have to depend on anyone in the Soviet Union to tell it this. Yankee ingenuity produced a Yankee solution. American team spirit, which always rises to the occasion in times of crisis, proposed a bold approach to weapon system development.

the concept of concurrency

Bold as it is, the concept of concurrency really embraces little more than the principle of teamwork, applied with modern management techniques and possessed by an attitude of urgency. It means, as has been observed many times, everybody moving forward with everything, all at once. Under the concept each element of the total weapon system is integrated into a single plan, program, and budget, and all are implemented concurrently, in unison, consistent with lead-time requirements. Simply speaking, concurrency implies progress in parallel fashion rather than in series fashion.

But if concurrency is simple in concept, it is anything but simple in practice. Concurrency was not adopted by the Air Force as the easiest way to produce workable ballistic missiles in an abbreviated time period. It was adopted as the *only* way to reconcile national security requirements with the inexorable hands of the clock. As an idea the concept was not new, nor is it unique to the ballistic missile program. But never before had it been practiced militarily to such an extent or to such dramatic purpose.

The 21 eminent members of the Strategic Missiles Evaluation Committee, headed by the esteemed physicist, the late Dr. John von Neumann, recognized that while the United States could not make time, or buy time, it could save time. The challenge was put in the hands of a brigadier general named Bernard A. Schriever, an Air Force officer who had demonstrated imagination and ability in development work. An executive management agency—known as the Western Development Division of the Air Research and Development Command—was set up in Inglewood, California, in 1954, to direct the ICBM development project. That responsibility grew into the largest development program in military history.

In early 1954 matters stood like this: Results of nuclear tests in 1952 and 1953 indicated that a lightweight, high-yield nuclear warhead suitable for use in an intercontinental ballistic missile could be produced, but the actual warhead did not yet exist except in theory. We took the risk that the calculations were correct and that by concerted effort the predicted advances in nuclear physics and warhead design could be achieved on schedule. Development of a suitable warhead was not the only contingency on which the technical feasibility of our Atlas intercontinental ballistic missile depended. There were other uncertainties, the most notable undoubtedly proceeding from the technical problems to be solved for the development of a practical re-entry vehicle. We felt sure we *could* overcome these problems, but we had to prove conviction by accomplishment.

To bring ballistic missiles into the inventory within the critical time period designated, we adopted the weapon system approach. A weapon system is much more than weapon hardware alone. A complete system includes the industrial base for production of the weapon, the facilities for its operation and maintenance, the command and communications system for its operational control, the supply and transportation system for its support, the training facilities and the instructors, and finally the people organized and trained to operate and maintain it.

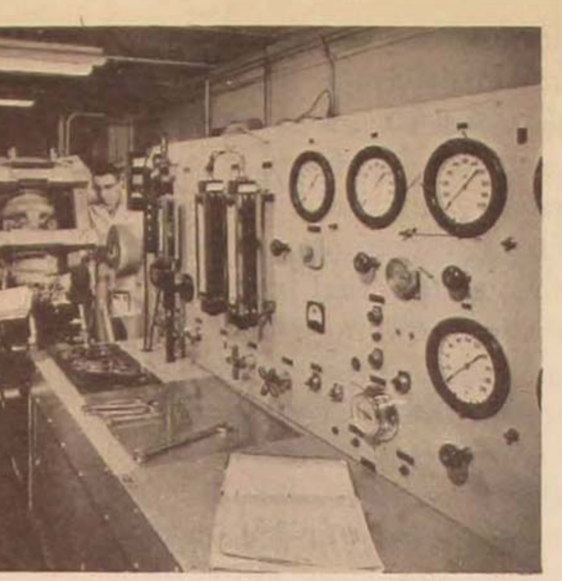
For the Atlas ICBM, none of these weapon system elements existed in 1954. The challenge was lead time—a variable factor exceeding eighteen months for certain of these elements. It was quite obvious that total lead time would be vastly increased by a sequential, series approach, in which the lead times for each major program element accumulate as the successive steps are taken. By means of the concurrency method in the ICBM programs, we have put training and operational bases under construction prior to the launch of the first test missile! In 1954, based on technically feasible facts of the time but not necessarily on facts actually demonstrated, the Strategic Missiles Evaluation Committee believed that an ICBM could be built to operational status in six to eight years; that such a weapon could have a circular error of probability, or accuracy radius, of about five miles; and that it could deliver a nuclear payload of a specified yield to a target 5500 nautical miles away. Now, in 1961, even such optimistic predictions have actually been proved. The Atlas became operational in just five years. Its accuracy has been modestly placed at two miles CEP. It can carry a payload of greater yield than anticipated. And ICBM ranges that are well in excess of the 5500 miles projected have been demonstrated to be clearly practical.

To tackle the myriad demands imposed by the original estimate, the Von Neumann Committee made certain recommendations, which the U.S. Air Force adopted: (1) to take maximum advantage of the scientific and technical state of the missile art and advance that art as quickly and extensively as possible, (2) to proceed with all aspects of the program concurrently, and (3) to streamline administrative and control procedures. Implicit in these recommendations was the understanding that a program of such magnitude must enjoy adequate funding and straight-line authority, along with the highest national priorities.

What we think of today as our functioning concept of concurrency properly reflects each of these recommendations, for without any one of them concurrency would fail. Concurrent action across *all* fronts demands concurrent action on *every* front. In other words, the ballistic missile program could never move along expeditiously as a whole unless each of the parts of the program moved in concert. Any deviation from the master schedule, anywhere along the line, has an immediate and adverse effect on the total program.

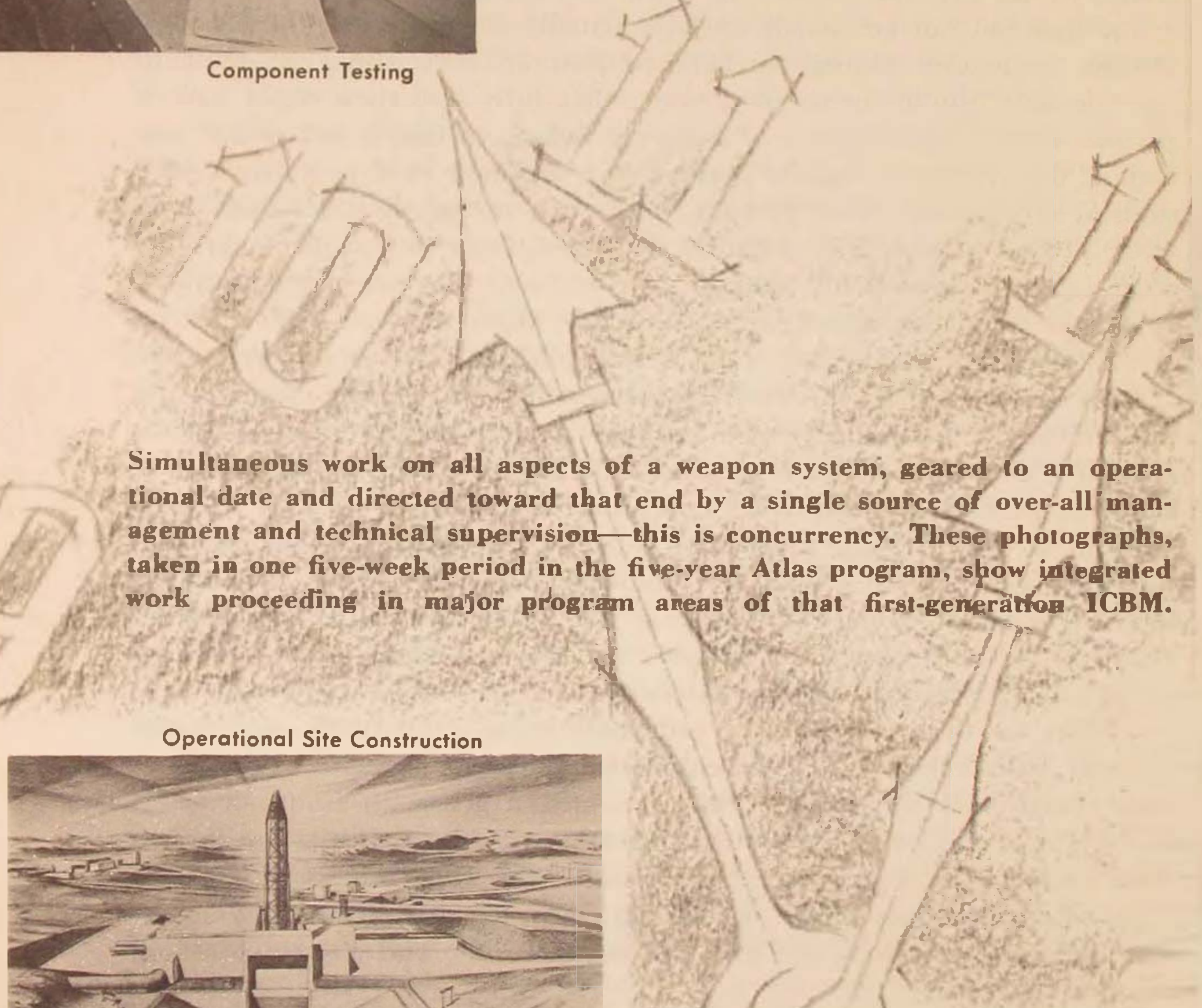
concurrency in operation

All of us, and particularly those of us who are career officers, know that at times decisions which seem forced by circumstance turn out in the long run to be extremely fortuitous. This fortune appears to be the case with the USAF ballistic missiles and the concept of concurrency, and the new, fresh approach to weapon system development now seems destined to be-



Component Testing

System Testing

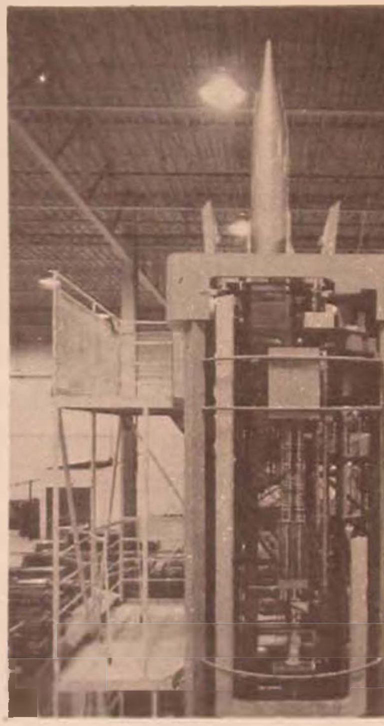


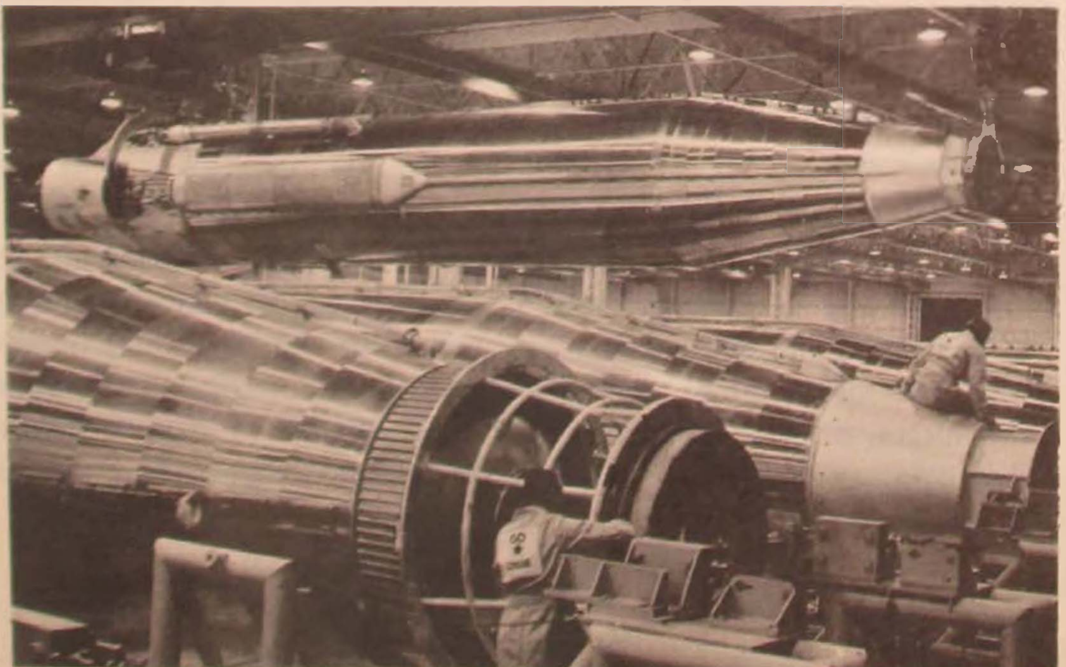
Simultaneous work on all aspects of a weapon system, geared to an operational date and directed toward that end by a single source of over-all management and technical supervision—this is concurrency. These photographs, taken in one five-week period in the five-year Atlas program, show integrated work proceeding in major program areas of that first-generation ICBM.

Operational Site Construction

Crew Training


Flight Testing


Ground-Equipment Development


Production

come the rule, rather than the exception, for future military weapons. There is good reason for this.

The objective of concurrency is to shorten lead time. Through the policies of concurrency we actually cut the development time for an ICBM in half—down to five years from the normally expected ten or eleven years for a system of such complexity. It follows, therefore, that as the lead time is reduced, the operational life of the system is extended. This is an important factor in these days when our fast flight into technology is raising the standards of our weapon systems but lowering their life expectancy.

If cutting lead time can indeed prolong the effective lifetime of our weapons, then the ways in which we can achieve this happy economic result bear even closer attention. And while science, technology, and management all play a part in shortening the time required to deliver new products and weapon systems, the truth, albeit little recognized, is that management—the effectiveness of management—is by far the most decisive element contributing to the goal. Actually concurrency in weapon system development could never work without the strong, firm hand of centralized management. It is a recognizable fact of business that two companies making similar products of comparable quality can reflect considerable differences in profit. One firm may be operating successfully, the other competing hopelessly in the red. The difference, nine times out of ten, is in the management.

In the Air Force we could not afford to be deficient in management ability, for the big Red peril facing us was not one of ink. And time was more critical than money. The Soviets had begun rocket propulsion development earlier than the United States, and, as the Gaither Report has since confirmed, they had effected a firmly disciplined system that beat our normal development lead time by about 50 per cent.

Accordingly we set out to do by democratic, free-enterprise methods what the Soviets were doing in totalitarian style. For the first time since the American industrial revolution moved forward under a full head of steam, we had been pre-empted in a new technology by another nation. Like the tortoise, we have been compelled to come from behind. Unlike the tortoise, we have not had to be content with a plodding pace.

The achievements of the past six years show that the United States has come from behind. Development lead time has been slashed. Our success stems from the dynamic marshaling of this country's unparalleled resources, sparked by the sustained drive of effective management concepts.

concurrency as practiced

By its very name, concurrency requires simultaneous action across different areas and at varying levels. It demands a vast and continuous interplay of objectives and achievements, all geared to time schedules permitting little tolerance for marginal accomplishments. Shortcomings at any point threaten the success of the total program. To prevent—or at least to detect in time—shortcomings of this import is the prime and commanding responsibility of our management system.

In the progress of our programs, concurrency has been practiced at three major levels: in development, in production, and in operational deployment. The friction-free movement of efforts in these three directions determines the rate of acceleration at which our total program can proceed. It goes almost without noting that progress within the framework of each of these areas must keep the pace or else jeopardize the success of our concept.

Development. By way of illustration the development phase may be considered. Before the concept of concurrency was applied to the Atlas weapon system, the sphere of interest of the former ARDC was confined primarily to the research and development problems associated with any fledgling weapon system. Not so under the concurrency approach. Development becomes a broad area encompassing a host of responsibilities. It overlaps production and, to a lesser extent, operational deployment. For when a ballistic missile weapon system has been fully and properly developed, it is already in production. The weapon has been delivered to the user and put into place. The responsibilities assumed by ARDC and now exercised by the newly organized Air Force Systems Command end only when the total programed deployment is in sight.

We have demonstrated this with the Thor intermediate-range ballistic missile. Airlift of the 60th operational missile to the United Kingdom early in 1960 formally completed AFBMD's management obligation in the Thor weapon system program. Support of the logistics requirements was then assumed by the San Bernardino Air Materiel Area.

It must be remembered that none of these elements of the system actually existed in 1954. There was no usable warhead. No nose cone had re-entered at mach 24 or even one third that speed. There existed no guidance system. There existed no suitable, fully developed power plant. In terms of the development pattern that is most familiar to traditional military procedures, we faced in the ballistic missile program the challenge of research and development in four major subsystems, none of which could await the breakthroughs that come with the passage of time and the expansion of technology. We could not wait. We had to evolve airframes, propulsion systems, guidance systems, and re-entry vehicles. The specifications for these subsystems were spelled out, and no allowances were made for compromise with the rigid demands of the end product. There were unsolved problems and technical question marks—and lots of them—in each of these areas. That the problems would be solved, the questions answered, and on scheduled time, was the calculated risk.

This is why Atlas airframes were being tested while the rocket engines were being assembled; why nose cones were being fabricated to withstand the tremendous 12,000-degree temperatures of re-entry at the same time complex guidance packages were being put together. The systems had to be compatible. It was difficult enough to bring them to the required levels of performance separately. It was more difficult to ensure peak operation of each once they were integrated.

Along with calculated risk we had to accept calculated confidence.

Coordination and cooperation, time-honored military attributes, were never more important. An airframe light enough to be propelled to the necessary velocities also had to be strong enough to withstand the stresses imposed by rocket engines of tremendous thrust. Engines demanding huge gulps of fuel had to have turbopumps capable of supplying that fuel. A re-entry vehicle designed to deliver a nuclear payload on target had to depend on an intelligent guidance system that would direct it to that target. The entire weapon demanded precisely computed launching techniques with almost infinitesimal tolerances.

But the complexities of development are not ended merely with the solving of isolated problems. The whole business of testing must be woven through the development cycle. Since a ballistic missile is used only once, it must have maximum reliability. A decade or so ago, when concepts of intercontinental ballistic missiles were in their infancy, there were those who took the opposite view. After all, they reasoned, a missile is launched and it is gone, never to return for re-use. Why not, then, build it "quick and dirty"?

The fallacy in this reasoning became readily apparent. Because there is no second opportunity to correct any mistakes that might be made on a first launch try, the missile *has* to perform perfectly during its first and only flight. This requirement was underlined by the growing awareness of the decisive part that ballistic missiles might be called upon to play in any future conflict. A low reliability rate could spell tragedy for the nation that put its survival on the line with these electronic warriors.

There is only one way to achieve reasonable reliability, and that is through exhaustive testing. In our ballistic missile development programs, testing is a pyramiding process. It is a continuing and pervading factor of our philosophy of concurrency. The suppliers of the smallest parts—and there are hundreds of thousands of parts in any ballistic missile weapon system—test each and every part intensively. These parts are then furnished to subcontractors, who combine them into components or subsystems. These in turn are vigorously tested. Subsystems are integrated into systems, and the systems are checked out under simulated environmental testing conditions. Next, the entire missile is static-tested. Ultimately the "bird" itself proves the compatibility of all its elements by the highest measuring device of all, flight test.

Of course, ballistic missiles that must be held battle-ready cannot be flight-tested. But by conducting an extensive flight-test program with a given number of operational-type missiles we can determine a sound index to the reliability of the missile. This is one of the objectives of our development program.

Production. Concurrency in the development of ballistic missile components makes concurrency in production possible. In all our ballistic missile programs the fashioning of prototypes is ignored in favor of assembly-line production from the outset. The calculated risk involved in this approach is more than compensated for by the savings in time.

In the production of ballistic missiles, careful attention to individual detail is of paramount importance. The mating of components and subsystems must be precise; tolerances to thousandths of an inch must be observed. Missile assembly is painstaking work, requiring the art of craftsmen. The exacting nature of a missile's function will not permit flaws that might be acceptable and even unnoticeable in other mechanical products.

The emphasis to date has been on quality rather than quantity. But the lessons learned, together with greater simplicity of product, make me confident that we shall achieve high levels of both quality and quantity in future ICBM production. The technical wisdom and practical experience gained in the production of liquid-fueled ballistic missiles have proven to be a tremendous value in our rapid progress toward serial production of solid-propellant ICBM's.

Production, however, involves more than the missile itself. Since only about 20 per cent of a complete ballistic missile weapon system ever leaves the ground, it is easy to see that there is much more, in the way of hardware, ground support equipment, and supporting facilities, that must be built by the hand of man. If the missile is going to be ready by a predetermined date, all the complementary equipment must also be ready by that date.

Concurrency in production means concurrency in all phases of production of all the elements that go to make up a ballistic missile weapon system. The missile is the expendable item. It must perform properly from the launching pad. But getting it airborne and ensuring its required velocity, trajectory, and accuracy involve many jobs, many talents, and many skills. Before a missile can be flight-tested, it must have a take-off point. For liquid-fueled missiles, this means construction of the launching pad, the flame bucket, the gantry, the erector, the water cooling system, the lox and fuel tanks, piping, electrical wiring, and the blockhouse and control centers. Furthermore ground support equipment including hundreds of items of electronic control mechanisms, mile after mile of wiring, and sensitive monitoring devices must be produced according to blueprint designs. With the solid-propellant ICBM, these requirements are reduced, thereby simplifying the total system and decreasing the amount of ground support equipment needed.

To make flight-testing pay off in terms of information, a missile must be instrumented to reflect the kind of data desired. This requires sensing equipment and extensive electronic connections which, through impulses conveyed to magnetic tape, will permit ultimate reduction of the signals transmitted from the missile.

Operational Deployment. Production of all required equipment and facilities while the missile itself is being fabricated makes possible the orderly progress of the missile operational deployment program, the third major area in which concurrency must be practiced. If the concept of concurrency is going to yield the full measure of savings desired in the compression of time, then progress in the design and construction of the operational environment must proceed simultaneously with development, testing, and production.

Any new weapon in the military arsenal requires corresponding new concepts and techniques for effective deployment. Never has this been true to the extent dictated by ballistic missiles. These are weapons not adaptable to runways or to hangars—or to any other facility already in existence for Air Force use. To make missiles useful immediately upon emergence from the development program, we had to begin at once to fashion the operational environment appropriate to their nature and their purpose.

Parallel planning of both development and deployment specifications and schedules has not been too difficult. Translating these ideas from design to hardware to installation, however, has proved to be a challenge to ingenuity and flexibility. In a way it is somewhat like building a house. The person who is designing it must have a keen ability to think dimensionally. Regardless of how carefully he draws his plans, though, it is almost inevitable that an unforeseen circumstance will crop up as the house takes shape in brick and mortar. Further, human nature being what it is, the builder may change his mind about the location of a room or a closet when experience or closer study suggests to him a more efficient arrangement. Since there is a comparatively long lead time in the construction of a house, as against the time spent in laying out the plans, it stands to reason that the more certain at the outset the builder is of the floor plan he desires the faster his home will come to fulfillment.

In building a ballistic missile base, design plans are not changed as a result of whim or fancy. But certain portions of the original design ideas may indeed be changed if the input from research and development and test indicates to the builder that greater economy or efficiency can be achieved by doing something a better way.

At any rate, we must be realistic. We have learned that laying out specific plans for an entire ballistic missile launching facility—while the weapon itself is still in development—is a most challenging task. We have been prepared to inject a reasonable number of modifications into the plans, and indeed changes have been incorporated, even at what has seemed to be the last minute. We think in all fairness, however, that our original concepts must be judged as basically sound, for we have been able to continue our design and construction of missile bases concurrently. Thor, now a completed weapon system, is a good example of the advantages of concurrency. Never before has a major weapon system matched so well the original configurations laid down before its full-blown development began. And Thor actually reached operational status a full year ahead of the most optimistic schedules. Moreover the total program was never "out of phase" more than a few weeks at any time.

EARLIER I noted that concurrency is not an easy concept to pursue. To make concurrency work requires the strictest attention to the prerogatives of sound management. Every step along the way must be monitored and controlled. Like an automobile assembly line, each item for assembly and every operation connected with that item must come together at the right place at the right time. Only an unrelenting adherence to milestone schedules can produce this result.

It was to ensure this sort of precision and this kind of strict observance of a commanding timetable that the Strategic Missiles Evaluation Committee recommended the establishment of a central management agency to direct all phases of the comprehensive ballistic missile program. The Air Force Ballistic Missile Division, which grew out of the Western Development Division, in 1957 joined together in one headquarters the authoritative Air Force commands that had the experience and the capability to make concurrency work.

The AFBMD team approach to the team idea implied by the demands of concurrency depended on the close interaction of three major Air Force commands—the Air Research and Development Command, the Air Materiel Command, and the Strategic Air Command. These commands were experienced in the three divisions of weapon system evolution I have described: development, production, and operational deployment. The fusing of three major command elements into one Air Force management organization represented a unique departure from traditional development procedures. But unique results have emerged: complex new weapon systems in a fraction of the development time normally required.

As AFBMD Commander from early 1958 through March 1961, I learned from firsthand day-to-day experience that this modern approach to weaponry does work. With my associates from ARDC, AMC, and SAC and their systems-engineering and technical-direction partners, the Space Technology Laboratories, Inc., and the Aerospace Corporation, I saw procedures streamlined, time trimmed, and tangible results achieved in a manner I would not have believed possible a few years earlier.

This innovation in the development of military systems has been geared to keep pace with the accelerated advances of modern technology. The purpose behind establishment of the Air Force Systems Command in April 1961 stemmed from a logical progression of the philosophies fundamental to the concept of concurrency. The paramount importance of streamlined management procedures, compressed development time schedules, and expeditious decision-making represent basic requirements reaffirmed and emphasized in the organization of the Systems Command.

Responsibilities assigned to the old AFBMD had multiplied both in scope and in number during the years between 1957 and 1961. At the beginning of 1961 we were, for example, managing some 19 major Air Force missile and space programs, many of them holding top priorities. The creation of the Air Force Systems Command—combining in one headquarters the research and development obligations formerly carried out by the Air Research and Development Command; and the related procurement and production responsibilities traditionally conducted by the old Air Materiel Command—also imposed major organization changes on what had been the Air Force Ballistic Missile Division.

The establishment of the Office of the Deputy Commander for Aerospace Systems, Air Force Systems Command, provides to the Los Angeles–Inglewood location a centralized authority for expediting the missile and space development programs and for hastening the decision-making processes. Functional responsibility for specific missile and space programs has been assigned to two divisions, the Ballistic Systems Division and the Space Systems Division. These divisions exercise comprehensive management responsibility for all phases of the development-to-deployment cycle—including research, development, test, procurement, production, construction, and installation. These divisions act also as the focal points of the total management team, the team which takes in many associate contractors as well. The Ballistic Systems Division, of course, devotes all its resources to the evolution of our intercontinental ballistic missile systems—the Atlas, Titan, and Minuteman. The Space Systems Division oversees the progress of virtually all the Air Force's flowering space programs.

Under the previous AFBMD organizational structure, the Air Research and Development Command acted as the developer, the Air Materiel Command as the buyer and producer, and the Strategic Air Command as the user of ballistic missile systems. It was in essence a triple-threat team for a triple-threat challenge. But aerospace challenges, extending far deeper than ICBM trajectories, have demanded further streamlining of this team attitude and clearer lines of authority in the prosecution of aerospace systems. Hence the Air Force Systems Command and its principal aerospace divisions, the Ballistic Systems and Space Systems Divisions.

The results of our concurrent approach to aerospace requirements are becoming increasingly apparent. I have mentioned the Thor IRBM as a product of concurrency. Thor was developed, produced, and deployed inside of four years. Atlas, the first U.S. ICBM, also is operational now at three U.S. bases and in the months just ahead is to grow to full deployment stature in 13 squadrons —a deterrent force that might still be a prototype rather than a reality but for the stimulation of concurrency.

On the immediate horizon are Titan and Minuteman, two more ballistic weapon systems born and bred in concurrency. Construction of the underground concrete and steel silos for the Titan missile began even before the first missile had been flight-tested. And the first operational squadron is near completion at Lowry Air Force Base, Colorado. The Titan is due to be declared operational in 1961, in the light of rapid progress achieved in the development and advanced testing of this missile and in the construction of operational sites. Construction of the silos to house the first three Minuteman squadrons is under way near Great Falls, Montana, and the Minuteman is undergoing flight test at Cape Canaveral. An operational date of mid-1962 has been set for Minuteman.

Any one of these four major weapon systems constitutes a graphic illustration of the influences of concurrency. Certainly the vital ingredients in our Air Force prescription for modern deterrence and counterforce power must include a greatly expanded technology, diligently applied talents, and unflagging perseverance. But subjecting all these characteristics to the intrinsic advantages of the concurrency concept has resulted in the fulfillment of our most urgent requirement of all—the productive compression of time.

Space Systems Division, AFSC

Manned Craft and the Ballistic Missile

MAJOR GENERAL JAMES FERGUSON

BECAUSE Air Force research and development has been so intensely concerned with ballistic missiles in recent years, it is sometimes assumed that this proves a heart-and-soul commitment to the concept of "push-button warfare," conducted entirely with automatic weapon systems carrying nuclear warheads over great distances.

Nothing could be further from the facts. On the contrary, manned craft are needed in any force to complement the automatic weapons and perform certain jobs which missiles cannot do; various international situations may occur, short of total war, in which the use of manned aircraft is essential; and future operations in space will most probably be carried out largely in vehicles under the control of human flyers.

Ballistic missiles have provided us with two major advances in the science of flight: first, a weapon of tremendous power, which can be directed to its target either from the ground or from the air; and, second, a new method of propulsion that works best in the near-vacuum beyond the earth's atmosphere. That these technological achievements spell the end of the flight crew's usefulness is as unlikely as that the automobile will supersede the driver.

force composition: interim planning

In the past decade we have concentrated on the vehicle, rather than on the flyer who will ultimately guide it, because its performance is so radical—especially in speed—that we have not yet determined the best means of adapting it to flight by human beings. Besides, the ballistic missile is a weapon of such enormous potency that we have been compelled to find the quickest and simplest way of using it. Otherwise we might have been left at the mercy of a rival armed with this new messenger of destruction.

The ballistic missile of today is a marvelously sophisticated mechanism. Its electronic guidance systems are amazingly accurate. For all its wondrous complexity, however, the missile lacks selectivity, judgment, and perception—qualities that are innate in an intelligent human operator. The object of war is not indiscriminate destruction but immobilization of those elements in the adversary's strength that enable him to resist and eventually perhaps to win. Wholesale destruction not only is indefensible and a waste of one's own resources but liquidates facilities that might be of use later on and alienates large population groups which might otherwise be friendly.

The ballistic missile cannot choose its target, or, once launched, change its plan of attack if the tactical situation should change, or observe the enemy's defensive position, or report on the results of a strike. It cannot be recalled if circumstances develop that make it desirable to cancel the operation. The missile does not return to a friendly base, to be refueled and fly again.

Some of these functions can be performed eventually by satellites. Even then, they will be most effective under human guidance and control. The great advances made by electronics in recent decades do not alter the fact that sensing devices are merely substitutes for and extensions of the human nervous system. They do not replace the brain of the operator, especially at the spot where the decision takes effect.

Just as tactical aircraft provided advantages in range and selection over the capabilities of artillery between World Wars I and II, so the piloted satellite or spacecraft can be expected in the future to provide similar advantages over the automatic missile. When the change will occur is mainly a question of the time it will take to develop suitable vehicles. Meanwhile ballistic missiles are being brought as close as possible to perfection, not as a permanent and complete substitute for the trained flyer but as a complementary weapon system until more advanced vehicles become available.

When development of the supersonic B-70 jet bomber was cut back in December 1959 to an experimental prototype instead of the fully equipped operational version, many people in the Air Force, as well as in the aerospace manufacturing industries, assumed that this action heralded the gradual obsolescence of strategic aircraft in the years to come. Even though the B-70 is under development, the idea persists in some circles that this may be the last strategic airplane—that by the time the B-70 could be ready to fly, automatic weapon systems may have made the manned bomber as anachronistic as the chariot or the trireme galley.

I do not believe that this pessimistic view is justified or that it is held by even the most enthusiastic proponents of a strong missile force. Modern weapons of all types are highly expensive. Our intensive development of ballistic missiles over the past six years has placed us in a position where we can produce a powerful force of these weapons in the immediate future—including especially the economical Minuteman. Our most urgent need is for a superior inventory of ICBM's, to make our deterrent strength as nearly overwhelming and invulnerable as it can be. In concentrating our resources on this task, we must necessarily make some reduction of other programs.

The B-70, though it may promise a tremendous advance in our over-all strategic capability, is not as close to realization as the missile force. The B-52, equipped with Hound Dog air-breathing missiles and to be equipped later with the Skybolt air-launched ballistic missile, will complement our ICBM counterstrike force for the next few years, giving it the flexibility that it would not otherwise have as our sole reliance in a war emergency.

The "mixed force" concept today offers the greatest counterforce potential. Once our missiles have been launched in the initial counterstrike, aircraft will be used to search out, locate, and destroy whatever military targets remain, whether they be mobile or static. Furthermore these same aircraft are recoverable and can be employed in successive counterstrikes.

Without question, the ballistic missile is an effective argument against aggression. Missiles will play a prominent part in the first massive counterstrikes. Aircraft participating in the initial strikes will also be needed for mopping-up operations and especially to pinpoint small or elusive targets. For example, if we should be faced by an enemy possessing light, mobile ICBM's like our Minuteman, it would take aircraft to hunt down the railborne launching pads and destroy them.

We cannot be sure, either, that the next war in which we are involved—if any—will be a large-scale global conflict. To say the least, it would be tragic indeed if we were prepared to counter only one kind of military action—a concentrated assault on our homeland by ballistic missiles—and hostilities actually started elsewhere in some other form.

the balanced force and security

On the statute books in one of our Midwestern states there used to be a law intended to keep railroad trains from colliding at points where the tracks crossed. The law provided that "when two trains meet at a crossing, both shall come to a halt, and neither shall proceed until the other has passed."

Some would argue that there is a resemblance to that piece of legislation in the situation existing today between the United States and the Soviet Union. If this truly were the case, it could be said that a stalemate exists. But stalemates derive their stability from the willingness of the opposing forces to maintain a standstill. Few would agree that the dynamic forces at work in the world today have any of the static qualities of a stalemate.

Arms limitation or control is obviously a desirable goal. On the other hand the question is still left open: Would, for example, a nuclear arms limitation banish war from the earth? There are other ways of conducting hostilities than with nuclear weapons. There are other kinds of war than general war.

Several times within the past quarter of a century we have seen examples of what might be termed local, or "limited," wars. Wars of this kind could occur again without necessarily bringing on direct hostilities between the major powers represented.

Lesser degrees of aggression have been known in the past. They range from repeated border incidents—for example, the series along the Manchurian frontier in the 1930's involving Japan and the Soviet Union—to armed intervention in the affairs of a neighbor, such as that of the U.S.S.R. in Hungary a few years ago. They range from revolutionary outbreaks, fomented inside the boundaries of other states, to minor harassments such as the shooting down of unarmed aircraft, from furtive kidnapings and assassinations to overt displays of military strength as in the Berlin Blockade.

At all these techniques of using force without proclaiming war the Communists are adept. There is no reason to think that they would abandon these tactics and live in amiable fellowship with the rest of the world simply because they preferred not to risk general war. We must be prepared for military situations of different types, at widely separated points around the globe, in the years ahead.

In localized actions ballistic missiles would be of little use. Nuclear weapons of any kind—if employed—would be limited to the smaller, tactical varieties. Aircraft, however, would be of great value not only to our own forces but also in the hands of our allies. In my opinion it is vital that we maintain a modern inventory of conventional air weapon systems, large enough and sufficiently varied to cope with any contingency that may arise.

We should remember that many of our smaller allies do not have the manpower and resources to operate complex weapons like the Nike-Hercules defense system or sophisticated all-weather interceptors. Their need is for up-to-date weapons of a simpler type, for tactical support of a kind that some of our advanced systems are not designed to fulfill. Yet these smaller nations—often strategically located at points difficult for us to defend—could contribute in a large measure to the security of the Free World as a whole, as well as their own defense, if properly equipped for dealing with peripheral actions.

Most of these countries do not build their own weapon systems but instead rely on our industrial resources to supply them. This is one of the responsibilities that we assume as a major arsenal of freedom on our globe.

The extreme cost and complexity of modern weapons compel us to concentrate on a select few of the most essential systems for ourselves. Our purchases of aircraft at the present time, for example, are reduced to hundreds rather than the thousands we used to buy, and they are much restricted in the variety of types.

On the other hand we can bolster our over-all posture mightily in the eyes of a potential aggressor by fostering the growth of complementary forces in other parts of the world—forces capable of resisting isolated probing actions and military encounters having a low order of violence. This we can do by encouraging our allies to equip themselves with weapons responsive to their most probable needs. In effect we would achieve a combined force, capable of meeting any aggressive action, through our allies' contributing a substantial share of the conventional forces while we contribute the main weight of the nuclear strike forces.

When we disperse a large part of our total deterrence around the world in this way, we compel the opponent to vary and disperse his effort too. Considered from this broad view, our defense is not confined to the North American continent where we live. It begins far from our shores, wherever free people still exist outside the bonds of Communism.

space weapon systems: emerging trends

We are now in a period of transition—brought about by the tremendous progress in technology over the past two decades—from a conventional concept of security, based on the interplay of national forces and rivalries, to a concept of security maintained by systems operating in the space around our planet. Some years will elapse before the full effect of the change becomes apparent. Until it does, we may expect to see some of the traditional roles of manned aircraft being assumed by unmanned ballistic missiles and instrumented satellites.

As the space age matures, I believe that the trend from manned to unmanned vehicles will be reversed. The reason is quite simple. Automatic mechanisms of any kind, following the patterns built into them in advance, have a certain rigidity of behavior that by its very nature is slow to recognize and respond to the rapidly shifting circumstances in a military situation. The environment of war, including preparations to conduct or deter it, is highly fluid. The most maneuverable combat forces almost invariably are the most successful.

At present we are in the earliest phase of our military space effort. We must consider that the weapon systems we are now building for the immediate future are primitive compared with the highly sophisticated types which will eventually replace them. Almost certainly the space systems of tomorrow will be fully manned, to achieve the fullest measure of maneuverability.

It would be idle at this point to predict in detail how those future systems will perform. They will evolve gradually as our competence and experience in space flight increase. But we can already perceive the direction they are taking. Their characteristics will be determined by their operational environment. The two most notable features of that environment, in the vicinity of the earth, are its gravitational field and the near presence of the atmosphere beneath it. The gravitational field governs the motion of the craft and therefore its propulsion. The atmosphere governs its behavior on re-entry, when its mission is completed, or in an emergency. Gravitation provides the spacecraft with a unique capability. Once in motion, it needs no power whatever to continue traveling at hypersonic speed on a predetermined course. In a satellite orbit that is high enough, it will go on circling the earth indefinitely.

The military spacecraft will be basically a satellite, proceeding on station in its orbit until it is called upon to take some action. The nature of its mission will determine the characteristics of the orbit. It will rarely depart from its precomputed course, because of the necessity to conserve its rocket propellant. It will be designed for ultimate re-entry into the atmosphere. For that reason it will have the configuration of a hypersonic aircraft or glider, a configuration which will not affect its performance in space. There is the possibility that it could take off under its own power. It appears more likely that it will be mounted as the terminal stage of a large booster rocket, which will almost certainly be recoverable.

The early prototype of just such a military spacecraft is now under development by Air Force Systems Command. It is the experimental boost-glide vehicle, Dyna-Soar. It will be lifted into space as the terminal stage of a rocket system with an ICBM as its booster. When its mission is completed it will re-enter the atmosphere and glide down to a landing, using a brief burst of power to correct its course and speed before touchdown. At the present time it is planned to place Dyna-Soar in its free-flight trajectory at somewhat less than orbital velocity. It will make one or more circuits of the earth, losing altitude, before it glides back into the atmosphere. This is a question which does not materially affect the design of Dyna-Soar as a true space vehicle. Its cutoff speed is a function of the booster system, not of the craft. If a sufficiently powerful rocket should become available by the time it is ready for its trial flights, Dyna-Soar might conceivably be sent into orbit.

The Dyna-Soar is limited for the present to an experimental version. However, something like it must inevitably become a part of our aerospace force.

By then, perhaps, the popular notion advanced by some today, that the unmanned mechanism will supersede manned systems, will have been discarded, and the missile will be accepted as a complementary element in a manned aerospace weapon system. This is the most logical relationship between them, once they are both developed to a high point of operational utility.

The purpose of this discussion has been to show that in any kind of counterstrike force the two elements are indispensable—that the inanimate missile and the manned craft both are essential to a positive aerospace deterrent. The mix of the two is a question that can only be decided on the basis of our technological advancement at the moment. But it is vital to our security that we maintain an appropriate combination of both, at every stage of our efforts to produce and maintain for this country the world's foremost aerospace force.

Headquarters Air Force Systems Command

Military Uses of Man in Space

COLONEL JOHN P. STAPP

THE STORY is told of an overseer of an African plantation who became tired of the constant surveillance required to keep his lackadaisical natives on the job. Finally he devised a scheme to take advantage of their voodoo superstitions. Calling them together, he removed his glass eye and convinced them that it could see and report to him what they were doing in his absence. Thereafter he mounted it conspicuously on a fence post overlooking the field. He surreptitiously spied on them enough to keep them convinced of the magic powers of the glass eye, and they remained diligent under its surveillance. One day he came by the field unexpectedly and found all hands taking their ease. Not one was working. Glancing at the post on which he had left his glass eye, he saw that someone had slipped a tin cup over it.

The ingenious techniques of subtle sabotage possible in space electronic countermeasures might well render an unmanned surveillance satellite as ineffectual as a glass eye in a tin cup orbiting the earth. The responsibility for launching a vehicle from orbit calls for direct human control and decision. Other orbital launch techniques cannot be absolutely dependable.

Progress in missile propulsion with resultant increased payload capacity, combined with microminiaturization of electronic components by the use of molecular-film transistor modules, will enormously increase the versatility and complexity of sensing and computing devices in space satellites as well as simplify the mechanics of modifying or maintaining them. The increased complexity and variety of such instrumentation will enhance the desirability of direct human monitoring, checkout, recalibration, and reprograming, either continuously or intermittently. Reprograming the instruments to transmit new and different signals, and even updating circuits while in orbit, are inviting possibilities. Instrumented satellites launched to date have fallen short of expectations in many instances by mechanical failures during ascent into orbit, by premature breakdown of transmission after initial success, by calibration ranges and sensitivities that failed to match the characteristics of the events they attempted to measure, and finally by transmitting the same data with extravagant redundance long after there was no further profit in recording it. In all these instances a trained operator aboard the satellite could have enormously enhanced the usefulness of a very expensive orbiting observatory.

Not only is the increased reliability and versatility of instrumentation possible in a manned satellite a factor, but the observations and performance of tasks by the astronaut have unique value, beyond weight saving in pounds of "black boxes" to replace him. Granted that man cannot be miniaturized as readily as the electronic components in their characteristic black-paneled cases and that he has constant requirements for oxygen, water, food, waste disposal, viable atmosphere, and living space, these liabilities are outweighed by his decision making, his capacity for overriding or bypassing mechanical failures, his versatility in complex tasks, and his skill in returning the total vehicle for re-use. As space vehicles continue to improve, the balance of trade-off between the weight of a man and his logistics versus the weight of black boxes with backups required to replace him will come at an ever earlier time in the duration of an orbital satellite flight. From this point of increasing returns, a saving in weight and complexity of a space weapon system can be realized while gaining also in reliability of communications and control by using a human operator. An astronaut can improvise against the unforeseen and unknown more effectively than can remote-control instrumentation. Some things done by remote control lose more than is gained—consider the case of making a bed with a walking stick instead of using your hands, or, more specifically, of trying to use a black box where using your head would be more profitable.

The question resolves itself into an evaluation of manned space systems, in terms of their unique capabilities and effectiveness, and not into a polemic over the relative merit of man versus his alleged equivalent in black boxes—a piece of illogic by reason of comparing noncomparable objects. The higher functions of his nervous system and the compactness and sensitivity of his sense organs defy duplication by electronic and other instrumentation, even without considering the restrictions in weight and size of present space systems. Furthermore, man on the ground as an observer via electronic sensing and transmitting devices can receive calibrations from man the observer in space, verifying and correcting observations made aloft, simultaneously with the ground station.

manned space missions

Now that the feasibility of orbital flight has been verified and assuming that the feasibility of satelloid systems of the Dyna-Soar type will be advanced by the maximum altitude and speed trajectories of the X-15, what are some of the military missions that would require the unique capability of manned space systems?

Radiation hazards of the Van Allen layers apparently restrict unshielded orbital flight to altitudes below 600 miles. Certainly, I believe, first priority from a military surveillance standpoint calls for thorough evaluation of surveillance techniques, most favorable altitude and direction of orbits, and calibration of optical and electronic observations against direct human observation and the unique value of human manipulation of optical and electronic instruments. This evaluation is needed to establish range and resolution of objects of military significance. Very essential tables of altitude versus range and resolving power for instruments in the full spectrum of visible and infrared light, of radar and all radio frequencies, can be obtained from a systematic search. At the same time spherical projection mapping through a selected sequence of circular orbit altitudes can be accomplished by means of photographs taken in those orbits. The photographs can then be compared with television transmission to calibrate television and to compile permanent, accurate ballistic and astrogation maps.

The space patrol concept from an orbital satellite would naturally follow the exploration of optimum altitudes and orbits and development of the reentry techniques. Because of the anticipated payoff from human capabilities, self-maintainability, and ability to maintain equipment, a great deal of emphasis has been given by aerospace medical scientists to human-factors aspects of this type of relatively prolonged space flight. This emphasis has been largely incited by systems engineers, who have made thorough operations analyses and find the manned systems highly profitable if it can be demonstrated that a minimum crew can tolerate a 30-day mission. To this end in March and April 1960 the Aerospace Medical Division of Wright Air Development Division completed two 15-day work cycle studies with Strategic Air Command B-52 crews who volunteered for a simulated space mission in the confines of a space weapon mockup at Marietta, Georgia. In September and October of 1960 two Air Force pilots were confined in a ground-level space flight simulator for a little over 30 days at the Aerospace Medical Center, Brooks Air Force Base, Texas.

Further proof of feasibility for a manned space patrol system with 30-day orbiting capability, and for larger patrol-type systems of even longer flight duration, will require an orbiting space research vehicle to evaluate effects of prolonged exposure to weightlessness. No ground-level device or aeronautical research vehicle limited to exposures ranging from fractions of a second to less than a minute can provide sufficient duration of weightlessness. An orbital laboratory is also required to determine the effects of maintained environmental stress and adaptation to a drastically different environment on a continuous basis, which cannot be simulated under other than actual conditions. Total low-grade radiation effects must also be monitored in the space environment to estimate any chronic hazards that may be found. Other than these special problems, ground-level simulation and aeronautical experiments have reproduced anticipated space-environment factors acceptably for feasibility study and life-support system development purposes.

A properly spaced squadron of such 30-day or longer space patrol systems can serve a secondary function as communications relays for electronic signals, particularly in an emergency electronic blackout of standard signals. The size and sophistication of these vehicles will allow considerable man-machine versatility of operations. Weather information could be computed and coded on board for quick transmission around the world. The unique capabilities of human observers could be reinforced by successive crews orbiting over the same suspicious objects at relatively short intervals, confirming each other's observations.

the human factor

The clocklike predictability of satellite orbits minimizes the element of surprise in orbital systems while increasing opportunity for antimissile countermeasures in direct ratio to the duration of flight. Passive orbital flight denies evasive action to such attacks. These shortcomings are surmounted in spacecraft flown under control of the astronaut, either in satelloid flight of one circumference or less around the earth at slightly less than orbital speed or with power to enter and leave orbit at the will of the pilot. Here the proven aeronautical capabilities of man meet a higher challenge.

Space pilots must adapt themselves to reaction controls, which steer the spacecraft by accelerative force of thrust nozzles but permit dangerously sensitive overcontrol in comparison to the linear response of the aerodynamic stick and rudder.

Weightlessness has not impaired the performance of jet pilots or interfered with their control of the aircraft during brief exposures obtained in Keplerian trajectories. Diminished threshold to acceleration may occur during prolonged orbital weightlessness, with the possibility of giving the pilot a few bad seconds in a sudden exit from orbit; but this condition remains a supposition until it can be tested in space flight.

Visual problems in space flight will be presented both by the high closing speeds and by the lack of reference cues for depth perception. VFR flight of a spacecraft at increasing distances from the earth will be weird and difficult because of the radically different and unfamiliar visual environment, particularly at altitudes where the curvature of the earth gradually merges into a spherical horizon. New systems of instrument flight and of celestial and terrestrial navigation will need to be developed along with spherical mapping techniques.

Nevertheless, meeting the challenge of these complexities will give man his greatest usefulness—approaching irreplaceability—in space systems. Surprise and evasion are at the command of his skill and discretion, as the enemy is forced to find and track him without a predictable orbit to compute. His autonomy of the spacecraft exempts him from interference. The astronaut will be on equal terms with the aeronaut as a flyer, but with infinitely expanded performance at his command.

Thus far, rocket motors have been used to thrust missiles into various single-stage or multistage ballistic trajectories, to accelerate them to orbital velocities and altitudes, to control spin rate of instrumented satellites, to retrothrust missiles out of orbit, and to attain escape velocity for interplanetary exploration. Another use for rocket thrust is available as the state of the art develops: the use of thrust for lift. Lighter-than-air displacement enables helium-filled thin plastic balloons to carry 500-pound payloads to 140,000 feet and smaller payloads still higher. Theoretically one million cubic feet of helium can carry one pound up to 220,000 feet. Since one million cubic feet of volume cannot be enveloped by less than a pound of any known material, even a monomolecular film, an absolute ceiling for displacement lift is evident. Aerodynamic lift, depending on air density, flight velocity, and wing area and design, likewise has a finite ceiling, which is less than 120,000 feet. Above this ceiling only brief zoom on momentum is possible—somewhat like the brief aerodynamic excursions of the flying fish above his normal aquatic medium.

Since rocket thrust is exempt from atmospheric limitations, there is no altitude ceiling on its use as an opposing force to the pull of gravity. By adjusting the vertical component of thrust to exactly offset the earth's gravitational attraction at any given altitude, a space platform could be made to hover at constant height without tangential motion. The use of thrust for lift as well as translational displacement makes true space flight possible, independent of velocity and with complete control of acceleration down to zero from either positive or negative.

It is within existing capabilities to lift a lightweight open gondola with two pressure-suited occupants to 100,000 feet by means of a 5-million-cubic-foot helium-filled thin plastic balloon. The balloon could be discarded at this height, and solid-fuel rockets ignited below the gondola could—perhaps by manifolded successive stages—lift the gondola at low acceleration to between 50 and 100 miles above the earth. It might be possible to hover for several seconds on retarded thrust before descending by deployed cargo chute or even by bailout such as Captain Joseph Kittinger proved feasible from 102,800 feet in August 1960.

There is a wide selection of off-the-shelf solid-fuel rockets available for progressively augmenting the performance of such a poor man's space "go-kart." The next stage in sophistication of this approach would be to use a closed cabin lifted by a variable-thrust liquid-rocket motor. A feasibility inquiry has shown that an existing, reliable, liquid-rocket motor can be modified to provide lift-thrust vertical flight of low acceleration up to 500,000 feet. Even these primitive attempts at controlled lift-thrust above the aerodynamic atmosphere can attain some profitable information.

There is a prospect of eventual development of lift-thrust in combination with an aerodynamic airframe to enable such a manned aerospace vehicle to hover or fly slowly or swiftly at selected altitudes above the atmosphere for useful durations and with aerodynamic capability of selected landing. Demonstrable military usefulness of space flight between the top of the atmosphere and the lowest practical orbital altitudes would be indisputable, particularly if it can be accomplished with complete range of control on speed and altitude.

Finally, it is worthwhile to investigate the possibility of manned space flight in which the motors operate as jets on take-off, convert to ramjets in flight at appropriate speed and altitude, and finally introduce appropriate oxidants and reductants to function as liquid-rocket engines beyond the altitude and speed practicable for ramjet propulsion. Conventional runways can be used for take-off and landing; the regimes of aerodynamic subsonic through high hypersonic speeds progress into space flight and attainment of orbital and even escape velocities in a sequence tailored to human demands and abilities. This is a welcome prospect in comparison with current Procrustean approaches by which man is compressed, confined, made to adapt himself to engineering limitations of existing ballistic propulsion.*

Space speculation has almost displaced sin as a favorite topic of conversation, and it is a fertile field for metaphysical phantasy, unchallengeable until research establishes the facts. This is particularly true about the psychological factors. Most psychologists are loath to leave a single problem behind, anticipating that every earthly abberation will have its counterpart in either isolated or group space flight. In the presence of overwhelming threat to survival, some personality factors may be overridden by more imperative considerations. It becomes academic to wonder whether an introvert would bail out a sinking life boat more diligently than an extrovert—although which personality type would keep up the effort longer might be significant. A more pleasant speculative alternative would be on the possible beneficial effects on cerebral cortical activity, freed from neuromuscular bombardments of gravity reflexes, isolated except for selected sensory inputs and information. Perhaps the "break-off" phenomenon described by many test pilots and by Lt. Col. David G. Simons during his 32-hour-10-minute balloon-borne sojourn in near space may be put to use in pure objective thinking.

Going beyond military requirements and considering manned space flight in terms of scientific exploration of the universe, the best statement to date on the need for man to venture into space comes from a report dated 25 January 1960 and issued by the National Aeronautics and Space Administration's Biosciences Advisory Committee of seven distinguished scientists under Dr. Seymour S. Kety. It is summed up in the following passage:

> The basic study of extraterrestrial environments is ultimately likely to be most productive in furthering an understanding of the fundamental laws of nature. Among the most perplexing questions which have challenged men's minds are the nature and origin of life and the possibility of its presence elsewhere in the universe than on the earth alone. For the first time in history, partial answers to these questions are within reach. Limited knowledge acquired over the past century concerning atmospheric and climatic conditions on other planets, the topographical and seasonal variety in color of the surface of Mars, the spectroscopic similarities between scattered sunlight from portions of that planet and those demonstrable from algae and lichens on earth have suggested the presence of extraterrestrial environments suitable for life and permitted the formulation of hypotheses for the existence there of some forms of life at present or in the past. These hypotheses may, within the foreseeable future, be tested, at first indirectly by astronomical observations made beyond the interference of the earth's atmosphere and by samplings taken mechanically from various celestial bodies, and finally, by direct human exploration. The discovery of extraterrestrial life and a description of its various forms, knowledge of the presence and types of complex molecules based on carbon or other elements, or conversely, the absence of living organisms or of their traces in environments conducive to life will have important implications toward an ultimate understanding of biological phenomena.
>
> These studies will not be complete until the scientist himself is able to make meticulous investigations on the spot. This is true, not only for the biological, but, also, for many other physical, chemical and geological problems which are involved. Although significant engineering achievements in automation, sensing, recording, programming and telemetering have been realized and considerable future development is in prospect, the indispen-

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*Considering the miniaturization of electronics and the rapid progress of propulsion development, it is futile to juggle payload distributions which will be happily discarded as outdated before they can be used. Likewise the cataloging of projected human-life-support requirements, protective devices, biologistics, psychophysiological limitations, and crew selection criteria would be needless repetition of subjects well covered in *Air University Quarterly Review* (Vol. X, No. 2, Summer 1958).

> sability of the human observer in much of space exploration is well established. Man's versatility and selectivity, his ability to perceive the significance of unexpected and unprogrammed findings or to react intelligently to unanticipated situations have not been simulated by any combination of physical devices, however complex, which have been developed or are even contemplated. Human intelligence and manual skill in servicing the complicated mechanisms of space vehicles or repairing breakdowns in flight are not readily dispensed with or replaced. When along with these attributes are considered his weight of 70 kg., his total resting power requirements of 100 watts, his ability to function for years without maintenance or breakdown, then even the most elaborate provisions for his sustenance, welfare and safety are amply justified simply in terms of engineering efficiency. A national program in space science which does not recognize the essentiality of the human observer and does not plan to utilize him most effectively may wait indefinitely for the automatic devices to replace him or be limited to incomplete and opportunistic observations.

We have briefly reviewed the possibilities of manned space systems. None of these possibilities is being neglected by our competitors. I am convinced that negotiation from strength will be reinforced by our possessing manned space vehicles and using them in the pursuit of world peace.

Headquarters USAF Aerospace Medical Center (ATC)

Technical Breakthrough

COLONEL FRANCIS X. KANE

WE ARE engaged in a war of technological maneuver with the Soviets. Our goal must be to exploit technology so as to demonstrate a position of unquestioned and unmistakable military dominance. In brief, we must recapture the position we attained through the development of the jet aircraft and the atomic bomb and through the creation of our air power. In the past fifteen years the Soviets have used technology to build military strength comparable to ours and thus have eliminated our once clear superiority.

We are now entering a new phase of maneuver; we stand on the threshold of a major advance in weapon capabilities which can give a clear advantage to us or to the Soviets. We look to a technological breakthrough, trying to anticipate when it will occur and to foresee the changes it will bring. We will find a partial answer to these questions if we examine the nature of a breakthrough. For the purposes of this inquiry we should look at this phenomenon in three parts:

- a description of the process by which a technological breakthrough occurs,
- an examination in broad terms of the present state of our technology,
- a discussion of the probable course of technology.

the process of a breakthrough

In discussing the technological breakthrough we must keep foremost in mind that we are dealing with the realm of human action, i.e., planned action toward desired goals. Terms such as "technological explosion" and "onrush of technology" give the impression that there is an impersonal, inexorable force in society which is producing major advances spontaneously, particularly in military capabilities. It cannot be emphasized too strongly that such advances result from human action on the broad aspects and specific problems of technology. A viewpoint based on the belief that they are automatic and self-generating reduces us to the role of observers and commentators, rather than recognizing that we are planners and doers. If these advances did not result from planned action, there would be little practical value in examining this aspect of the future.

The term "technological breakthrough" is used to describe developments of such widely differing types that it has many meanings. For the sake of clarity we should examine the genealogy of major advances, so as to have an insight into the full range of meaning.

Step One: The Intellectual Breakthrough. The revolution in weapon systems today is a result of the revolution in science, notably in physics, which began a century ago. An intellectual breakthrough was made during the period when Maxwell and Mach were making their discoveries, and it paved the way for Einstein's special theory of relativity. These intellectual advances were a "breakthrough" because they eliminated some of the restrictions imposed on scientific thought by acceptance of classical principles. By proposing new theories individual scientists established a new era in science. We should note several characteristics of this revolution:

(1) It was the consequence of creative action by men of genius.

(2) It took two generations of scientists for these ideas to be recognized and accepted.

(3) The basic advances were started nearly a century ago.

(4) They occurred in science, i.e., in that part of human activity which is directed toward understanding of the real world.

Step Two: The Invention. The second step is a process of translating theory into a device which appears to have some usefulness. This step could also be termed "the application," for in it we find the first application of a theory to a useful device. The essence of invention is the first confidence that something should work, and the first rough test is that it will in fact work. We should note several characteristics of this step:

(1) It, too, is a creative process.

(2) Invention usually takes place only after a scientific theory has been recognized and accepted. For our purpose we should note that at times this is a circular proposition in that invention may be the key to the acceptance of a theory.

(3) Invention is considered a part of technology as compared to the first step, which is the realm of science and the philosophy of science.

(4) Invention has been a lengthy process, and during the period when inventions were the work of one man this period often covered the major portion of his adult life.

Step Three: The Policy Breakthrough. This step results from a decision made at the management level, whether it is in industry or in the military sphere. Such a decision is based on recognition of the potential importance of the invention. The essence of the decision is to allocate resources so as to translate an invention into a product which is materially useful, and the purpose is to gain a time advantage, whether in marketing a product or in achieving a military capability. Naturally in the military case this is a weapon system or a major component of one. The characteristics of this step are:

(1) It is the result of a decision process, based on recognition.

(2) It is managerial in nature.

(3) The choice of this invention from among a number of potential advances has a major influence on the future of the industry or of military capabilities.

(4) In the past this step has taken a much shorter period of time than the first two.

Step Four: The Engineering Breakthrough. In this step the invention chosen by management is produced in numbers. An essential part of the engineering breakthrough is the advanced development or prototype. In industry the construction of a pilot plant provides the bridge between the "bread board" model and series production. In the military sphere we have taken several approaches to this aspect of the engineering breakthrough. In the past we built prototypes of aircraft prior to production. In the development of our missiles we telescoped the construction of the prototype and production of the operational model into a single phase under the concurrency principle. However, we now have advanced developments for systems such as Dyna-Soar and the nuclear-powered airplane without concurrent tooling for production. The distinction between phases is further blurred by development of one-time, unique systems, such as our command and control systems. The characteristics of this step are:

(1) The engineering breakthrough is a result of the work of creative people, generally with different qualities than the scientist or inventor.

(2) It comes as a result of technology which aims at usefulness.

(3) Success in this endeavor is the only step meaningful for immediate military capabilities.

(4) It covers a much shorter period of time than steps one and two.

This division in steps, into bits and pieces, is for illustrative purposes only. We should recognize that scientists sometimes take on the role of technologists; that technologists have made scientific discoveries; that production may require invention; that scientists, engineers, and managers participate in the decision process. Also it is impossible to summarize in four simple steps the activities of a multitude of individuals in complex technological relationships. Some state that invention is a part of step one; others that it is a part of step three; others that it is a distinct step in itself. There is no uniformity in this process. At times individuals have tried to stimulate closer ties between science and technology. Galileo and Newton, for instance, tried to cross-fertilize these two fields. Also in the area of innovation, Black's discovery of radiant heat enabled Watt to invent a more efficient steam engine, but there is no clear indication that Watt set out to employ Black's discovery. It is fairly clear that Watt was knowledgeable in the science of his day as the result of his work as maker of scientific instruments. Diesel's attempt to apply the law of thermodynamics (made possible by the high-pressure steam engine) led to the invention of the diesel engine. But the forecast that it would be the engine for aircraft clearly missed the mark. Historical experience is complex, and our four steps are only indicative of broad areas of human activity.

However, our interest is in the impact of science and technology on military capabilities. Let us look at the four steps in this context. The revolution in physics beginning with Maxwell and Mach led to new theories which culminated in the building of the atomic bomb. The policy breakthrough in this historical example—the decision of the President to spend the required large sums of money—was based on the recognition by the scientific community, notably by Einstein, of the importance of the theoretical advance.

In the case of the ballistic missile the direct relationship between science and weapon is not quite as dramatic and clear-cut as in the example of the atomic bomb. However it is clear that Goddard's initial investigations of rocket propulsion and Oberth's theoretical calculations played key roles in the German development of the V-1 and V-2 rockets. Here is an example of an invention being recognized and resources being allocated for an engineering breakthrough. This decision was made in 1932, and the first V-2 flew ten years later.

The German engineering work played a significant role in Russian rocket development and in our own as well. For example, both U.S. and Soviet postwar rocket engines used the oxygen and alcohol propellant of the V-2. At this point the technical paths diverged. The relatively primitive state of Russian nuclear weaponry forced the Soviets to pursue instead an engineering approach to missile development. We, on the other hand, chose to await an invention in nuclear weaponry to give us a lightweight, high-yield, nuclear bomb. Once this invention was achieved, we made the decision to allocate resources to our missile program and sponsored the many engineering breakthroughs in guidance, airframe construction, and re-entry technology required for operational missiles. We see, then, that the creation of the atomic bomb followed the pattern of four steps but that in the missile field the step division is not so clear-cut.

In its broadest sense the term "technological breakthrough" applies to the entire process when it results in advances which thrust us into a new era of military capabilities. We should note, however, that the term is used also in connection with limited parts of the process. A new theory may be described in scientific circles as a breakthrough. An inventor may describe his work as a breakthrough. The engineers working on a specific part of the problem of production may describe an advance they make as a breakthrough, particularly when the invention is necessary for production. Use of the term has some validity in that, without the invention, production would not be a reality.

The key step in the entire breakthrough process is step three, the policy breakthrough. A decision in the realm of the engineering breakthrough cannot be considered in isolation from effort allocated to steps one and two. The importance of the policy breakthrough cannot be overemphasized.

restraints on the breakthrough

At the present time, in the initial phase of the space age, we are waiting for a technological breakthrough, in the broadest sense of the term. However we are faced with a basic uncertainty. Because the advances in theory and invention (steps one and two) are the result of a creative process, we cannot anticipate their nature or the time of their appearance. Thus we cannot forecast when essential major innovations will take place.

In attempting to bring order and control to the technological breakthrough, we have in the past concentrated on steps three and four in the process, the policy and the engineering steps. We have studied management and decision procedures in more detail than the intellectual breakthrough and invention. We have brought a great effort to bear on production, so that systems are made realities in a minimum of time. We consider it a major breakthrough when the time covered by steps three and four is reduced from eight to five years. We have not made a similar effort to reduce the total time covered by the entire breakthrough process.

At the present time the period covered by the intellectual breakthrough and the invention cannot be reduced. This is an unavoidable consequence of our scientific and technological effort, partly because steps one and two lie outside the military sphere. In their broadest sense they are the consequence of our society, and our contemporary society has not organized an effort to influence these steps.

Furthermore these considerations reflect the sharply contrasted technological strategies of the Soviet Union and the United States. The Soviets have a strategy of focusing their effort, including their basic and applied research. Central direction and control are the key aspects of their strategy. This means that discovery and invention must be on schedule. The motivation of Soviet scientists has been an important factor in meeting goals, but sanctions and punishment for failure are also an important part of this approach. Also, by focusing their effort, the Soviets leave to atrophy areas which are not considered vital.

Our strategy is to advance on a broad front. Direction and control are minimized. Invention and innovation are where we find them. We exert our effort in capitalizing on what our rich technology can give us. For the long pull we should continue to follow our strategy while being aware of the danger of an advantage which the Soviets can attain in a limited aspect of technology. In effect the Soviets are gambling that such an advantage will prove to be vital to their goal of domination.

In connection with step two we should note a change in the way the Air Force now approaches invention. In the past invention was usually the work of an individual. Today we are making an institutionalized effort to get inventions.

Once again there is much to be said on both sides of the question. It is not clear-cut that a team approach is superior to an individual approach to an invention. Studies indicate that certain creative individuals cannot work as members of a team, while others function best as part of a team. Some fields of science, notably chemistry, seem to require a team effort in order to make advances; but in the fields of physics and mechanical engineering more advances seem to be made by the individual working alone. Regardless of the approach followed, it appears difficult to reduce the time necessary for intellectual breakthrough and invention. It may well be that recognition and acceptance of new theories and inventions will always require a period of mellowing, testing, and evaluation. But we should note that as far as our immediate interest is concerned a new theory or invention would have little impact within the current decade. This brings us to another aspect of a technological breakthrough.

Our principal concern is in the time when such advances occur. The invention of a new jet engine today would not produce a new era in military capabilities as did the first jet produced by Whittle. Conversely, the invention tomorrow of a practical way of using focused energy beams as weapons would alter radically the whole sphere of military activities. The consideration of time is especially crucial for us in the war of technological maneuver.

Today we face many restraints in regaining a clear advantage over the Soviets. Some of these lie in the broad field of technology itself. This is not to say that technology is the result of an impersonal historical force. It is a reflection of the fact that the state of technology results from the endeavors of individuals and the state of their knowledge. The first jet could never have been produced in 1900 nor the first atomic bomb in 1915. Today we do not have a space technology on which to build for a breakthrough. The space systems now under development are an outgrowth of our missile technology. We lack facilities such as space-environment laboratories, either on earth or in orbit. Some of our projects, such as Discoverer, will give us empirical data on which to build our space technology. Also it may well be that we will not need an extensive effort beyond the existing technology. But until now we have had a "wait and see" attitude. We should be following a strategy of identifying problems and allocating the effort necessary to solve them.

Considerations of strategy impose another restraint. We must have at all times the in-being force necessary to win wars. This means being ready for operations at every moment in the foreseeable future while providing simultaneously the foundations for major advances in capabilities. These are requirements that compete for resources. Our in-being capability is not static; we cannot allow it to dwindle or become obsolete. Thus modernization of our forces must be continuous but must not detract from having sufficient power at any given point in time.

This restraint is compounded by a third restraint, which is financial. There is an upper limit on what we can expend to advance technology in general and on what we can allocate to develop specific systems. For example, no amount of money spent in 1935 would have given us our first ICBM. Unlimited resources in 1950 would not have given us the Dyna-Soar. In attempting to achieve a technological breakthrough we must reckon with restraints imposed by the state of technology, by strategy, and by funding. Today there is also the fundamental shortage in scientific manpower.

These restraints have their greatest impact on step three, the policy breakthrough. Here the attitude toward technology plays an important role. As long as decision makers are convinced that advances occur automatically, as long as they believe that contemporary technology can give us at any moment an unexpected but major advance in military capability, they will be restrained from taking effective action. Such an attitude makes them reluctant to choose a weapon or warfare system to develop and produce because a breakthrough would make it obsolete and unnecessary. A belief in the "millennium tomorrow" is based on the unstated assumption that advances come automatically because of the nature of our present environment. From a cursory glance at past breakthroughs it should be apparent that they are the result of human action—that is, a combination of goals and work to attain goals. Nevertheless the result of this attitude is a belief that choices are unnecessary because advances are spontaneous.

Another aspect of restraint on the policy step offers a seeming paradox. The decision maker, while awaiting a technological breakthrough at any given point in time, feels he is suffering from an *embarras de richesse*. As he faces the choice of a course of action, he sees so many ways to proceed that he finds it difficult to choose any one of them. Furthermore the rate of advance makes him hesitate, for if he chooses he may soon find that the system selected has been made obsolete before it is usable.

The rate is exponential. For instance in 1935 there were two designs of a major bomber weapon system available; in 1955 there were more than 360. Complicating the choice of a system is the problem of evaluating the interrelationships of the growing number of choices and the other aspects of the force in which they will operate. And these too are increasing in number.

These considerations have important repercussions. The first is that they delay decisions. Secondly, the decision makers press the military planner to examine minutely the entailed decisions which spring from the courses of action possible. Additionally they press him to forecast with certainty these anticipated effects. A recourse to science is the planner's response to such demands.

Here we should note another paradox in this process. The scientist and technologist are responsible for advances in knowledge and in applications. Authority in these fields does not, per se, give them insight into what is either commercially or militarily useful. The management level in industry, while using scientists for technical advice, does not depend on them for managerial decisions. However, in the military sphere, management procedures are designed to have scientists participate. Thus, while individual scientists can initiate a breakthrough, other scientists can restrain the fulfillment of the breakthrough because of their influence on decisions.

The control of the technological breakthrough in the decade of the Sixties and beyond requires that we take a more comprehensive approach to the problem. We must consider it as an integrated process and devise procedures just as we have for weapon system development. As has been pointed out, we have had a pragmatic philosophy in the past. We have given emphasis to parts of the process and have neglected others. We have not made a systematic approach to controlling steps one and two. We do have a primitive solution in our basic and applied research programs, but it has not been the consequence of a rational choice between various strategies or methods for stimulating advances. By and large the nature of the intellectual and inventive steps is unknown, and we do not have a program designed to promote understanding of them. Such an effort is essential to the control and direction of the entire process of making technological breakthroughs. As we have noted, because of the nature of steps one and two, we may never find it possible to control them.

the state of our technology

Within the limits just described, we have a constantly evolving program in basic and applied research. We are promoting these programs today to lay the foundations for a dynamic technology tomorrow. In basic research we are seeking new knowledge essential to step one in future technological breakthroughs. The Air Force is playing a significant role in supporting the Nation's basic research. The size of our effort is shown by the fact that we currently have some 1600 basic research contracts with laboratories, universities, and industries in the United States and elsewhere in the Free World. We are spending some 42 million dollars in fiscal year 1961 on basic research, exclusive of our in-house research activity. While this is about ten times the amount we were spending in the early Fifties, we still do not consider it adequate. We plan to nearly double our annual expenditure over the next few years, but we are not satisfied that even this is sufficient.*

In some cases progress in science and technology awaits the development of new fundamental mathematics. We all know that a single new mathematical method can revolutionize an entire area of application. We are seeking the development of new ideas in mathematics, as well as improvement of known techniques. We hope to obtain new structures for linear and nonlinear mathematics and for mathematical analysis. New and better computational methods are needed. One example of the areas in which we are working relates to information theory.

In our applied research program we are seeking to develop the specific technology which we can apply to future military systems. For this extensive program, to which we are giving constantly increased emphasis, we are spending some 243 million dollars in fiscal 1961. While this is a very substantial sum, we are yet able to investigate only about 50 per cent of the technical opportunities presented to us. The applied research program covers 28 technical areas:

nuclear application
nuclear warfare
support equipment techniques
deployable aerodynamic decelerators
materials
navigation and guidance
flight control
weapon fire control
vehicle defense
computer and data-processing techniques
advanced weapons
mechanics of flight
propulsion
flight vehicle power

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*Brigadier General Benjamin G. Holzman, in his article "Basic Research for National Survival" in the Spring 1960 issue of the *Air University Quarterly Review*, describes our present basic research program. The principal areas of investigation are propulsion, materials, electronics, geophysics, biosciences, and aeromechanics.

surveillance techniques
communications
electromagnetic warfare
electronics techniques
reconnaissance
electromagnetic vulnerability reduction
intelligence techniques
electromagnetic wave techniques
aerospace environment
biologistics
biomechanics
radiobiology
human performance
systems syntheses and analyses

Some of these areas will be discussed, not including propulsion because it is covered elsewhere in this book. The importance of propulsion to the future is indicated by the fact that it is allotted a separate chapter.

One research area of particular importance is navigation, guidance, and control for future aerospace vehicles, and a portion of our applied research effort is directed toward it. We are not yet truly navigating vehicles in space; that is, they are steered only during the powered portion of flight. The controlled maneuver of space vehicles requires the development of new and unique sensors and control devices. We must have a means of determining position in space in order to navigate accurately. We certainly will need a device to establish a drift-free attitude reference and an instrument to measure absolute velocity in space flight. Our more immediate needs include an altimeter that will accurately indicate altitudes of from 100,000 feet up to several hundred miles. We require a means of sensing atmospheric variations in the upper portion of the atmosphere, and we need a method of reading the earth's surface position from satellite altitudes.

It is clear that very substantial advances in guidance and control are necessary if practical space operations are to become a reality. We are pleased with advances made thus far, such as the stabilization of a vehicle in orbit and the recovery of a payload from orbit. But we have not yet been able to undertake the solution of many key problems in aerospace navigation and guidance.

Pictorial sensing is a field in which the Air Force has been working for years. By "pictorial sensing" is meant radar or radarlike devices that can provide pictorial data concerning the earth's surface. While great advances have been made in radar in recent years, we need a device that will have near-photographic resolution at very high altitudes. Obviously much work lies ahead.

The art of recovering vehicles from orbit must be improved, and one of the key problems is the deceleration and landing of such objects. We hope through applied research to achieve more effective and predictable deceleration and recovery of disorbiting objects. Research efforts being made in this area are promising.

The broad field of electronics embraces many of our applied research activities. A significant part of our effort in electronics research is to improve the reliability of electronic components. We are also continuing to look for techniques for miniaturization and for the automatic assembly of parts and circuits. We are conscious of the great progress made in this field in recent years, but we are convinced that many important advances can come in the next few years. Our resources do not permit the exploration of many possibilities in electronics. To cite one example, we need self-checking and self-stabilizing circuits to increase the operating life of electronic equipment in remote locations.

It has been said that the proper study of man is man himself, and we are doing so in some specialized ways in our applied research program, notably in our human factors research. Man is already experiencing a rather severe environment in the altitudes we are now reaching. When we project him into space he will be confronted with extremes of environment which strain our technological capabilities. While we have made progress in developing suits and capsules to protect him, many problems have not yet been solved adequately, such as the radiation problem that appears to exist at certain altitude levels. The problem of sustaining man in a closed environment for an extended period is also rather well known. Other problems concern, for example, the performance of man under the stress of a space environment.

Extensive efforts are being made to gain new knowledge of the factors affecting man in space, but we remain conscious of our relative ignorance. One of the tools we need is a simulator for research and training in manned space flight, but a device which substantially duplicates the required conditions is beyond the state of the art.

Between one fourth and one fifth of our total research, development, test, and evaluation budget is devoted to basic and applied research. We are acutely conscious of the value of these efforts and would devote an even higher proportion of our budget to them if it were not for the critical demands in developing our advanced and operational systems.

the probable course of technology

As has been pointed out, the policy step is the key step in the entire process of the breakthrough. Yet decision makers cannot go beyond the possibilities afforded them in the other three creative steps. They can give direction to the entire process and allocate resources. In the broadest sense the course over the next decade is already determined by past efforts. Even though we were to make a concentrated effort to understand and control the entire process for the technological breakthrough, the effects of such a program would not be felt until after that time. Therefore we can anticipate that major advances must come within the framework of our present technology and the programs to exploit it. Nevertheless, as stated in a recent Presidential report,* we must promote and encourage technological change. We must advance knowledge and innovation on every front.

The time required for the intellectual breakthrough and the invention will in the main effectively prevent the results of our basic and applied

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*The Report of the President's Commission on National Goals, November 1960.

program from having a direct influence on our immediate military capabilities. Basic and applied research programs will lead to advances in military capabilities only late in the decade. Proof of the utility of investigations in the applied research program can lead to new systems in 1968–1970. At the earliest, products of our basic research program will be felt only beyond 1970. Some of the systems can be useful within the decade, that is, those which lie in the area of advanced development between the applied research program and the weapon system development program.

We feel intuitively that we stand on the threshold of an advance into a new era of military capabilities. We anticipate that space-based systems will revolutionize military affairs as radically as air power and missile power have altered them in the past. We are conducting an extensive and continuous examination of our technological capabilities to determine the systems which we must develop so as to accelerate our capabilities in space. We have great resources in skilled personnel, facilities, and acquired data. Nevertheless at the present time there is no one indicator—be it an intellectual breakthrough, an invention, or an engineering breakthrough—which will permit us to pinpoint the time when this advance can take place. There is great hope that a decision breakthrough will be made to establish the national goal of accelerating our space capability. Such a decision would entail financial risks and increased spending, for as we have seen we cannot afford to disrupt our in-being capability at any given point in time.

From the viewpoint of technological strategy, we are in a situation roughly parallel to that which we faced a decade ago. At that time we were evaluating the technical path to pursue in developing our missile forces. We foresaw that the missile was clearly in the offing. Nevertheless it took us two years after the forecast advance in nuclear weaponry to make a policy breakthrough which led to development of missiles. It took us another five years for an initial operational capability. It will take us another three to five years to complete the transition to a balanced missile and aircraft force. Thus while we are currently evaluating our technological capability to go into space we cannot anticipate a major advance into a new era within the decade.

We are trying to provide comprehensive choices for sound decisions which will give us military space capabilities. We are laying the foundations for a space-oriented technology. We are searching for multiple approaches to propulsion. Thus the key decisions are still in the future, and it is apparent that the most difficult choice will be in the funding of such an effort. The funding necessary to exploit technical capabilities must be additive to the present programs designed to give us a balanced missile and manned-aircraft force. The technological breakthrough awaits these key decisions.

IN ASSESSING the relative technical strengths we believe it is apparent that we have a decided edge over the Soviet Union. At the level of pure science we have the talents and resources of the Free World. We have an advantage in the scale of effort we can apply to evaluating advances and to exploiting proven advances. We have another advantage in the engineering plant, an aspect of technology in which we have excelled during this century.

On the other hand, the spark which leads to a breakthrough results from a creative process, from the efforts and talents of individuals. The time when such individuals will appear and the results of their work cannot be forecast. This is an aspect of the technological breakthrough which does not favor either side. We can only try to influence and direct such individuals so that their talents will contribute to our security. Here is an area to which we should devote greater emphasis. The relative effort now devoted to this area should stimulate urgency on our part. For example, the Soviet educational system is graduating some 75,000 to 100,000 engineers a year, while we are graduating on the order of 50,000 to 60,000.

Finally it is the author's opinion that in the past decade the Soviets have surpassed us in making policy breakthroughs. They have identified the aspects of technology which are essential to Soviet objectives, and they have devoted resources adequate to develop and exploit them. This is well demonstrated by the fact that a decade ago we had unchallenged superiority. Today the Soviets have challenged our dominance.

The course of the future will be determined in large measure by the policy makers who can appreciate the importance of an advance in the intellectual, invention, or engineering levels of science and technology. The more we can shorten the process of the breakthrough and the more we can accelerate the rate at which we translate ideas into weapon capabilities, the sooner we will be able to regain our unquestioned superiority. In the war of technological maneuver the advantage will go to the side which understands the nature of the technological breakthrough, works to achieve it, and capitalizes on it. A basic consideration is that we face an uncertainty. We cannot anticipate the exact nature and time when the breakthrough will occur.

Even though it may be a decade away, the breakthrough into space capabilities will undoubtedly be made. We must achieve it before the Soviets, and we can do so through understanding, planning, and acting intelligently and in time.

Headquarters United States Air Force

The Propulsion Barrier

Brigadier General Ralph L. Wassell

ONE OF the keys to the aerospace force of the future is propulsion. The aerospace force will include vehicles that operate entirely within the earth's atmosphere, vehicles that pass through the atmosphere into space, and vehicles that operate entirely in space beyond the earth's atmosphere. All of them will demand propulsion systems that are more efficient, more durable, and more reliable than any we have yet developed. In addition these systems must meet, as far as practicable, the requirements of economy and safety.

Future Air Force requirements for vehicles that operate within the atmosphere will include a variety of missiles and manned aircraft. One suggested future need is a mobile striking force that can penetrate enemy territory from any direction and at a choice of altitudes, a force that can range for days on airborne alert without refueling and is capable of sustained low-altitude flight. Long-range aircraft developed for such a force could also be used on extended patrol as part of a far-ranging defense system against intercontinental ballistic missiles. Carrying detection devices and armed with air-launched anti-ICBM's, they would give us an excellent chance of destroying enemy ballistic missiles in the early phase of their flight. They would also be valuable for extended antisubmarine-warfare patrols.

Strategic missiles with the capability for high-speed, sustained, low-altitude flight could greatly augment our ballistic missile forces. Unlike the ballistic missile, which flies in a fixed trajectory, they would need to be able to change direction in flight, either to dodge enemy defenses or to strike at alternate targets.

Aircraft and missiles with such long-range capability seem to be out of the question for our present propulsion systems. If we are going to produce them, we must either greatly augment our present propulsion systems or seek new sources of power.

As far as we can now see, there are two energy sources that may be used for propulsion within the atmosphere. The first, of course, is chemical fuel, which we are now using in our reciprocating, jet, and rocket engines. The other is nuclear energy, which is being used successfully for electric power production and for submarine propulsion. As a propulsion source in aerospace it offers both promise and problems.

In discussing the relative merits of various propulsion systems, we must distinguish between two terms, *thrust* and *specific impulse*. Thrust, which is measured in pounds, is simply the "push" developed by a rocket engine. For vertical take-off from the earth's surface, thrust must be high—at least

30 to 50 per cent greater than the total weight of the rocket. A rocket weighing 100,000 pounds, for example, must develop a thrust of between 130,000 and 150,000 pounds in order to take off successfully. Specific impulse, on the other hand, is a measure of the efficiency of a propulsion system and is defined as the number of pounds of thrust produced per pound of propellant consumed per second, expressed in seconds. The two terms apply to rocket engines in roughly the same way as "pickup" and "miles per gallon" apply to automobile engines. An eight-cylinder automobile is likely to have more pickup, but a six-cylinder automobile will generally give better mileage per gallon of gas. Similarly rocket propellants with low specific impulse may produce relatively high thrust, and propellants with high specific impulse may produce relatively low thrust.

chemical fuels

Chemical systems, in one form or another, are likely to remain our major source of aircraft and missile propulsion for at least ten years. For one thing, they are now available. Many chemical fuels are easily obtainable and are relatively cheap and safe. Furthermore they can produce large amounts of thrust quickly. But chemical propulsion has certain limitations. Fuel weight limits the range of our aircraft, thereby limiting the flexibility of our tactical and strategic forces. An extended airborne alert, for instance, cannot be conducted without complex refueling operations. And the prohibitive fuel cost of low-level operations largely precludes the planning of desirable "on deck" penetration of enemy defenses.

Turning from manned aircraft to long-range missiles, we encounter other limitations. We have not yet found the "ideal" propellant. Cryogenics such as liquid oxygen (lox) are used extensively, but they present severe storage and handling problems. Lox cannot be easily stored in the missile. It must be produced and stored on the launching site and pumped into the missile just before launch. Corrosive oxidizers such as nitric acid present problems in pumping and metering. Cost is also a consideration. Hydrocarbon fuels such as RP-1* are relatively cheap but have a much lower specific impulse than several more expensive propellants.

Solid propellants solve the storage problem and simplify the design of rocket motors, but they generally have a lower specific impulse than the best liquid propellants. Moreover a solid-propellant rocket cannot be throttled, and the thrust cannot be shut off and restarted except for a limited number of cycles.

We recognize these limitations, but we are not letting ourselves be bound by them. Already we have developed storable liquid propellants that yield a relatively high specific impulse and can be used in advanced ICBM's. Because they are noncryogenic, they can be transported, pumped, and stored much more easily than the extremely cold liquids. At the same time we are developing solid propellants with about 80 per cent of the specific impulse obtainable from advanced liquids.

*[A propellant consisting essentially of kerosene.]

The most serious propulsion barrier for engines using chemical fuel lies in the physical laws of nature. We know that it is possible to make certain gains. Propellants in current use (chiefly RP-1 and lox) yield a maximum specific impulse of around 250 seconds (chamber pressure of 500 pounds per square inch absolute expanded to 14.7 psia), while a system using hydrogen and fluorine has the theoretical specific impulse of about 373 seconds. But we will not be able to go much beyond this. It is virtually certain that no possible conventional chemical combination will yield a specific impulse of more than 400 seconds.

One proposed unconventional method of passing the 400-second barrier has been under study for several years. This method would use the energies released through the reassociation of unstable molecular fragments known as "free radicals." If a way can be found to release these energies in a controlled manner, enormous amounts of energy can be obtained, yielding specific impulses of 700 seconds or better. In fact it has been calculated that atomic hydrogen, the best of the free radicals, has a theoretical specific impulse of nearly 1200 seconds. There are serious problems, however, in generating and stabilizing free radicals, and further problems arise in controlling their reassociation so as to yield useful energy. The free-radical method therefore does not yet offer a practical source of propulsion but is rather a theoretical possibility.

Although we are working to raise the energy level of chemical fuels, we have found other lines of attack on the propulsion problem to be more profitable. One of these is improvement in structural design. Further increases in the mass ratio (that is, the mass of the loaded vehicle divided by its empty mass), will increase range and velocity. But here too we approach definite limits. To attain a forward speed equal to its exhaust velocity, a rocket must have a mass ratio of 2.72; to attain twice the exhaust velocity, it must have a mass ratio of 7.4; and to attain three times exhaust velocity, a mass ratio of 20.1. At present the only way to pass these limits is by use of multistage rockets—a costly procedure but a necessary one.

The most practicable means we have at present of increasing specific impulse, so long as the vehicle stays within the confines of the earth's atmosphere, is the ramjet. We are currently using twin ramjet engines in the Bomarc air-breathing missile to attain speeds of mach 3. Theoretically ramjets can attain twice this speed or the equivalent of a specific impulse of 3400 seconds. This fantastic increase in specific impulse is not a contradiction of the 400-second limit. It simply means that for the ramjet we leave the weight of the oxidizer out of our calculations, since the oxidizer is obtained entirely from the atmosphere and is not a part of the weight of the missile. The specific impulse for a ramjet engine, then, is higher than the specific impulse for a rocket engine because it is figured on the basis of the thrust obtained from one pound of fuel alone, rather than from one pound of fuel-oxidizer combination.

The ramjet is the simplest of jet engines, for it has no moving parts. The air necessary to oxidize the fuel is compressed by the engine as it moves through the air at high velocity. The design of the engine—basically little more than a tube open at both ends—is responsible for the "ramming" effect. After the ramjet is boosted to a high speed by rocket or other means, it becomes self-operating. The ramjet can fly at subsonic speeds, but it is most efficient above mach 3.

nuclear propulsion

The release of energy at levels far above those obtained by conventional chemical means is possible through nuclear fission. For several years the Air Force has carried on research in aircraft nuclear propulsion, in cooperation with the Atomic Energy Commission. A nuclear-powered aircraft would use the heat generated in a nuclear reactor, this heat being converted into thrust by turboprop, turbojet, turbofan, or ramjet engines. The turboprop would be best adapted to low-speed operations, the turbojet and turbofan to intermediate speeds, and the ramjet to high-speed, supersonic operations.

Regardless of which engine is used, the nuclear-powered aircraft has two advantages. The first is range and endurance far beyond anything likely to be obtainable through chemical propulsion, and the second is the capability of sustained operations at low altitudes. The potential use of nuclear-powered aircraft may be seen in the continuously airborne, missile launching, and low-level penetration system, which was proposed about three years ago. This system calls for a high-subsonic-speed aircraft with long flight endurance, large payload capacity, and the ability to launch standoff missiles and to penetrate the enemy heartland at low altitude. The limiting factor for such aircraft would no longer be fuel considerations but the endurance of the crew.

A nuclear-powered turboprop aircraft with boundary-layer control* would be well suited to antisubmarine missions of several days' time. Nuclear aircraft could also be used to fly logistic missions. With a payload of 100,000 pounds a nuclear turboprop is a better transport than a chemical turboprop at ranges over 2300 miles; with a payload of 200,000 pounds it begins to show its superiority at ranges of 1750 miles. Such a nuclear transport is still far in the future, however, and will not become economically competitive until reactors can be produced with a life expectancy of more than 3000 hours and at a cost of less than $2 million per aircraft. At this point, nuclear propulsion promises neither greater speed nor greater altitude; these still must be attained through improved means of chemical propulsion. Rather nuclear propulsion offers us the one advantage that chemical propulsion has not yet given us—vastly increased endurance or range, particularly at low altitudes.

It is also true that there are many problems still to be solved in nuclear aircraft propulsion. The first of these is the problem of the most efficient heat exchange between the reactor and the working gas (normally the surrounding air) that supplies the actual thrust. Two methods have been proposed. In the direct-cycle system the working gas is heated directly by passing

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*[The design or control of airfoils to reduce or remove undesirable aerodynamic effects caused by the boundary layer, a thin layer of air next to the airfoil with distinctive flow characteristics set up by friction.]

through the reactor. In the indirect-cycle system the working gas is heated by a liquid metal which flows through the reactor core and then is pumped to radiators in the propulsion units. The efficiency of both methods depends on the development of materials that can withstand prolonged exposure to radiation and to extremely high operating temperatures.

The second major problem is that involved in attenuating the radiation produced by the fission reaction device inherent in presently conceived nuclear propulsion systems. Such radiation, unattenuated, constitutes a hazard

Jet Propulsion

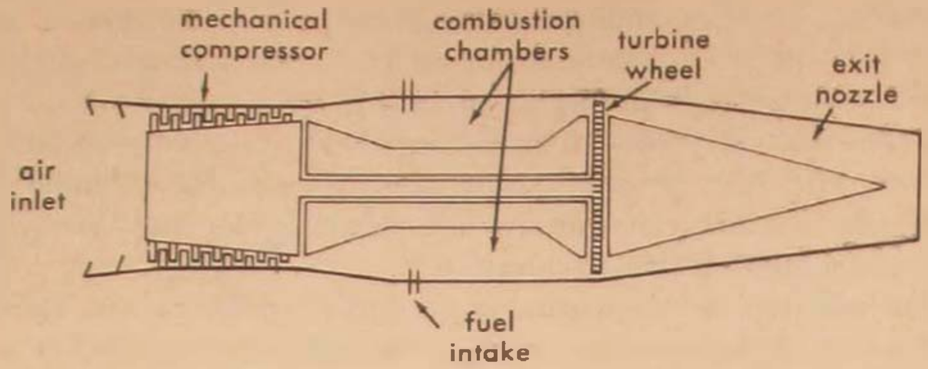
Jet propulsion engines may be classified as duct propulsion or rocket types. The duct propulsion engine, essentially pipe-shaped, takes in air at one end, accelerates it to greater momentum by heating it, and exhausts it at high velocity through a nozzle at the other end to produce useful thrust. Principal types are the turbojet, the turboprop, the ramjet, and the rocket engines.

The turbojet engine makes use of a rotary compressor driven by a turbine wheel for mechanical compression of the intake air in the combustion chamber, into which fuel is also continuously sprayed. Before exhausting through the nozzle, the hot gases from the combustion of fuel and air strike the turbine wheel, imparting rotary motion that is transferred by a shaft to turn the compressor. In the nuclear turbojet engine the combustion of chemical fuel is replaced by heat transfer from a reactor, as by a radiator, to raise the temperature of the compressed intake air. The turbofan engine is a form of the turbojet deriving additional efficiency and higher take-off thrust from a fan, often formed by extensions of the first few compressor blades, that operates within a duct behind the air inlet.

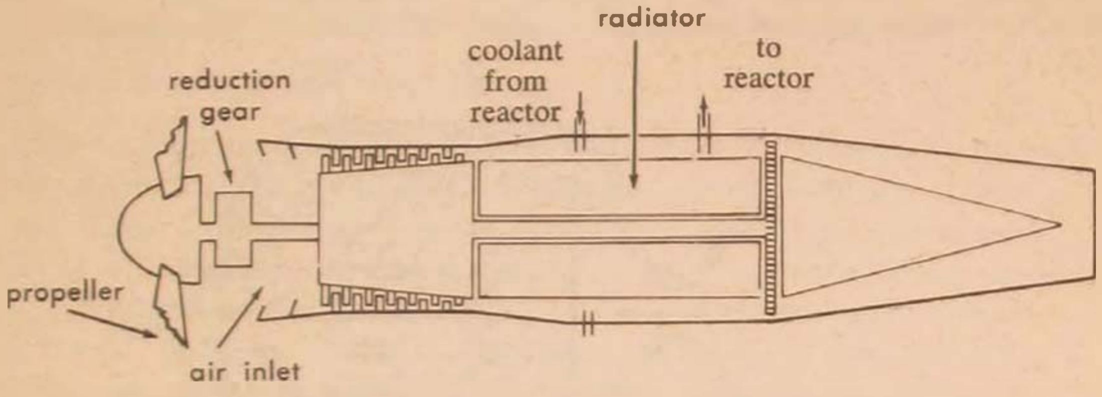
The turboprop engine differs from the turbojet in that the heated air is expanded to greater degree in the turbine to produce more shaft power, which is used to turn a propeller through a reduction gear. The turboprop derives most of its thrust from the propeller and only a small amount from the jet exhaust. Under certain conditions it offers advantages of fuel economy and thus of endurance and range.

Simplest of the duct engines, in principle, is the ramjet, which has no rotating parts. Necessary compression of intake air in the combustion chamber is obtained by the forward motion of the engine through the atmosphere. Conceptually the ramjet consists of three major components: a diffuser that decelerates and compresses the inlet airstream, a heat-addition region, and an exit nozzle to expand the heated airstream back to ambient pressure. In the nuclear types the gases for jet exhaust are accelerated by heat transfer from a reactor rather than by heat of combustion.

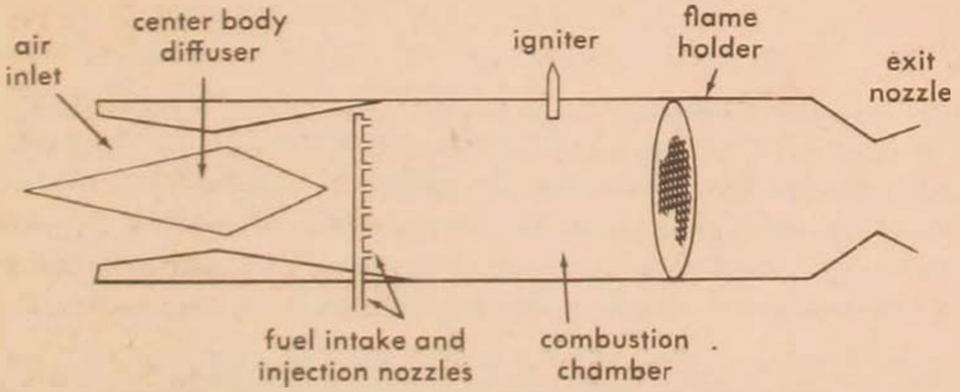
Simpler yet in principle is the rocket engine. Fuel and the oxidizer, which furnishes oxygen for combustion of the fuel, are contained directly in the combustion chamber, if solid propellant is used. Liquid propellants are pumped into the combustion chamber from fuel tanks. The operation of the rocket engine is therefore independent of the atmosphere.



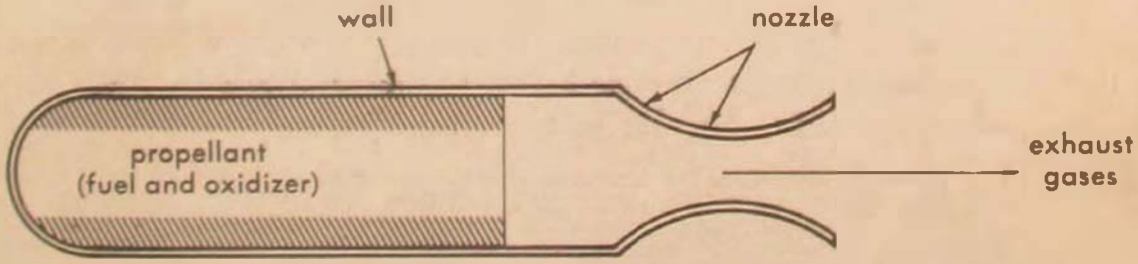
Schematic diagram of a conventional turbojet engine.



Nuclear-powered turboprop engine with radiator heat transfer from external reactor by circulation of a coolant, such as liquid metal.



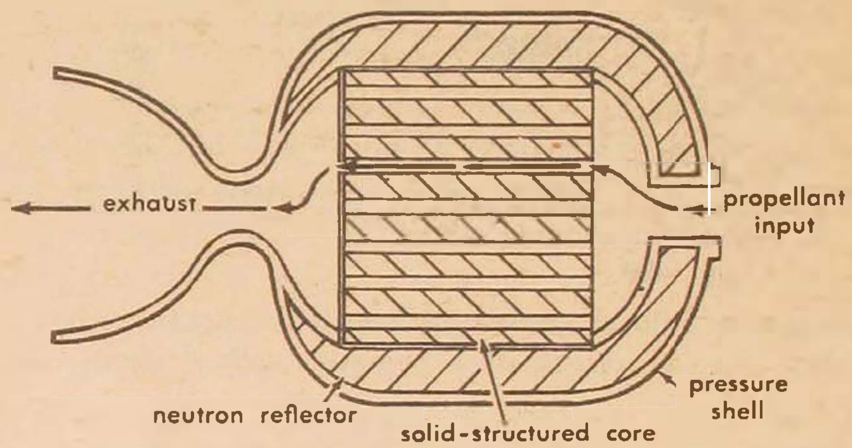
Ramjet engine, high supersonic combustion type.



Solid-propellant rocket engine.

to operating aircrews and ground-support people. Further it produces a severely limiting environment to the effective functioning of highly sensitive airborne equipment. While we cannot yet build a flyable nuclear propulsion system that will carry enough radiation shielding to solve completely all of the above problems, we think it is presently possible to build a subsonic nuclear aircraft that can contain safe shielding for the operating aircrew throughout a flight of limited duration.*

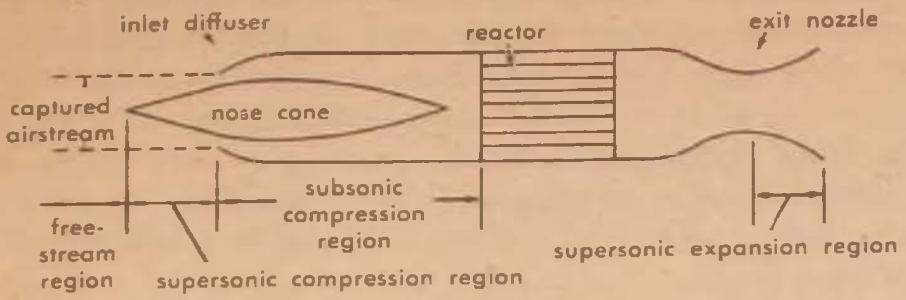
One solution to the radiation problem would be the successful controlled use of thermonuclear energy, obtained from the fusion rather than the fission process. This process would give even more energy at less cost than the fission process now used and would produce less radiation. But in spite of vigorous research being pursued by several groups, the goal of controlled nuclear fusion has not yet been attained even in the laboratory.



Nuclear rocket engine. Schematic diagram of the solid-fuel heat-exchanger propulsion reactor. Propellant is pumped through a number of parallel channels in the reactor core and removes heat generated in the nuclear fuel plates. It then expands through a convergent-divergent nozzle to exert thrust by virtue of its momentum. Not shown here are the control rods, methods of support, methods of cooling the pressure shell, or the nozzle—all of which are essential to an actual propulsion reactor.

Nuclear energy can also be used for rocket or ramjet propulsion of missiles. At the request of the Air Force, the AEC has sponsored research into the first of these possibilities, in a project known as Rover, and into the second in the Pluto project. Missiles powered by nuclear ramjet would have long flight duration and would be controllable in flight. They would be a valuable addition to our ballistic missile force.

*[Nuclear propulsion of aerospace vehicles is extensively discussed in a special issue of *Air University Quarterly Review* (XI, 3 and 4, Fall-Winter 1959) on "Air Force Nuclear Propulsion." This issue is reprinted as *Nuclear Flight: The United States Air Force Programs for Atomic Jets, Missiles, and Rockets*, edited by Lt. Colonel Kenneth F. Gantz, New York: Duell, Sloan and Pearce, 1960, 207 pp.]



Simplified schematic of a nuclear ramjet engine, open-cycle type in which the inlet air is passed directly through a nuclear reactor.

recoverable boosters for missions in space

As we consider the Air Force propulsion needs in connection with vehicles that pass through the atmosphere into space, we find that one of the most expensive items is the booster vehicle, which at present is nonrecoverable. One way of reducing booster costs is to use higher-energy fuels. The relatively low specific impulse of present rocket propellants (RP-1 and lox) means that we pay around $600,000 to place a thousand pounds in a 300-mile orbit, or about $600 per pound. As shown in the accompanying table, higher-energy propellant combinations, such as hydrogen and fluorine or hydrogen and oxygen, could boost much greater weights into orbit and cut the cost per pound by 90 per cent or more. A nuclear rocket using hydrogen as a working gas could cut costs still further, to about $37 per payload pound.

A similar reduction in cost can be achieved through the use of recoverable boosters, for the major portion of booster expense is wrapped up in hardware and research and development costs. If a booster can be recovered and re-used for thirty flights, the cost per pound of payload in orbit can be reduced from about $600 to about $35.

Economics of Nonrecoverable Booster

pellant	Specific impulse (sec)	Total propellant cost	Propellant cost per lb	Hardware cost	Payload in orbit (lb)	Hardware cost per lb of payload in orbit	Propellant cost per lb of payload in orbit	Total cost per lb of payload in orbit
— 1 + O_2	250	$10,500	$.06	$600,000	1,000	$600.00	$10.50	$611.00
+ F_2	375	650,000	4.28	990,000	23,300	42.50	27.80	70.00
+ O_2	365	38,400	.25	990,000	22,000	45.00	1.75	47.00
(nuclear)	850	95,000*	1.00	2,500,000*	70,000	35.60	1.50	37.00

eactor cost is factored in with hardware costs.

At present we are studying both simple recoverable rocket booster systems and more complex air-breathing recoverable boosters in the form of a launching platform or even airplane that can take off and land horizontally. There are several advantages in using launching airplanes. By using the oxygen of the atmosphere in the boost and landing phases, airplanes eliminate the need for carrying large amounts of oxidizers—a saving in both weight and expense. They can use existing runway facilities, eliminating the need for complex launching sites. And finally, they can be flown to a landing with a minimum possibility of damage.

The recoverable boosters now under study are powered primarily by hybrid ramjets that can accelerate to speeds of mach 12 or higher. They would carry landing-phase engines, probably lightweight turbojets capable of speeds up to mach 4. The propulsion systems projected for these boosters represent a significant improvement in specific impulse over present rocket boosters. We estimate that they will be able to accelerate from zero speed to mach 3 using only 10 to 25 per cent of the total fuel available, as compared with present rocket vehicles that may use 47 per cent of their propellant to reach the same speed. The new launch systems, like our present systems, would use conventional hydrocarbons.

The recoverable booster, chemically powered for the next few years and possibly nuclear-powered in the more distant future, will represent a real step towards economy in aerospace propulsion. There is also another benefit: the development of recoverable boosters means an even greater emphasis on booster reliability. This is of utmost importance as we move toward putting a man into space in the NASA Project Mercury and the Air Force Dyna-Soar program.

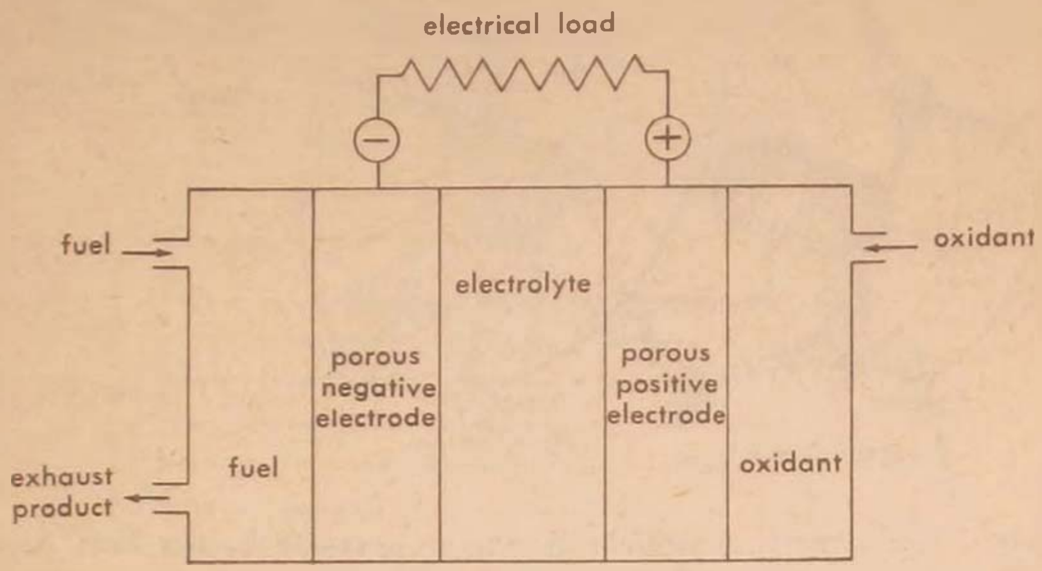
power for satellites

We encounter a somewhat specialized propulsion problem when we turn to the propulsion and auxiliary power requirements of satellites. There is a very real distinction between propulsion systems and auxiliary power systems, of course, although there is a definite relationship in their development, particularly in connection with our propulsion needs in the future.

If large orbital changes over short periods of time are not demanded, then the incremental propulsion needs of satellites in orbit are small relative to the initial booster requirements. Such propulsion systems, however, must meet three stringent requirements: they must be extremely efficient, for weight is at a premium; they must be reliable beyond anything yet produced; and they must be capable of supplying power, possibly intermittently, over a long period of time. These requirements are equally applicable to auxiliary power systems for satellites.

One of our primary goals is the development of new lightweight power systems that can operate in space and not be dependent on continuously operating propulsion systems. Our emphasis is not on the refinement of existing aeronautical systems but on the independent production of power and on the transmission of that power.

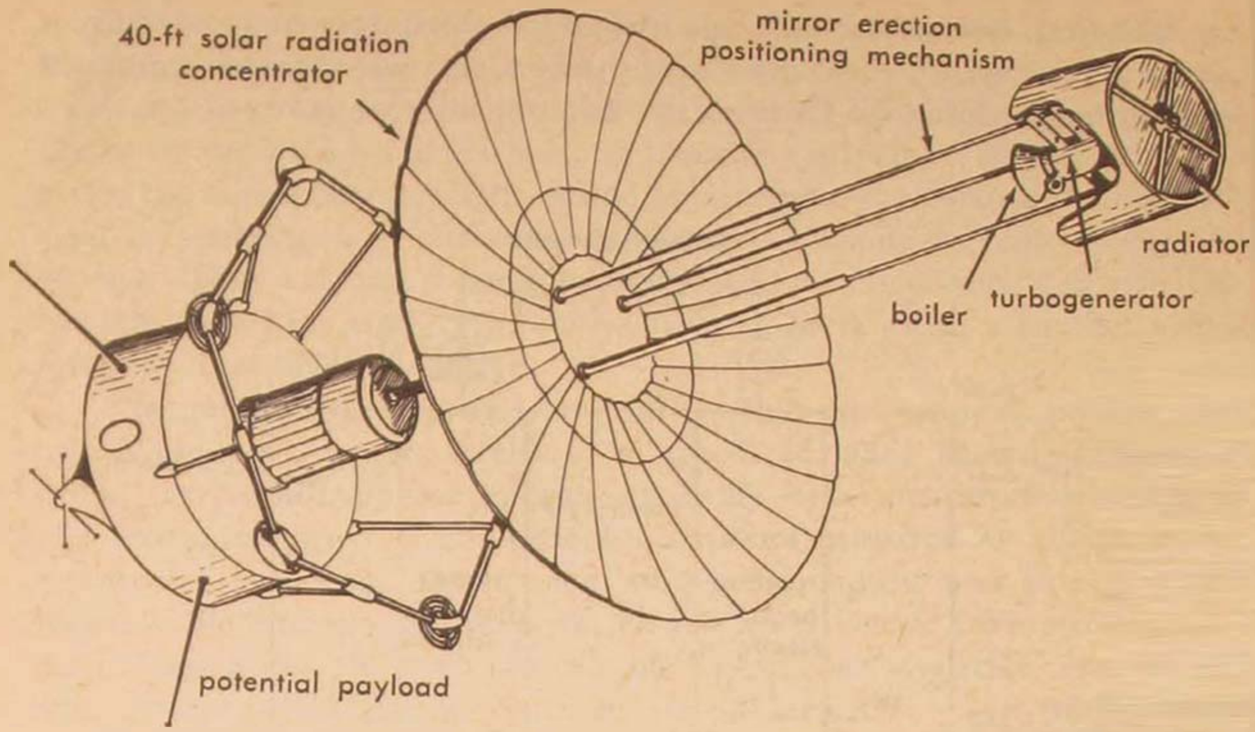
Chemical systems are still best for short-term power requirements of two or three days, in some cases up to two weeks, and there are prospects for even longer duration. Theoretically fuel cells—devices that convert chemical energy directly into electrical energy—can prove to be the lightest and most efficient of all chemical systems, for a wide range of output and duration.



Fuel cell. A device fed by gases or other chemical fuels that converts chemical energy directly into electricity through the process of electrolysis. Most of the fuel cells presently under development follow the hydrogen-oxygen cycle. Fuel and oxidizer are introduced at the electrodes and combine chemically with the aid of a catalyst, generating an electric current in the external circuit and forming exhaust products such as water for the hydrogen-oxygen case. Fuel and oxidizer are supplied continuously to meet the external electrical load placed upon the cell.

Most space systems require power for durations achievable only through the use of solar or nuclear-reactor sources. In such systems—at least for the next few years—power below 500–1000 watts will be produced by static conversion. As it is now visualized, higher power will be produced by the dynamic systems—i.e., systems utilizing moving masses, such as turbines, in the conversion process.

Solar dynamic systems seem to have a weight advantage over all other long-duration systems in the range from about 0.5–1.0 kilowatts to about 25 kilowatts. The lower end of this range will move upward in three to five years if we make anticipated improvements in the conversion efficiencies of static devices. The range from 0.5 to 25 kw is important because it encompasses most of the anticipated nonpropulsive power requirements of long-duration satellites of the next decade. But we need to know more about component design and performance factors. Applied research is needed on

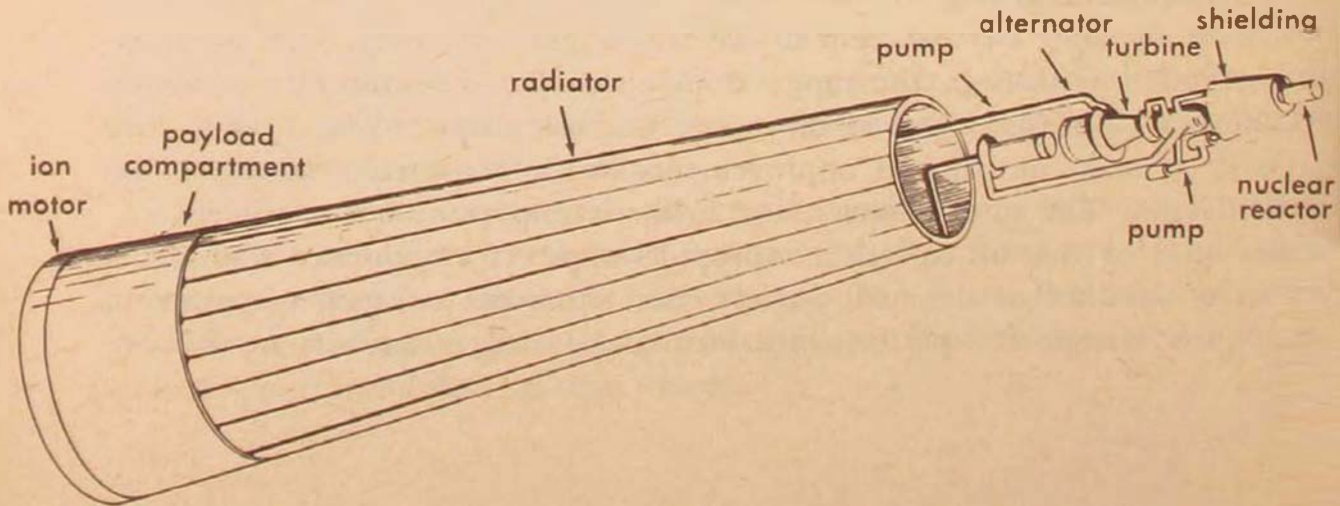


Solar dynamic heat engine. A mechanical engine operated by sun heat. Solar radiation is concentrated by a reflector into a boiler, where it is tranferred to a working fluid which drives a rotating turbogenerator. Diagram shows working of the Air Force 15-kilowatt solar mechanical engine now under development for power applications in space. A potential payload package is at left of the mirror.

collectors, boilers, and other zerogravity heat exchangers, radiators, higher-efficiency turbines, generators, thermal energy storage, voltage and speed controls, and orientation. Even so, we can begin now to make use of partially developed hardware.

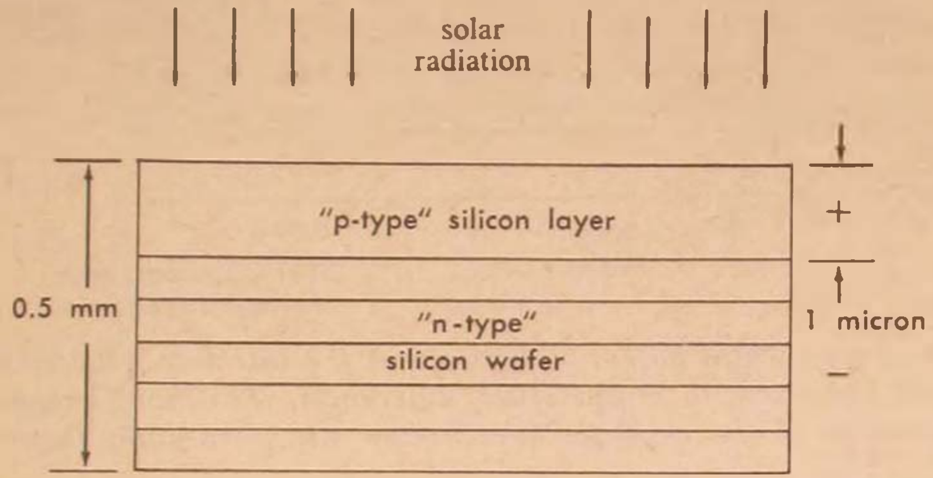
Future power requirements above 100 kw can now best be met by nuclear-reactor turboelectric systems. Sizes of most interest in the immediate future

Nuclear dynamic heat engine. Heat from a nuclear reactor is transferred to a suitable working fluid to drive a rotating turbine coupled to an electric generator or alternator. Exhaust working fluid is recycled through a radiator (condenser). Diagram shows the working scheme of the Air Force nuclear-reactor power-conversion system now under development. It is designed to produce 300 to 1000 kilowatts of electrical power for spacecraft, as for use in energizing ion-drive propulsion.



range from 30 to 300 kw. Studies and development of high-voltage electrical generating equipment are needed, particularly of electrostatic generator concepts and designs.

Currently achievable conversion efficiencies of 10 per cent and estimated system weights of 10 watts per pound make practicable now—although at high cost—the use of photovoltaic systems with up to about 500 watts of power output. But we need to improve cell conversion efficiency and to reduce system cost and cell weight. For the low power ranges, photovoltaic systems are preferred over all other long-duration solar energy conversion systems, at least until either thermoelectric or thermionic conversion efficiencies become competitive.

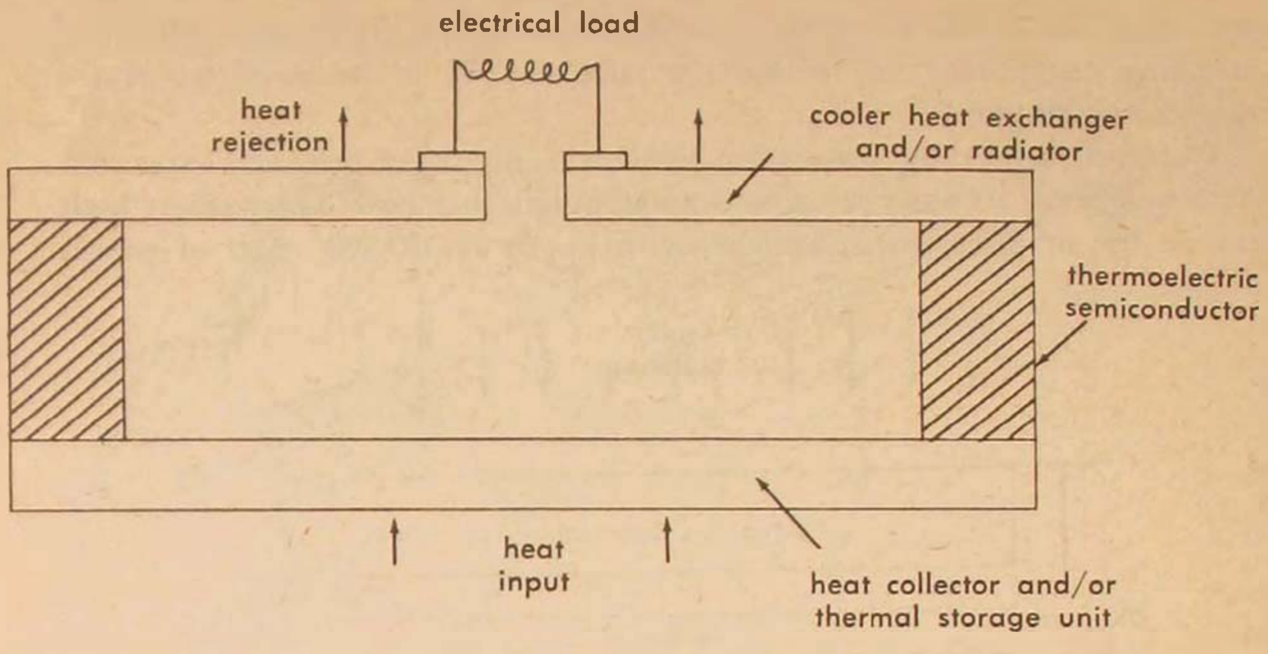


Photovoltaic converter. The photovoltaic converter, or solar cell, absorbs solar radiation and converts it directly into electricity through bombardment of a semiconductor material, such as silicon, by solar photons. A continuous shift of electrons is caused within the cell and through the electrical load. This electron flow is made possible by an N-type silicon wafer which has an excess electron, the result of doping it with material having five electrons in its valence orbit, and a P-type silicon layer which lacks an electron, the result of diffusing it with a material having three electrons. The N-type wafer is usually made up of "stacked" layers, each of which is sensitive to a different wave length, in order to intercept the maximum amount of light and attain maximum conversion efficiency.

Thermoelectric systems are attractive from the standpoint of simplicity in low-power applications, but their ultimate utility depends upon obtaining higher conversion efficiencies at the elevated temperatures at which space power equipment must operate. Thermionic systems promise potentially high conversion efficiencies of above 25 per cent, with either a solar or nuclear energy source. We can justify development of the system if we can achieve 10.8 per cent efficiency with close-spaced diodes.

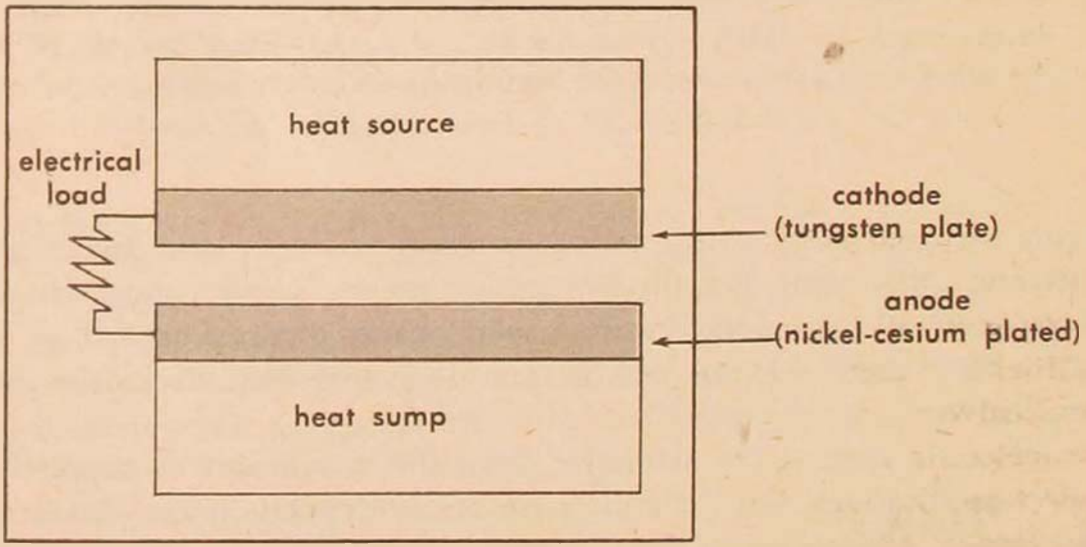
propulsion for space vehicles

Much of our present work in development of auxiliary power systems



Thermocouple. An electrical potential develops at the interface between dissimilar metals that are subjected to temperature differences. This long-known thermoelectric phenomenon is the basis for present-day instrumentation thermocouples.

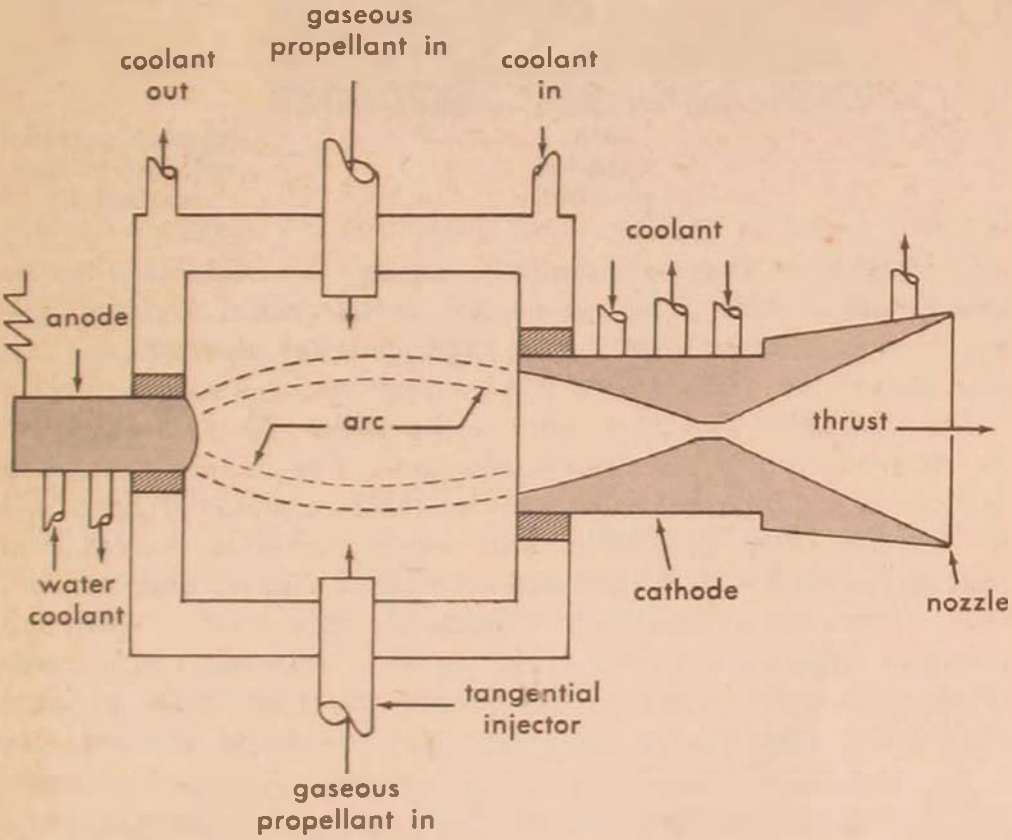
Thermionic converter. Application of heat, as from a nuclear reactor or solar radiation, to a specially coated cathode causes electrons to escape to the cold anode by virtue of their kinetic and potential energy. Useful work is done by the flow of the electrons through an external resistance load back to the cathode.



for satellites is in laying the foundation for propulsion systems that can be used in future space vehicles. We may still be able to make some use of chemical propulsion, although it does present formidable staging requirements. But the requirements for the utmost in efficiency, durability, and reliability all suggest that we look elsewhere for power and propulsion sources.

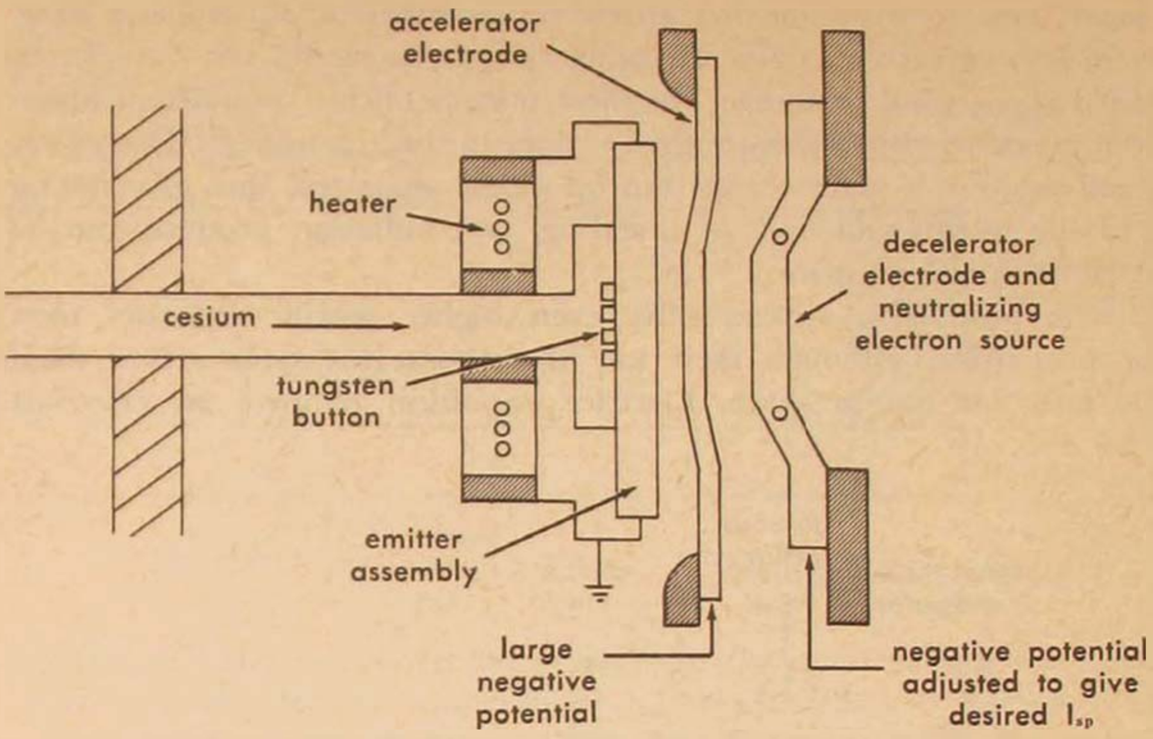
In space we will no longer have some of the problems that face us in atmospheric flight. We will not need large amounts of thrust, as we will no longer have to overcome the effects of gravity and atmospheric drag. Our vehicles can take a variety of configurations, as we do not have to be concerned about wind resistance. For these reasons nuclear propulsion promises even greater benefits in space than it does in the atmosphere. The power plant and cabin of a space vehicle can be widely separated, thus eliminating much of the weight and bulk of shielding, and radiation products can be dissipated harmlessly in space.

Electric propulsion systems offer even higher specific impulses than nuclear propulsion, although their low thrust-to-weight ratio makes them suitable only for use in space. Electric propulsion requires an electrical power source, a supply of propellant, and an engine in which the electrical power is used to add energy to the propellant so as to produce a high-velocity exhaust jet. Three general types of electric propulsion engine are now in research and development. They are the thermal arc jet, the ion engine, and the magnetohydrodynamic (MHD) plasma engine.



Thermal arc jet. Thermal energy, added to the propellant fluid in an electric arc, is converted to directed kinetic energy in the nozzle, thereby producing thrust.

In the thermal arc jet, the propellant is heated by an electric arc, which produces higher temperatures than can be produced by chemical combustion. It can use hydrogen alone as the propellant, thereby achieving the least possible molecular weight in the exhaust jet. The higher temperature and

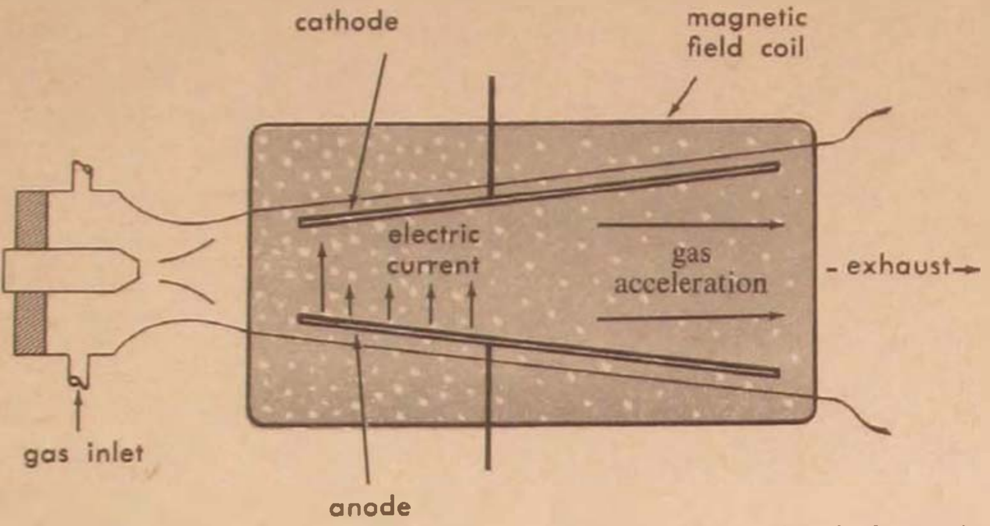


Contact ion engine. Cesium vapor is ionized by passing it through porous tungsten which is heated to about 1100°F by the heater. An electrode, designated accelerator electrode, which is at about 10,000 volts negative with respect to the tungsten, extracts positive cesium ions, leaving the electrons of the originally neutral cesium propellant at the tungsten. The ions form a jet which flows through holes in the accelerator electrode and a decelerator electrode. The cesium ions, if accelerated by the potential of the accelerator electrode alone, would achieve a higher velocity than can be used effectively and would consume excessive power. Power in the jet is proportional to mass rate of flow in the jet and the square of the jet velocity. Therefore a decelerator electrode, at a lesser negative voltage than the accelerator electrode, provides the voltage difference with respect to the tungsten emitter in order to reduce the jet velocity of the beam of ions to an effective velocity level. Electrons to neutralize the ion beam are fed from the emitter through an electrical power source (not shown) to the decelerator electrode, from which they are injected into the beam, so as to neutralize the beam. Thrust is produced as the reaction to the forces which accelerated the cesium propellant and changed its momentum. The thrust is proportional to the product of the mass rate of flow of the propellant and the velocity of the ion beam. Specific impulse (I_{sp}), an index of performance commonly used in rocket technology, is the ratio of the thrust to the mass rate of flow and is proportional to jet velocity.

lower molecular weight account for the higher specific impulses than can be achieved with chemical rocket engines. The expected specific impulse for thermal arc jets is in the range of 1000 to 1500 seconds.

In the ion engine the propellant is ionized. A jet of positive ions is extracted from the ionized propellant and is accelerated by an electrostatic field. The positive ions are then neutralized by adding electrons to the jet. Specific impulse of the order of 5000 to 10,000 seconds appears to be the useful performance range of ion engines.

In the magnetohydrodynamic plasma engine the propellant is heated to a sufficient temperature to cause it to ionize and become an electric conductor. An electric current is then caused to flow in the plasma, and a magnetic field is used to drive the current-carrying plasma by use of the same phenomenon which causes the field of an electric motor to drive the conductors on the rotor of the motor. Specific impulse in the range of 2000 to 5000 seconds is particularly of interest in propulsion research.



Magnetohydrodynamic plasma rocket. Gas entering the device is heated sufficiently to produce ionization, making the gas an electrical conductor. Electric current flows into the gas while simultaneously a magnetic field is applied. The interaction of the current and magnetic field accelerates the gas to provide thrust.

The entire range of specific impulse is of interest—from that achievable using the arc jet through the intermediate range of the MHD plasma engine to the higher values achievable using the ion engine. The optimum range will depend on the mission. Assuming that the power available is fixed, time required for a mission and payload tend to increase with increased specific impulse. Assuming the time available for a mission is fixed, the power required and hence the weight of the electrical power source tend to increase with increased specific impulse. The very great effect of the weight of the electric power source on choice and utility of electric propulsion systems provides incentive for research on electric power sources from about 300 kw to several megawatts.

Completely unforeseen propulsion systems may lie ahead. In fact a number have been proposed that I have not mentioned. At this stage all we can do is to work on the most promising. We do not know enough yet to discount completely any reasonable proposal, although we may be unable to do any work on it ourselves.

THE propulsion picture is summarized in the accompanying table. As we have seen, some propulsion systems are suitable for use only in the atmosphere, some in both the atmosphere and space, and some in space alone.

Future Propulsion Systems

Name	Area of use	Estimated range of specific impulse (seconds)	Advantages	Disadvantages
Air-breathing engines:				
Turboprop, turbojet, turbofan*	Atmosphere		Self-accelerating; suited for lower speeds.	High fuel consumption; probably limited to about mach 3.5.
Ramjet*	Atmosphere	1500–6000	Oxidizer obtained from atmosphere; low temperatures; low pressures.	Not self-accelerating.
Rockets:				
Liquid chemicals	Atmosphere/ space	250–400	Large impulse; long burning time; flexibility.	Expensive; complex.
Solid chemicals	Atmosphere/ space	175–250	Simple; high volumetric loading.	Short burning time; logistic problem in larger sizes.
Nuclear fission	Atmosphere/ space	300–1200	High impulse.	Radiation; excessive heat; expensive; very heavy engine weight.
Nuclear fusion	Atmosphere/ space	1500–3,000,000		
Arc	Space	1000–1500	Simplicity; flexibility in working fluid.	Limitations of any heat engine.
Ion	Space	5000–20,000	High efficiency at high specific impulse.	Beam neutralization necessary.
MHD plasma	Space	1500–3,000,000	Neutralization of beam not necessary.	Electrode losses.

*Long-range, extended operation depends on use of nuclear power.

Our aim in propulsion is to increase the specific impulse, consistent with other considerations. Within the atmosphere we expect to achieve increases in speed and altitude through refinements in the use of chemical fuels and particularly through use of the ramjet. We hope to increase range and endurance through the development of aircraft and missiles powered by nuclear fission. Successful development of controlled nuclear fusion would, of course, solve many of our propulsion problems, both in the atmosphere and in space.

We are aiming for economy in our space launches through development of recoverable boosters, propelled either by chemical or nuclear energy. And in space, both for immediate use as auxiliary power sources and for future use as propulsion devices, we are developing a variety of systems that we hope will give us the endurance, efficiency, and reliability we need.

As we develop new systems we recognize that propulsion is not an isolated problem. Questions of structural design are intimately involved with it. This is particularly true in the development of the nuclear-powered aircraft. Another problem is the development of materials and of hydraulic, pneumatic, and electrical systems that can withstand the high temperatures necessary in the more efficient propulsion systems. And much work needs to be done in a number of fields of physics and chemistry before we can make practical application of theoretical predictions.

These are some of the barriers to the final development of the propulsion systems we need. The real propulsion barrier, however, is not in nature but in ourselves—in our inadequate knowledge. With persistence, imagination, and hard work there is no reason why we should not break through this barrier.

Headquarters United States Air Force

The Quarterly Review Contributors

General Thomas D. White (USMA) is Chief of Staff, United States Air Force. Commissioned in the Infantry in 1920, he served with the 14th Infantry in the Canal Zone until 1924, when he entered flying training. After two years with the 99th Observation Squadron, in 1927 he began a four-year tour as a student of the Chinese language in Peking. Between 1934 and 1942 he filled attaché or air mission assignments in Russia, Italy, Greece, and Brazil. He graduated from the Air Corps Tactical School, 1938, and from the Command and General Staff School, 1939. In 1942-1944 he was ACS/O and C/S, Third Air Force. Other wartime service was in New Guinea, Borneo, and the Philippines as Deputy Commander, Thirteenth Air Force, and on Saipan and Okinawa as Commander, Seventh Air Force. After the war he commanded the Seventh Air Force in Hawaii, served as C/S, PACAC, and commanded the Fifth Air Force in Japan. During three tours in Hq USAF General White served in Intelligence, Legislation and Liaison, Plans, and Operations, and was Vice Chief of Staff for four years before becoming Chief of Staff in July 1957.

Lieutenant General Walter E. Todd (USMA) is Commander, Air University. After a year in Field Artillery he took flying training in 1931, then served with pursuit and bombardment units. In 1936 he attended the Air Corps Technical School, then for four years at the Air Corps Primary Flying School he was flight commander, instructor, and post adjutant. In 1942 he became a member of the War Department General Staff, and in 1944 went to ETO as DCS/O, Eighth Air Force. In May 1945 he was assigned to Hq AAF, and the following November was sent as U.S. Air Attaché to Russia. In 1947 he was again appointed to the WDGS as Deputy Director of Intelligence, later becoming Deputy Director of the Joint Staff, JCS. Other assignments have been as Assistant for Programing, DCS/O, Hq USAF, 1949; Commander, Western Air Defense Force, 1952; Commander, Joint WADF, 1954; Vice Commander, Fifth Air Force, 1955; Vice Commander, FEAF, 1956; and C/S, United Nations Command, from 1957 until his present assignment in August 1958.

General Curtis E. LeMay (B.C.E., Ohio State University) is Vice Chief of Staff, United States Air Force. He entered the service as a flying cadet in 1928, and after receiving his wings he served in various assignments in fighter operations before transferring to bomber aircraft. In 1937 he participated in the first mass flight of B-17's to South America, a feat repeated in 1938. In 1942 he organized and trained the 305th Bombardment Group and took it to combat in Europe. As Commanding General, 3d Bombardment Division, he led the B-17 shuttle missions from England to Germany and terminating in Africa. In 1944 he was transferred to the Pacific to command the XX Bomber Command, later becoming C/S, Strategic Air Forces, Pacific. After the war he briefly commanded AMC before becoming the first Deputy Chief of Air Staff for Research and Development. In 1947 General LeMay commanded USAFE, and he was Commander of SAC from 1948 until his present assignment in July 1957.

Lieutenant General Roscoe C. Wilson (USMA) is Deputy Chief of Staff, Development, Hq USAF. After flying training in 1929, he served with the 1st Observation Squadron, attended the Air Corps Engineering School in 1933, then served four years in the Aircraft Branch, Wright Field. He taught philosophy at USMA for three years, and in 1939 attended the Air Corps Tactical School. Again at Wright Field 1940-1942, he was Director, Design Unit, Aircraft Laboratory. Then in Washington for two years, he was AF Project Officer in support of the Manhattan Engineering Division. He served in the Pacific as C/S, 316th Bombardment Wing, 1944-1945. In Washington, 1945-1951, his assignments were in research and development, in special weapons, and in atomic energy. He was Commandant, Air War College, 1951-1954; commanded the Third Air Force in England until 1957; and was AF Member, Weapon Systems Evaluation Group, until his present assignment in 1958.

Lieutenant General Dean C. Strother (USMA) is DCS/Operations, Hq USAF. Following flying training in 1932, he served with pursuit and bombardment squadrons. From 1940 to 1942 he was with the Gulf Coast Air Corps Training Center, becoming Assistant Director of Training. In the South Pacific from 1942 to 1944, he was successively Staff Fighter Officer, U.S. Army Forces; Commander, XIII Fighter Command; and Commander, Solomon Islands Fighter Command. Ordered to Italy in February 1944, he commanded the 306th Fighter Wing and then the XV Fighter Command. He led a fighter task force to Russia to provide direct assistance for the eastern offensive. Following graduation from the National War College in 1947, he served in DCS/Personnel, Hq USAF, becoming Assistant DCS in 1950. In 1951 he assumed command of the Twelfth Air Force, Germany. He was named Deputy Commander, Air University, in 1953, Acting Commander in

1955, and Commander from 1956 until his present assignment in 1958.

Major General Hewitt T. Wheless is Director of Plans, Hq Strategic Air Command. He graduated from Gulfport Military Academy; majored in engineering at the University of Texas, 1933-1936; on completion of flying training was commissioned a 2d lieutenant in 1939. In October 1941 he went with the 19th Bombardment Group to the Philippines, Java, and Australia. Returning to the States in 1942, he served a number of assignments as staff officer in bomb units and as Commander, 7th Bombardment Group. In 1947 he became Chief, Operations Division, Hq SAC, and then Deputy Director of Operations. From 1950 to 1953 he was successively Director of Operations, Second Air Force, and 7th Air Division. From 1953 to 1957 he commanded the 306th Bombardment Wing and then the 801st Air Division. At Hq USAF he was Chief, War Plans Division, then Deputy Director for War Plans, then Director of Plans, from 1957 until his present assignment in September 1960.

Major General Stanley J. Donovan (USMA) is Deputy for Operations, Hq Tactical Air Command. After flying training in 1936, he served with the 28th Bombardment Squadron, P.I.; then with Air Corps Flying Schools, Central District; later as Commanding Officer, Primary Flying School, Carlstrom Field. After a year in Operations and Training, Air Corps Hq, in 1942 he was assigned to the VII Bomber Command, England, and four months later assumed command of the 97th Bombardment Group, North African Theater. In 1943 he was transferred to the Strategy Section, War Department General Staff, and in 1945 was named Air Attaché, Buenos Aires. He was Deputy Chief, War Plans Division, DCS/O, Hq USAF, 1948-1952; then was successively C/S, 21st Air Division; Commander, 40th Bombardment Wing; and Commander, 14th Air Division. He went to Spain in 1955 as Deputy Chief of Military Mission and Deputy Commander, Sixteenth Air Force, later as Chief of JUSMG and of MAAG.

Major General Arthur C. Agan, Jr. (B.S., University of Texas) is DCS/Plans, Hq Air Defense Command. He took flying training in 1937, returned to college and graduated in 1939, then obtained a regular commission. In 1942 he went overseas as Operations and Training Staff Officer, Hq Eighth Air Force. In 1944 he moved to the Mediterranean as Assistant Air C/S for Operations, AAFMTO, then commanded the 1st Fighter Group. After 45 combat missions he was shot down and interned as a prisoner of war. Postwar assignments have been as Chief, Personnel Services Division, Hq AAF, 1946; as Deputy for Personnel and Administration, Hq ADC, to 1949; as Commander, 4th Fighter Wing and of 33d Fighter Wing to 1951; as Commander, 32d Air Division (Defense); as Chief of Personnel and Administration, AC&SS; as student, Air War College, 1953; as Commander, 58th Fighter-Bomber Wing, in Korea, 1953; as Deputy for Operations, later C/S, CONAD Forces, Eastern CONAD Region, 1954-1957; as Commander, 26th Air Division (Defense); and as Commander, New York Air Defense Sector, 1958-59.

Lieutenant General William H. Tunner (USMA) was Commander, Military Air Transport Service, at the time of his retirement 31 May 1960. After flying training in 1929, he served with various tactical and training units until 1939, when he was assigned to the Military Personnel Division, Office of the Chief of the Air Corps. When the Air Transport Command was organized in 1942 he was named commander of the Ferrying Division. During World War II he commanded the India-China Division, ATC, with responsibility for the "Hump" airlift. In 1948 he assumed command of the Atlantic Division of the new Military Air Transport Service. Shortly afterward he was ordered to Germany to command the USAF-RAF airlift into blockaded Berlin. After a tour at Hq MATS as Deputy Commander for Operations, 1949-50, he commanded the Combat Cargo Command, FEAF, during the Korean War. He then served as Deputy Commander, AMC, until 1953, when he returned to Germany as Commander in Chief, USAFE. At Hq USAF General Tunner was DCS/Operations from 1957 until his final assignment in 1958 as Commander, MATS.

Brigadier General Thomas R. Ford (A.B., Michigan State College) is DCS/O, Hq Ninth Air Force, Shaw AFB, S.C. After flying training in 1939, he first served with bombardment squadrons in Panama, the Dutch West Indies, and the Caribbean area. In 1943 he joined the 416th Bombardment Group for duty in the European Theater, later commanding the 409th Bombardment Group in combat. Postwar assignments have been as Commander, Lake Charles AFB; as Director of Training and Operations, Hq Ninth Air Force; with the Air Force mission in Turkey, 1947; as student, Armed Forces Staff College, 1951; as Chief, Tactical Air Branch, Operational Plans Division, DCS/O, Hq USAF, to 1954; as Commander, 461st Bombardment Wing, to 1958; as Commander, 837th Air Division, until his present assignment.

Major General John K. Hester (B.S., University of Illinois) is Deputy Director of Operations, DCS/O, Hq USAF. After flying training in 1939 he served with fighter units. In the CBI Theater, 1943-1945, he flew 50 combat missions with the Air Force Provisional Training Command, with the Fourteenth Air Force, and with the 68th Composite Wing. Assigned to Hq AAF in 1945, he served in Personnel Planning Division; as Assistant Executive, Office of the Assistant Secretary of War for Air; and as Military Aide to the Secretary of the Air Force. He graduated from the Air War College in 1949. Other assignments have been as Executive, Plans and Operations Division, Armed Forces Special Weapons Project; Deputy Commander, 22d Bombardment Wing; Commander, 22d Air Base Group; Deputy Commander, 43d Bombardment Wing; Commander, 303d Bombardment Wing; Director of Operations, Fifteenth Air Force; and as Commander, 806th Air Division. He was C/S, Second Air Force, from 1957 until his present assignment.

Colonel Campbell Palfrey, Jr. (USMA) is Chief, Force Plans Branch, Directorate of Plans, Hq Strategic Air Command. He completed flying training in 1943 and after flying six missions over Europe in B-17's was shot down over Saarbrucken in February 1944, remaining a prisoner of war until April 1945. Postwar assignments have been as instructor, USMA, 1947-1951; as Chief, Legal Section, Secretary of the Air Force Personnel Council, 1952-1956; as Deputy Commander, Dyess AFB, 1957; as Commander, 490th Bombardment Squadron, 1958; as Deputy Commander for Operations, 341st Bombardment Wing, 1959; as Commander, SAC Task Force, Eielson AFB, Alaska, until his present assignment in August 1959.

Colonel James W. Bothwell (B.S., Cathedral College, Pa.) is Director of Plans and Development, DCS/Plans, Hq Air Defense Command. He entered the service in 1941 and during the war and after served in overseas assignments in the Pacific with the 414th Fighter Group, Iwo Jima; Hq FEAF; and the 18th Fighter Group, Clark AFB, P.I. Other assignments have been as Director of Operations, 33d Fighter-Interceptor Wing, Otis AFB; and from 1951 to 1955 on the staff for Air Defense Plans, Western Hemisphere Branch, Directorate of Plans, Hq USAF. He was Chief, Air Defense Branch, DCS/Plans, Hq USAFE, prior to assuming his present position in 1958.

Brigadier General Noel F. Parrish (B.A., Rice Institute) is Assistant for Coordination, DCS/Plans and Programs, Hq USAF. Appointed a flying cadet after a year as a private in the Army, he was commissioned in 1932. Early assignments were with attack and transport squadrons and as a student, Air Corps Technical School. From 1938 to 1946 he served in the Air Training Command as flying instructor and supervisor; Assistant Director of Training, Eastern Flying Training Command; and Director of Training, later Commander, Tuskegee Army Flying School. After graduation from the Air Command and Staff School, 1947, and the Air War College, 1948, he was assigned to Hq USAF as Deputy Secretary of the Air Staff, later as Special Assistant to the Vice Chief of Staff. In 1954 he was made Air Deputy, NATO Defense College, France, and in 1956 became Deputy Director, Military Assistance Division, U.S. European Command.

Lieutenant Colonel Donald F. Martin is assigned to the Office of the Assistant for Coordination, DCS/Plans and Programs, Hq USAF. After flying training in 1943, he was assigned to the Eighth Air Force and flew thirty combat missions. Postwar assignments have been as a student at the Statistical School, Harvard University; in the Comptroller's Office, Hq AMC; again in England 1948-1951; in the Directorate of Flight Safety Research, Norton AFB, 1951-1954; as a student, Air Command and Staff School, 1955; and as Deputy Director of Operations, 38th Air Division, Strategic Air Command.

General Samuel E. Anderson (USMA) is Commander, Air Force Logistics Command. After graduation from flying school in 1929, he served at Mitchel and Chanute Fields before returning to Kelly Field in 1934 as a flying instructor. From 1939 to 1941 he served in Hawaii and at Langley Field, then was assigned to the Office of Assistant Chief of Air Staff in Washington. In June 1943 he became Commander, IX Bomber Command, in England. In 1945 he was named C/S, Continental Air Force, and in 1950 was transferred to the Office of the Secretary of the Air Force. In 1950 he assumed command of the Eighth Air Force, and in June 1953 moved to command of the Fifth Air Force in Korea. In 1954 he became Director, Weapons Systems Evaluation Group, DOD. General Anderson commanded ARDC from 1957 until he assumed his present command in March 1959.

Major General Augustus M. Minton (B.S., University of Illinois; M.S., Harvard University) is Director of Civil Engineering, Hq USAF. He was commissioned in the Corps of Engineers Reserve in 1933, was on active duty 1935-1939, and has continuous service in the Air Force since 1941. During World War II he served in the Air Training Command and as DC/S, Twentieth Air Force, Guam. Subsequent assignments have been with the Air Materiel Command, Alaska; as Comptroller, Alaskan Air Command, 1949-1951; as C/S, ATC, 1951-1954; as Deputy Commander, 3345th Technical Training Wing, 1955; and as Commander, Chanute AFB, from 1955 until his present assignment in 1957.

Lieutenant General James E. Briggs (USMA) is Commander, Air Training Command. After flying training in 1930, he served with pursuit squadrons, attended the Air Corps Technical School, and in 1940 joined the mathematics faculty, USMA. In 1942 he became Operations Officer, VIII Fighter Command; in 1943 Air Officer, European Section, War Department General Staff; in March 1945 Deputy Commander, North Atlantic Division, Air Transport Command; in December 1945 ACS/Plans, Hq ATC. From 1947 to 1949 he was successively C/S, Fifteenth Air Force; Commander, 92d, 98th, 306th, and 307th Bombardment Wings. During the Korean War he was Deputy Commander, then Commander, FEAF Bomber Command, until June 1951. Later assignments have been as Deputy Commander, Fifteenth Air Force; Assistant DCS/Development, Hq USAF; and Assistant DCS/Operations and project officer in Hq USAF for the Dew Line and for the USAF base project in Spain. General Briggs was Superintendent, U.S. Air Force Academy, from 1956 until his present assignment in August 1959.

Major General Kenneth P. Bergquist (USMA) is Commander, Electronic Systems Division, Air Force Systems Command. After flying training in 1936, he served first with the 37th Attack Squadron, next with the 8th Pursuit Group. He was with fighter units in Hawaii and New Caledonia, 1939-1942; attended the Air Defense and Fighter Command Schools; then at Air Force Hq was Chief, Allocations Branch, later Executive Officer to

ACAS/O. Again assigned to the Pacific in 1944, he served as DCS/O, later DCS/Adm, 73d Bombardment Wing, Saipan, and as Operations Officer, VII Fighter Command, Iwo Jima. Postwar assignments have been as Deputy to ACS/O, Hq USAF, 1945; as Air Attaché, Greece, 1947; as student, National War College, 1949; as Director of Plans and Requirements, Hq ConAC, 1950; as Director of Plans and Requirements, later Deputy for Operations, Hq ADC, 1951; and as Director of Operations, later Assistant DCS/O, Hq USAF, from 1955 until his present assignment in 1958.

Major General Bruce K. Holloway (USMA) is Director of Operational Requirements, DCS/O, Hq USAF. Receiving his wings in 1938, he served with pursuit units in Hawaii; as a transport pilot, Duncan Field; with the Field Services Division, Wright Field; and as a postgraduate student in aeronautical engineering, California Institute of Technology. In 1942 he was assigned to the American Volunteer Group in China; flew combat missions as "observer" until that group became the Army Air Corps' 23d Fighter Group; then was its Operations Officer. In 1943 he commanded the 23d Pursuit Group. In 1944 he went to the Pentagon in the Operations Branch. Subsequently he was a student, Air Command and Staff School; Director of Plans, Hq ConAC and ADC, 1947; student, National War College; Assistant Deputy Director, R&D, Hq USAF, 1951; Deputy Director of Requirements, 1953; and Deputy Commander, Ninth Air Force, and then Twelfth Air Force, from 1955 until his present assignment.

Major General Robert J. Friedman (B.A.E., Alabama Polytechnic Institute) is Director of the Budget, Hq USAF. Commissioned in the Field Artillery Reserve in 1935, he was on active duty for three years. Just before World War II he re-entered the service and for four years was Special Projects Officer, Hq Air Service Command. In 1945 he served in Europe as Air Inspector and Deputy for Materiel and Maintenance, 95th Bombardment Group, later as DCS/M, 3d Air Division. Subsequent assignments have been as Assistant Chief, Aircraft Maintenance Division, Wright-Patterson AFB; at Hq USAF, 1946-1950, in DCS/Materiel and DCS/Operations; as Plans Officer, later Assistant for Programing, Hq FEAF, 1950-1952; as student, Air War College, 1953; as DCS/Comptroller, Hq ADC, until 1956, when he returned to Hq USAF on the Comptroller's staff.

Lieutenant General Bernard A. Schriever (B.S., Texas A&M; M.S., Stanford University) is Commander, Air Force Systems Command. After flying training in 1933, he served as a bomber pilot before reverting to inactive reserve status in 1937 to fly for Northwest Airlines. Re-entering the service as a regular 2d lieutenant in 1938, he served a year with the 7th Bombardment Group, then was assigned as test pilot at Wright Field. There he attended the Air Corps Engineering School in 1941, then took advanced aeronautical engineering at Stanford. In 1942 he joined the 19th Bombardment Group, Southwest Pacific Theater. In 1944 he assumed command of the Advance Headquarters, Far East Service Command. Postwar assignments have been as Chief, Scientific Liaison Section, DCS/M, Hq USAF; as student, National War College; as Assistant for Development Planning, DCS/D, Hq USAF; as Assistant to the Commander, ARDC; and as Commander, Air Force Ballistic Missile Division, ARDC, from 1954 until his present assignment in 1959.

Major General Osmond J. Ritland is Commander, Space Systems Division, Air Force Systems Command. After attending San Diego State College for three years, he enlisted as a flying cadet and graduated in 1933. He served as a fighter pilot and "flying the Army Air Mail" before going on inactive status in 1935 to fly for United Airlines. He accepted a regular commission in 1939 and at Wright Field was an experimental test pilot for five years. Assigned to the CBI Theater in 1944, he commanded the Assam Air Depot. Returning to Wright Field in 1946, while Chief, Aircraft Laboratory, he was instrumental in development of the ejection seat. In 1950 he was assigned to the Special Weapons Command, where he organized and commanded the 4925th Test Group (Atomic). Following graduation from the Industrial College of the Armed Forces in 1954, General Ritland served for two years at Hq USAF as Special Assistant, DCS/Development. He has been with AFBMD since 1956.

Major General James Ferguson is Vice Commander, Air Force Systems Command. Following graduation from Fullerton Junior College, he enlisted in the Air Corps, a year later was appointed a flying cadet, and received his regular commission in 1938. He served in various fighter units until 1943, when he organized the 405th Fighter Group and took it to combat in Europe. Operations Officer of XIX Tactical Air Command during the planning of the Normandy invasion, he was its Director of Operations on V-E Day. His first postwar assignment was to Air University as instructor in tactical air operations. In 1947 he went with the American Mission for Aid to Turkey, later becoming its C/S. During the Korean War he became Vice Commander, Fifth Air Force. In 1952 he became Deputy Commander, Ninth Air Force, TAC. Assigned to Hq USAF, DCS/Development, in 1955, General Ferguson served as Deputy Director of Requirements, then as Director until his present assignment in July 1959.

Colonel John P. Stapp (B.A., M.A., Baylor University; Ph.D., University of Texas; M.D., University of Minnesota) is Assistant for Aerospace Medicine, Advanced Studies Group, USAF Aerospace Medical Center, Brooks AFB, Tex. He entered the Medical Corps in 1944 and completed the Medical Field Service School that year and the Flight Surgeon's Course in 1945. He has served as General Duty Medical Officer, Industrial Medical Officer, Flight Surgeon, and Research Specialist in Aviation and Space Medicine. He organized the aeromedical facility at Edwards AFB and the Aero Medical Field Laboratory at Holloman AFB. During 1946-1958 he researched the effects of mechanical force on living tissues, subjecting himself to rocket-sled deceleration and windblast experiments. He directed high-altitude balloon flights in 1957. Colonel Stapp was Chief, Aero Medical Laboratory, Wright Air Development Center, from 1958 until his present assignment in 1960.

Colonel Francis X. Kane (USMA; M.A., Ph.D., Georgetown University) is Special Assistant to the DCS/Development, Hq USAF. In World War II he served in the Pacific Theater as a fighter pilot and instructor. During the Korean War he was an operational planner in Hq USAF. Other assignments have been in joint planning and USAF war planning; as assistant in establishing the Mutual Defense Assistance Program; and as Assistant Air Attaché, American Embassy, Paris. His articles have been published in *Missiles and Rockets*, *Air Power Historian*, and *Air Force* magazine.

Brigadier General Ralph L. Wassell (B.S., Oklahoma University; M.S., Stanford University) is Director of Research and Technology, DCS/Development, Hq USAF. He enlisted as a flying cadet in 1931, after graduation served on active duty for a year, then returned to college. He re-entered the service in 1938 as Assistant Engineering Officer, Middletown Air Depot, and received his regular commission in 1939. He attended the Air Corps Engineering School in 1941. At Wright Field until 1949, he served as Chief, Operations Section, Power Plant Laboratory, and as Acting Chief of that laboratory. After graduation from the Air War College in 1950, he went to the Atomic Energy Commission as Chief, Aircraft Reactor Branch. He attended the Industrial College of the Armed Forces, 1954, then served at Wright Air Development Center, first as Chief, Nuclear Powered Bomber Office, then as Director of Nuclear Systems, Detachment 1. He was Assistant Deputy Commander, Research and Development, Hq ARDC, from 1957 until his present assignment in 1960.

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