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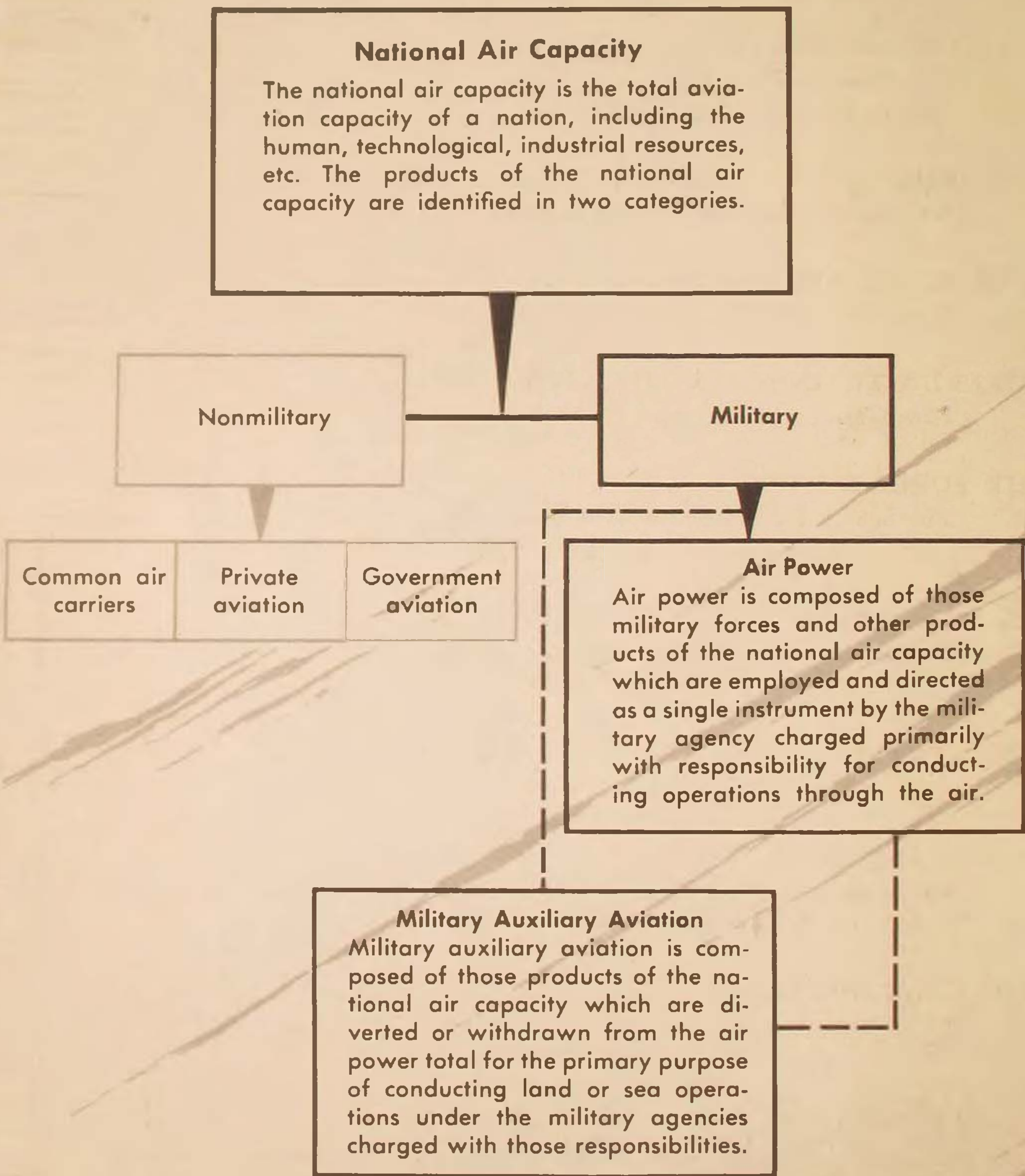



*The Composition of National Air Capacity*

# What *Is* Air Power?

Colonel Jerry D. Page, *and*
Colonel Royal H. Roussel

THE real meaning of the most vital element of national security—air power—is getting lost in a maze of diverse opinions. And if this trend continues, there is bound to be trouble ahead.

The provision of true air power and the progress of national security are inseparable. It is to be expected that much is being said about air power in many places by many different people. This focus of interest is desirable. But it is unfortunate that even now, with air power having been a part of our life for so long a time, those who speak of air power often mean different things. This condition is unfortunate because as long as air power is discussed with different meanings—as long as there is a widespread divergence of opinion as to what it is—how can we expect ever to solve the problem of providing the right kind of air power and of using it to the best advantage for national security?

It is not hard to see how a considerable amount of confusion about the meaning of air power has accumulated. In all the discussion that has been going on about it, all sorts of variables have been involved; all sorts of influences have made themselves felt. By doing a few minutes of simple research it is possible to find air power described in many different ways. In one instance an individual speaking from a position of authority will say that air power is the capacity to exploit the air as an instrument of national power. Another will say that air power is the all-inclusive military air capability. Yet another will say that air power is military aviation plus commercial aviation. And still another will say that air power consists of military aviation, plus commercial aviation, plus the capacity to design, develop, and produce the means of flight, plus the command and control ability to employ all these things effectively in pursuit of national objectives. In another case an opinion may be offered that each military service has air power—that there is such a thing as Army air power, Navy air power, and Air Force air power.

There is no need to belabor the points that air power cannot in reality mean all these different things, or that no good can possibly come from continued vagueness of this kind. One of the variations should be correct and the others wrong. Or possibly the question should be: "Do we have such a thing as a correct definition of air power?"

There are probably some who will say, "What's the difference? It's all a matter of semantics."

But saying that is not a solution. It is just a way of dodging the facts—an easy way out. Because actually there is much more than semantics or academic definition involved in the consequences that stem from the many-sided application of the term *air power.* If it is only semantics, then it follows that the disasters inherent in coming up with the wrong kind of air forces at the wrong time and in the wrong place would be nothing more serious than "a matter of semantics." The point to be made here is that those who cannot relate the meaning of the term *air power* to reality in the form of the kind of an Air Force in-being that we have are not seeing the facts clearly.

A precise definition of air power is needed. It is necessary to an accurate comparison of our capabilities with opponent capabilities. We cannot, for example, expect simply to add up airplanes, bombs, and people and get a total that is air power. This is so because air power is much more than numbers of items—especially numbers considered apart from the functions which they perform and the processes through which they are controlled and directed.

A precise definition of air power is necessary as a means of measuring accurately the air strength that our military budget money buys. To get the answer here, the dollars must be equated with the things they buy in order to counter directly the most vital threats to our security in this cold-war nuclear world. It may be well to consider again that to buy military airplanes is not necessarily to buy air power, although the latter may have been intended.

Furthermore, a precise definition of air power is necessary to consistent public understanding and support of air capabilities. The American individual deserves a clear, honest, and unchallenged explanation of what air power is, how much it costs him, and what air power is able to do to help achieve the ideals of our country.

There are many more reasons, just as practical as these, why we must have a precise definition of air power.

The purpose of this article is to offer a practical definition. By "practical definition" we mean a definition of air power which proves out on the basis of reality—of the facts that we can see all about us.

This definition begins with the fact that air power is an entity. Whatever its composition, it is something that can be employed as a *single instrument*. That is to say, all of it, or any part of it, can be directed, controlled, if need be, from a single source. We must be able to make this transition in direction and control from the part to the whole, or vice versa, with "supersonic" speed. Operations by the "committee system" or through the slow process of "mutual cooperation" cannot exploit fully the flexibility and versatility of air forces. Furthermore any employment of air power, whether on a large or small scale, is an employment as part of a global condition. Thus any segment of air power always remains a part of the total capability, and in this state it is and must always be subject to employment with the "supersonic" speed mentioned above as part of a global air force.

There are many ways of expanding the meaning of air forces as an entity in a narrative description. One way would be to recount the near-disasters that have occurred in battle when air forces were not employed as an entity. Another would be to say that the division of functions among the various military services—the Government's so-called Functions Paper—verifies the oneness of air power by the legal device of assigning the primary responsibilities for the conduct of air tasks to a single direction—the Air Force. However, it is enough to say that it is recognized that air power is an entity. Therefore it must follow that air power—in any way that it is described—always must be identifiable as an entity. If it does not stand out clearly and unmistakably as an entity, then it is incumbent upon whoever proposes such a meaning to explain satisfactorily in what respect it is that air power *is not an entity*.

The "definition" that follows is based on the premise that air power, being an entity, is indivisible.

AIR POWER is derived from the total air capacity of a nation. It is employed as an element of national policy. Nations use their air power in various ways to support their objectives and to advance them toward their goals. Air power may be employed for these purposes in either peace or war. Therefore it is a constant source of strength and influence.

The total *air capacity* of a nation—the national air capacity which produces air power—is an aggregate of the men and women, facilities and bases, aircraft and weapons, and the industrial, technical, commercial, and military resources that are needed to produce, sustain, and operate all the elements associated with flight.

It would be misleading, however, to think of national air capacity as a matter of physical resources alone. The physical resources are meaningless unless they are used properly. Proper use requires a full understanding of the relation of air capabilities to the welfare of the nation. When this understanding exists within a nation, it is manifested in public and official support of all forms of aviation. It is manifested also in evidence that the nation is able and willing to employ its air capabilities consistently in support of its policies. And it is evidenced moreover by confidence in the national air capacity as a source of strength.

The products of the national air capacity fall into nonmilitary and military categories. The distinction is based on function.

The nonmilitary portion of the national air capacity has three subcategories. The first is composed of the common air carriers—the domestic and overseas airlines of all types. A second includes aviation of all types that is used privately. A third is made up of Government aviation that is used in administrative functions and is not intended for combat operations or for the direct support of combat operations.

The nonmilitary category of a national air capacity is an important element of a nation's strength. It is one indicator of the production potential of the national air capacity. It also is evidence of a nation's determination to exert influence through the air. However, because of the variety of ownership and control of nonmilitary aviation, nations cannot ordinarily employ it in the physical sense as a single instrument. It is not administered as an entity.

The military products of the national air capacity are identified in the primary category of air power, and otherwise as military auxiliary aviation. Again, the distinction is a functional one. Aircraft of identical types may be a part of either air power or military auxiliary aviation, depending upon the purpose for which they are used and the manner in which they are controlled.

*Air power* is composed of those military forces and other products of the national air capacity which are employed and directed as a single instrument by the military agency charged primarily with the responsibility for conducting operations through the air.

*Military auxiliary aviation* is composed of those products of the national air capacity which are diverted or withdrawn from the air power total for the primary purpose of conducting land or sea operations under the military agencies charged with those responsibilities. When employed for these purposes they are auxiliary to land and sea forces.

Nations strive at all times to build their air power to such proportions quantitatively and qualitatively that it will represent dominant strength. When a nation succeeds in gaining the advantage of dominant strength through the capabilities of its air power, either in peace or in war, it holds the valuable advantage of control of the air. When a nation holds control of the air, it has the capability to exert desired degrees of influence in international affairs, or upon other specific nations. It may use this influence negatively or positively, as best suits its policies. Air power may be used as a deterrent to restrain nations with conflicting policies, or it may be used as a source of encouragement and as a rallying influence for nations with allied policies and interests. In either instance and at any time, the welfare of nations, the state of their security, and the prospects for their future well-being necessarily rest in a large measure on the state of their *air power* in relation to the *air power* of other nations.

Air power is a single instrument. It is indivisible. The inherent flexibility of air forces imparts to them the capability of operating and producing impacts on any scale from highly localized to global, from the psychological to the most violent. Air power may be employed over a wide range of conditions, from peace to unlimited war.

Air power is the most clearly discernible evidence of a nation's air capacity. It is also the most influential evidence. Having both offensive and defensive capabilities, the air power increment of a nation's air capacity is an instrument through which that nation most frequently applies directly the influence which accrues from its air capacity.

In time of hostilities air power is the one instrument which provides capabilities for employment immediately and directly against all elements of the strength of opponent nations. Conversely all elements of the strength of that nation are exposed in the same manner to the air power of its enemy nations. In time of war nations necessarily must employ their air power primarily against enemy air power in an effort to win dominance. The peacetime assessment of a nation's ability to attain a dominant position in the air in event of hostilities determines the degree of peacetime control of the air available to that nation.

Unlike air power, *military auxiliary aviation* is invariably confined in its use to support of operations which have definite land and sea boundaries. It is always subject to the limitations of the user's mission. Therefore both the application of military auxiliary aviation and the impacts created by it are always localized. In instances where the direction of certain elements of military auxiliary aviation or nonmilitary aviation pass to the control of the military agency primarily responsible for obtaining control of the air, whether in peace or war, those elements *become* parts of air power for the duration of the control and direction arrangements. Conversely if elements are withdrawn from the air power entity and passed to the control and direction of other agencies for limited application not directly contributing to the accomplishment of control of the air, they cease to be a part of a nation's air power for the duration of those arrangements.

It is not possible to make a compromise on the composition, control, or primary purpose of air power. It must be an entity, utilized primarily to gain, maintain, and exploit a dominant position in the air. It must be responsive to direction as a single instrument by the military agency of a nation which is primarily responsible for operations through space.

THE foregoing definition of air power should not be misconstrued. We hope that it will be accepted to mean exactly and only what it says. It does *not* say:

1. That all military aircraft should be owned by the Air Force.

2. That tax dollars should not be used for naval carrier aviation. (It suggests the use of appropriate aviation of all kinds, when necessary, as a part of air power.)

3. Whether or not the Army should have its own tactical aviation. (It *does* suggest that the pros and cons of this subject should be examined in the light of the principles contained in the above definition.)

*Evaluation Staff, Air War College*

## Global Aid to Air Navigation . . .

# Navarho

### *A Quarterly Review Technical Brief*

THIS fall a new air navigational aid will begin a year of intensive operational testing. Beaming its signals over a substantial portion of the Northern Hemisphere, "Navarho," as the new system is named, shows promise of becoming the long-awaited global aid to air navigation. It will mark one more large contribution of electronics to man's conquest of space.

In directing an aircraft along its course the navigator is constantly faced with three basic problems. He must know at all times the exact position of the aircraft over the earth's surface. He must be able to infer position for any given time during the flight. And he must calculate, compensating for the drift effects of wind, the precise direction to head the aircraft to reach destination.

Not long ago this was a relatively simple matter. In the days of low-flying, short-range aircraft passing over familiar territory, the pilot or navigator could keep track of his position by mere visual observation of identifying landmarks. This navigating by checkpoints is known as pilotage. But with the steady increase in aircraft range, flights over unfamiliar territory became the order of the day. As an aid to air navigation the Government and other agencies issued a series of aeronautical charts affording pertinent information to the navigator. For flights over water and areas devoid of conspicuous landmarks, celestial navigation was introduced as a further aid.

One very real limitation to navigation by pilotage, or map reading, or celestial observation is that they all depend on good enough weather for the navigator to observe the terrain below or the sky above. As the length of the flights and the speed of the aircraft increase, the need for reliable navigational assistance becomes progressively more important. It also becomes more difficult to provide. A truly versatile, flexible air force must be able to operate day and night, in all weathers. Radio ranges, beaming information to the pilot and navigator, have been and are the guiding mechanisms of airways. Radar has been highly successful in directing the descent and the landing of aircraft under extreme weather conditions. With their help aircraft, whether military or civil, have known an independence of operation never before possible.

But the degree of operational freedom afforded by these aids alone has not been adequate for an air power with global horizons. Jet aircraft fly at such high altitudes that they cannot rely on navigation by visual observation.

either by pilotage or through the use of charts. Terrestrial detail becomes too indefinite to be noted with any accuracy. The tremendous speeds of jet aircraft and their high rate of fuel consumption dictate precise and detailed flight planning from the moment of take-off, because their characteristics leave very little margin for error that would extend the duration of the flight. The navigator must necessarily have access to quick and continuous information. Celestial navigation is rather awkward and time-consuming and is therefore not adequate. Radar, networks of radio ranges, and other electronic systems inherently restricted to high-frequency emissions are limited to relatively short-range applications.

In the search for greater ranges the field of electronic navigation has been the most promising. Systems incorporating lower frequency emissions have been developed and used successfully for medium-long ranges. But global air power demands even greater coverage for far-ranging aircraft. Not only would the fewer transmitting sites of a long-range system be less complex and involve fewer variables than the networks of short-range sites, but they could provide coverage in the areas of the earth where it is impractical to locate transmitting facilities, such as arctic areas, ocean areas, and, of course, areas controlled by unfriendly nations.

The Air Force has long realized the importance of complementing her long-range aircraft with a long-range navigational system. Under the direction of the Air Research and Development Command with the actual work accomplished by the Rome Air Development Center in conjunction with the Wright Air Development Center as the supporting agency, the Air Force has developed a new electronic aid to air navigation. Named Navarho, this system affords the longest ranges for navigational aid yet attained and comes the closest to meeting the specifications of this jet age.

## *Long-Range Navigational Systems*

Probably no technical field is more confusing to the layman than the field of electronic navigation. We have heard of Loran and Shoran, and of their British counterparts Decca and Gee. We have heard of VOR/DME,

**In formulating a realistic air doctrine the air theorist must understand and effectively deal with a diversity of complex knowledges. Not the least among these is air navigation. Limitations on air navigation restrict the effectiveness and flexibility of air forces, particularly air forces that rely on fuel-devouring jets and on smaller aircrews. The global dimensions of the USAF's responsibility require a new order of mobility, versatility, and decisive action that has brought into sharper focus the demand for a complementing world-wide navigational facility. In conjunction with the Rome Air Development Center, the Editors of the *Quarterly Review* describe the latest advance in long-range air navigation. Called Navarho, this new electronic aid, now in final test, will afford aircraft a greatly broadened independence of operation. Its potentialities for guiding far-ranging aircraft make it the most promising navigational system yet developed.**

ILS, GCA, RDF, Tacan, and many more. The list is wearisome; the terminology is forbidding. And now we hear of Navarho, the latest in the field of electronic aids to air navigation. We are told that this new system affords extremely long-range applications, that from a single station it can beam reliable signals in all directions over a distance of 2000 to 2600 nautical miles. What exactly, then, is Navarho? How does it differ from the older, conventional systems now in use? Why is it regarded with such high expectation?

To give a meaningful answer to these questions and to clear some of the confusion surrounding an understanding of the fundamentals of electronic navigation, it is perhaps necessary to preface discussion of Navarho with a brief résumé of related systems. The characteristics and shortcomings of older systems may make more apparent the advantages and strategic significance of Navarho.

First of all it may be said that the many electronic systems which have been developed over the past twenty years fall into one of three general classifications: (1) radio detecting and ranging systems—such as radar; (2) differential-distance systems—such as Loran; and (3) azimuthal or directional systems—such as Navarho. Systems in all three categories are widely used for short-range purposes, but the latter two find particular application in long-range navigation. These are the aspects with which we will be concerned.

## Differential-Distance Systems

Of the long-range electronic systems probably the most familiar is Loran. It is an example of the differential-distance systems, so called because they measure the difference in distance between an airplane and two separated ground stations. Actually time difference of arrival of radio waves is measured, but this is translated to distance differences by making use of the known speed of travel of radio waves. Two ground transmitters, *A* and *B*, normally separated by several hundred miles, each emit brief pulses of radio energy at synchronized time intervals. To reach an airplane located at *X*, the signals travel along different paths. If the lengths of the two paths are different, one pulse is received later than the other. This time difference or delay is a measure of the difference in path length, or *BX* minus *AX*. Thus a 300-microsecond time delay would mean that the difference between the distance of the airplane from one of the ground stations minus the distance from the other is equal to the distance that radio waves can travel in 300 microseconds. In this case the difference in distance would be about 47 nautical miles.

Many different points may correspond to the same time or distance difference. The exact line of position depends upon the time delay and upon the location of the two transmitters, but in any case it is one of a family of hyperbolas (by the geometric definition of such curves). The line of position of no time difference—that is, of equal path length—is clearly perpendicular to and bisects a line drawn between the two ground stations.

A fix is established by observing the time delay with respect to another pair of ground stations within range and noting the intersection of the two lines of position, one line coming from each pair of stations. The two pairs of stations may have one station in common. Special charts are needed to interpret time delays into lines of position on a map. These charts have the ordinary lines of latitude and longitude, plus the hyperbolic lines corresponding to various time delays from a number of pairs of stations in the area, with allowances for the curvature of the earth and the properties of the map projection all calculated in advance.

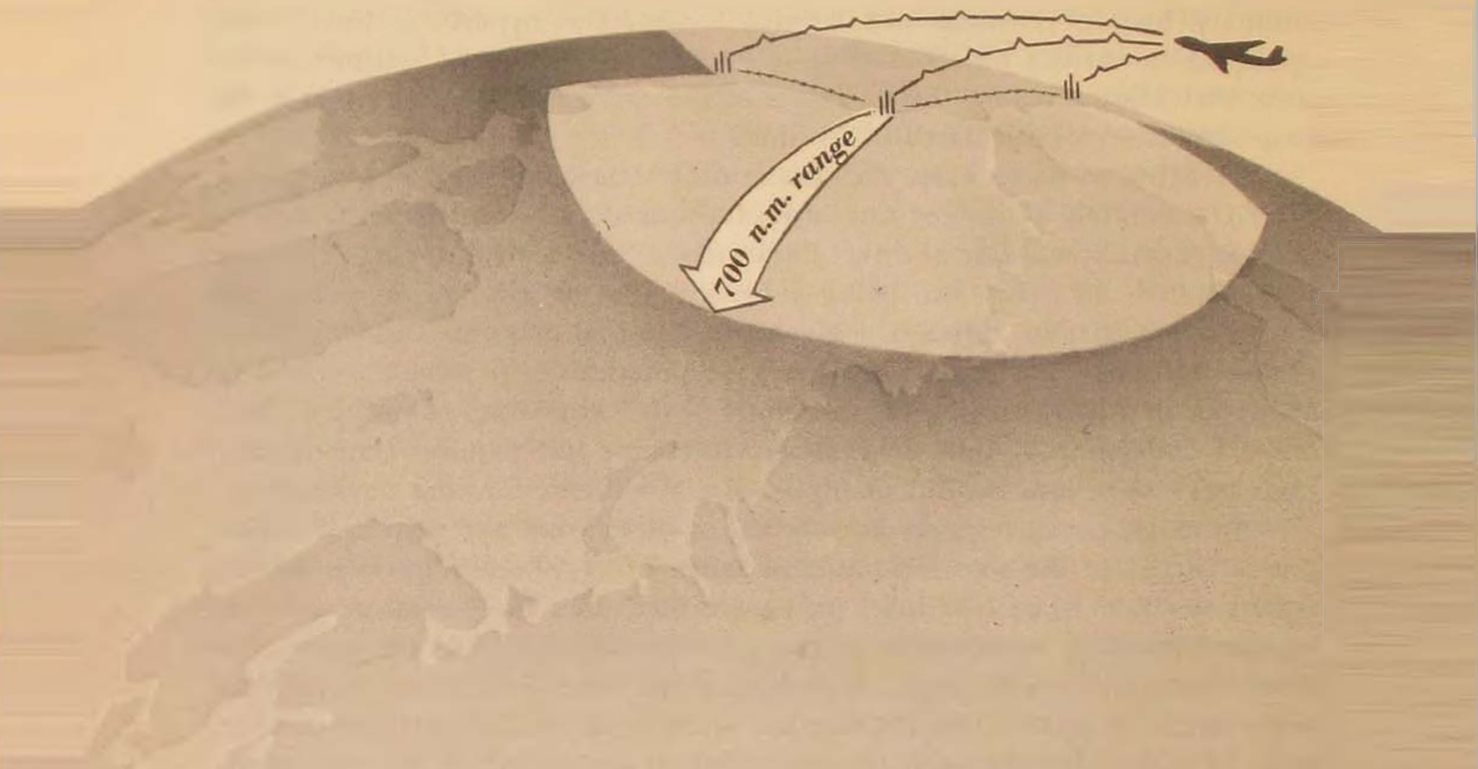
By flying so as to keep a constant time delay, the pilot can guide his aircraft accurately along any line of position as a track. But hyperbolic lines are not generally suitable as direct flight paths. The central or zero-delay line of position is an exception, being a straight line or great circle path. But for this line to pass through a given air terminal requires two additional ground stations. This may not always be practicable in remote regions or at islands in mid-ocean. In any case none of the other lines of position "lead home." Indication of time delay is not automatic but requires time-consuming observations and skillful manipulation of cathode-ray-tube devices.

Although Loran requires no rotating or directional antennas and is thus not restricted to the short operational range of very-high-frequency, line-of-sight systems, the fact that brief pulses are used does place some restrictions on the operating wavelength and bandwidth—factors that are critical in determining serviceable range. Wavelengths on which Loran usually operates allow reception up to about 700 nautical miles by day and about 1400 nautical miles by night. Unfortunately the transmissions are subject to the ionospheric disturbances that plague all relatively high-frequency radio signals. One great advantage of differential-distance over most other systems is that there is no need for a return signal from the aircraft. This increases the practical service range, since the deadening effects of radio absorption and attenuation are thereby halved. Also the system is not saturable. Any number of airplanes can use the signals simultaneously.

The two ground stations must be separated by considerable distance, up to several hundred miles, or the time differences become too small to be measured accurately. One of the stations, termed the slave station, must constantly receive signals from the other, the master station, for control purposes. The times of emission of signals from both stations must be accurately synchronized. Coverage of a given area with one family of lines of position requires two suitably related ground stations, and the aircraft must be within reception distance of both stations.

These are the essential characteristics of Loran, developed by the Radiation Laboratories at the Massachusetts Institute of Technology; of Gee, developed in Britain; and of a number of related systems—all sometimes referred to as hyperbolic systems. Despite all their drawbacks, differential-distance systems have been extensively used for medium-long ranges, especially in military applications. Their accuracy is extremely good, and reliability is also good up to a certain variable, limiting range. Whether world-wide coverage can be obtained, either by improving the dependable distance range or by finding sufficient pairs of suitable land sites, is a question that has not yet been answered.

# Loran




Sitings: 3 stations necessary for a fix

Coverage: Poor in certain directions

Range: 700 n.m. by day; 1400 by night

Accuracy: Good, but poor during twilight

Operation: Oscilloscope interpretations

Homing Paths: Hyperbolic curves

Since World War II the Loran system has been the most widely used long-range electronic aid to air navigation employed by the USAF. Its ground facilities consist of a series of transmitting stations separated from each other by two to three hundred miles. An aircraft must be within reception distance of at least three stations to obtain a fix. Pulses of radio energy are emitted at synchronized intervals from two stations operating as a pair and then from a third station paired with one of the first stations. The time difference in arrival of radio pulses is measured by oscilloscope devices in the aircraft and is translated with the aid of special charts into lines of position. These lines of position form hyperbolic curves. The fix is the point where two of the curves cross. Loran coverage is adequate in all areas except in those directions close to the extension of the line joining a pair of stations. Despite the penalty of atmospheric interference during twilight, Loran is one of the most accurate long-distance electronic aids in use.

## Azimuthal Systems

Historically, the first systems of long-range electronic navigational aids were not of the differential-distance type. It was not until World War II that Loran and the other hyperbolic systems came into use. The first systems were radial or bearing-giving devices. Directional or azimuthal systems are so called because the transmitter sends out differentiable information for each bearing of the compass. They are often described as radial, because the lines of position are straight, radial lines emanating from the transmitting site. Navarho is a system of this type, but it combines absolute-distance measurement with the azimuthal determination.

In all azimuthal systems the fundamental principle is that the transmitting antenna network has directional characteristics; that is, the radio signals transmitted in various directions from the station are different in some measurable respect. If the transmitter is at a ground station—which is the case in all long-range applications—radio lines of position are fixed, straight lines or Great Circles radiating from that point. Variations of the signal strength transmitted in different directions cannot by themselves be used immediately to indicate bearing. This is because the actual signal strength at a given point depends also on transmitted power, distance, and propagation conditions—factors that cannot be expected to remain constant. They must be made to cancel out in some manner, so that only the effect of the directional properties of the transmitting antennas on the signal remain. In fact a radiation pattern indicates only the relative strengths of signals in different directions, assuming all other factors to be constant. Fortunately these other factors are constant at a given point for short time intervals.

Therefore in these systems the transmitter always emits at least two types of signals, corresponding to two different directional patterns, so that, regardless of the actual strengths of the two signals at a given time and distance, their relation to each other is constant and depends only on the bearing of the observer. Both signals may vary for one reason or another—even the receivers may vary in sensitivity—but all of these variations affect both signals in the same proportion, provided that the two types of signals are emitted simultaneously or in very rapid alternation.

The major problem in azimuthal systems has been in securing well-defined directional effects from the transmitter without sacrificing the serviceable range. Signals of lower frequencies have the tendency to follow the curvature of the earth and hence are practical for long-range purposes. But sharp beams are not produced by such systems. The advantages of higher frequencies to obtain sharper beams are well known, but the propagation characteristics of higher frequencies forbid their use over great distances. Interest is strong in systems having about 1500 nautical miles reliable coverage, and it has recently become possible to talk of 2000 to 2600 nautical miles. This range requires low frequencies and high power. For very long distances the straight lines of position of directional transmitting systems are desirable, but no entirely adequate systems of this type have been installed. The problem of devising a system that is propagationally (frequency, bandwidth, etc.) suitable for very wide coverage and that is also omnidirectional, direct-reading, and free of troublesome ambiguities (the multiple intersection of lines of position) has been of major concern.

The first developments of azimuthal systems suffered from poor accuracy—two or three degrees of error—and afforded relatively small area coverage. While the Allies were researching differential-distance systems, the Germans concentrated on azimuthal systems and developed the Sonne system for use in World War II. This system—and our adaptation of it, Consol—was comparatively simple in operation, had good accuracy, and used receiving and transmitting equipment more conventional than that used in Loran. Its effective range approximated 800 nautical miles over land and 1000 nautical miles over water, with somewhat greater ranges possible at night. The Sonne system was highly susceptible to storm interference. It employed wide bandwidth receivers, which are very vulnerable to noise intensity, and noise always limits the maximum distance of radio reception. Furthermore the nature of its transmitting antennas prevented it from being omnidirectional. And the effect of ionospheric variations required correction charts for day and night operation.

In all purely azimuthal systems two stations are necessary to establish a fix. A bearing is taken from each station and plotted on the map, the point of intersection of the two lines of position determining the exact location of the aircraft. This necessity for a pair of stations limits the operational practicability of the systems. It is not always feasible for an aircraft to be within range of two stations, particularly in overwater flights. Navarho dispenses with this condition. A single transmitting facility provides both azimuth and direct distance information.

The azimuth or directional portion of the Navarho system—called Navaglobe—uses three antennas arranged triangularly at the station. Three is the minimum theoretical number of antennas capable of giving omnidirectional service. Each pair of antennas is excited equally and in turn, so that in effect three signals are radiated in rapid succession over and over again. The relative strength of each signal depends on the direction of the receiver in the aircraft from the antennas. Along each straight, radial line the relative strengths of the three close-intervaled signals are constant; at greater distances all three signals are weaker, but in the same ratio to each other. The receiving system measures this relation between signal strengths and translates it automatically into the setting of a pointer around a dial calibrated in degrees of azimuth or true bearing.

As with all directional transmitting systems, the indicated bearing read in the aircraft is the true bearing of the observer from the station. The line of position is that bearing laid off as a Great Circle bearing from the meridian of the ground station. On the Lambert projection, commonly used in Government air navigation maps, this is easily plotted, since on that projection Great Circles may be represented by straight lines for even moderately long distances. A similar representation may be drawn on the gnomonic projec-

# Consol


Sitings: 2 stations necessary for a fix

Coverage: Unusable in certain directions

Range: 1000 n.m. by day; 1500 by night

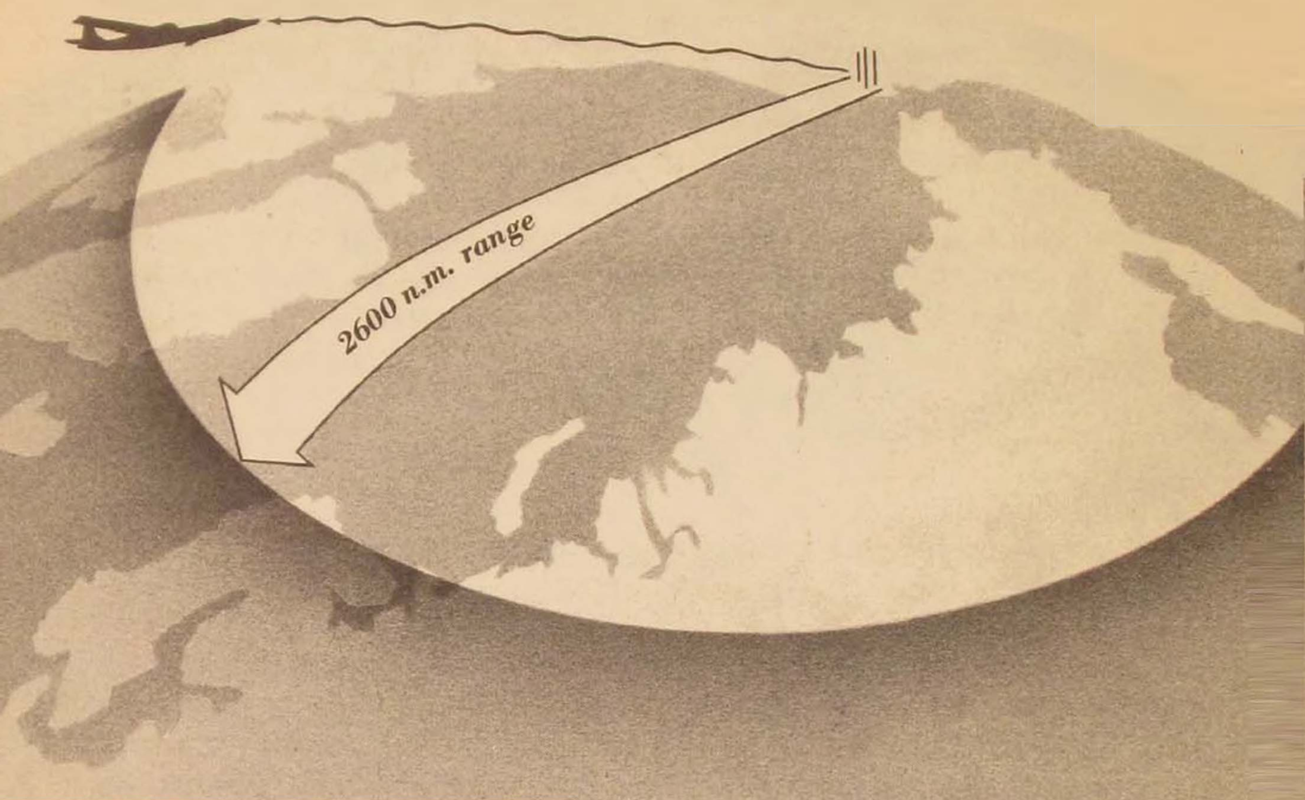
Accuracy: Subject to error during night

Operation: Aural tone interpretations

Homing Paths: Straight, radial lines


Consol is a long-range electronic aid to air navigation adapted from the Sonne system used by the Germans during World War II. An aircraft must be within reception distance of two Consol transmitting stations. An ordinary azimuthal bearing is taken from each station and the point of intersection of the two lines of position fixes the aircraft position. Consol data must be interpreted by the navigator from a series of aural tone patterns received on the standard radio equipment. During the day, under favorable conditions, Consol has an effective range of approximately 800 nautical miles over land and 1000 nautical miles over water. At night the range increases to approximately 1500 nautical miles over water. Consol is highly susceptible to storm interference. Day and night correction charts must be employed to compensate for ionospheric variations. Consol is generally quite accurate, but it is subject to error at night, and along or near the extension of the line joining the two stations it is unusable at most times.

# Navarho




Sitings: 1 station necessary for a fix

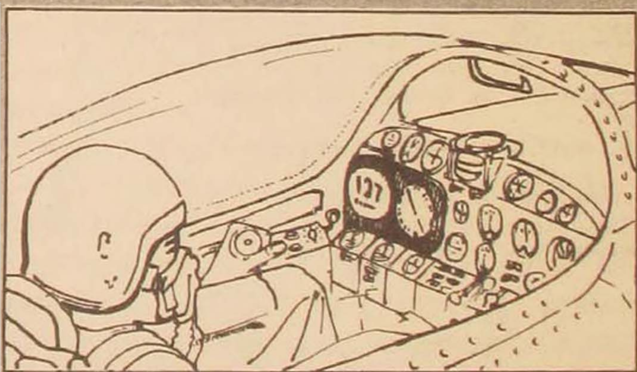
Coverage: Complete 360-degree coverage

Range: 2000 to 2600 n.m., day or night

Accuracy: Adequate at all times of day

Operation: Direct, visual dial reading

Homing Paths: Straight, radial lines



Newest of the long-distance electronic aids to air navigation, Navarho has unique characteristics especially advantageous in this strategic air age. High-flying, far-ranging aircraft need be within reception distance of only one transmitting station. Position is established by crossing an ordinary radio bearing with the circular line of position corresponding to the distance measurement from the station. In the cockpit the data is presented on simple calibrated dials, one for azimuth and one for distance. They are read directly at a glance, with no time-consuming, tedious oscilloscope manipulations or exacting aural tone interpretations. An aircraft may be as much as 2000 to 2600 nautical miles from the station and still receive reliable information. Whereas older electronic systems gave poor and even unusable coverage in certain areas, Navarho affords complete omnidirectional service. The accuracy of Navarho is excellent for general-purpose navigation—correct to one-half degree in azimuth and one per cent in distance.

tion, which is also furnished by the Government for air navigational purposes. In any event no special charts are necessary as in Loran navigation.

To obtain a fix, the method of crossed bearings from two or more stations can be employed, but it is not at all necessary. With the Navarho system one transmitting station can provide a fix. In addition to the Navaglobe portion, which furnishes the azimuth information and thereby establishes the first line of position for the fix, the Navarho system is equipped with Distance Measuring Equipment (DME), an electronic device employing an extremely stable crystal oscillator. DME, in effect, measures the time required for a radio signal to span the distance from station to aircraft and translates this information directly into a mileage reading. Thus the observer in the aircraft knows he is somewhere on a circle centered on the transmitting station and with a radius corresponding to the DME determination. This circular line of position, when crossed with the directional bearing, establishes the fix. Since every circle intersects both ends of each diameter line drawn through it, there are two possible fixes. This duplicity is referred to as a 180-degree ambiguity. In the vast majority of instances the observer already knows his approximate position and can readily eliminate one of the possibilities.

## *Advantages of Navarho*

The Navarho system possesses many advantages over differential-distance systems and other directional systems. Because the azimuthal lines of position are great circles they are useful—unlike the hyperbolas of Loran—as direct flight paths or radio beams for traffic to follow. They all lead to or from the ground stations. If these stations were located at or near the main terminals of long-distance air routes, the lines of position would be direct, fixed homing paths. Since Navarho displays its information on a direct-reading indicator with a pointer, the pilot could easily "keep on the beam" by setting an index mark along the dial at any desired bearing and steering to keep the pointer aligned with the index. A differential left-right meter might be added to give him corrective steering directions still more conveniently or to guide an automatic pilot.

Navarho has eliminated or reduced drastically the three major drawbacks of the Sonne system. The omnidirectional characteristic has been provided by a triangular base line. The correction charts have been eliminated by providing more directions which are close to a perpendicular bisector, reducing the separation between antennas and avoiding operation near the ends of the lines joining the antennas. The noise has been reduced by a noise-limiting circuit and by using very narrow receiver bandwidths. In addition Navarho indicates azimuth visually rather than aurally as in the Sonne system.

The expected accuracy of Navarho is one half degree in azimuth and one per cent in range. Thus an airplane 1000 nautical miles from the station will receive information accurate to within 10 nautical miles in any direction. While this is not as precise as Loran, it is good enough for general-purpose navigation. No ground-based, long-distance system is exact enough for precision bombing or other special purposes. Navarho has been developed to supply navigational aid information to an unlimited number of military and civil aircraft flying long distances over areas devoid of identifying marks.

Navarho is fundamentally simple to use because it is direct-reading and its charts employ simple radial and circular lines. The ground station can be considered to be unattended. The airborne equipment is as small as Loran equipment and eventually will be smaller. The ground equipment will also be more automatic, hence simpler to operate. The system can be operated by the pilot, and no separate navigator is necessary. This is an important consideration for fighter aircraft. Because Navarho employs a narrow bandwidth, together with certain other design parameters, it is much less susceptible to interference from precipitation static than are other systems. It has been outstanding in this regard.

Navarho affords complete 360-degree coverage, with no region of uncertainty and a single 180-degree ambiguity. It is one of the first systems to beam reliable information up to 2000 nautical miles in all directions, and an effective range of 2600 nautical miles is entirely feasible. A single Navarho station located in New York state can cover an area bordered by the Pacific Coast of the United States on the west, the Azores in mid-Atlantic on the east, the Arctic Ocean on the north, and the Gulf of Mexico on the south. Thus an aircraft flying at high altitudes, above the altitudes normally used by existing routes and airlines, could fly from the west coast of the United States to the Azores without retuning or readjusting the equipment. The pilot could obtain continuous indication of his position at all times with respect to the ground station. For a jet traveling at 600 knots this would be guidance for a flight of four and one-half hours.

### Status

Navarho has developed to the point that a full-scale facility is being made ready. A ground transmitting station is being installed at Camden, New York. This station will be equipped with 15-kilowatt transmitters at each of the three towers, with an additional transmitter in one of the towers used for the distance-measuring transmission. The transmitters have been completed and are ready for installation. The ground control equipment that maintains the equality of the radiated signal to close tolerances during the bearing period is being developed and will be ready for installation in November 1955. The DME crystal oscillator has been delivered and is being further improved. Ruggedized units of it are scheduled for delivery in March 1956. This master timing unit, with a stability requirement of drift of not more than one part in a billion for 12 hours, is one of the most accurate timing devices in existence.

The radio-frequency unit has been completed. Only minor changes are required to integrate it with the distance-measuring unit. The development model of the bearing unit has also been completed. The Navarho receiving equipment is constructed on the "building block" concept. That is, the bearing-deriving portion of the receiving equipment can be used without any part of the distance measuring equipment being required. Failure of the DME will not affect the bearing data. Addition of the DME will not require any change in the bearing installation. This "block" concept will enable operational requirements to be met for a variety of flight conditions. In addition an Arbitrary Course Computer, capable of taking the outputs from Navarho, bearing and distance, and converting the information to "course-to-fly and distance-to-go-to-destination," is to be developed as part of the Navarho facility. Flight tests have been performed, demonstrating the feasibility of the techniques being employed for both distance and azimuth. No attempt has been made as yet to miniaturize any of the airborne equipment, pending completion of the field evaluation program. This program is scheduled to start in November 1955 and to be completed by 1 January 1957. It will cover all of the aspects of the equipment as an operating facility and will determine whether Navarho is applicable as a world-wide facility.

IF NAVARHO is able to live up to its promise, if it proves successful as a long-range aid to world navigation, another battle will have been won in the struggle to create an all-weather, global mobility for air forces. The significance of Navarho resides in this fact: its development will afford aircraft, whether peaceful or bent on a mission of retaliation, a freedom of operation never before attained. Such an advantage could conceivably be decisive in this nuclear age of global air power.

*Air University Quarterly Review*

# The Royal Air Force

*A Gallant Force Re-equips for the Jet-Atomic Age*

WING COMMANDER M. H. LE BAS

THE Royal Air Force came into being as a separate service of equal status with the Army and the Navy on 1 April 1918. The establishment of the Air Force as a separate service was due almost entirely to the foresight of a few men such as Churchill, Smuts, and Trenchard. Even today the reports by the first two, written at a time when most military thinkers could view air forces as nothing more than "flying artillery" and the means whereby land-locked army commanders could see "the other side of the hill," makes one marvel at the breadth of their vision. That the R.A.F. retained its integrity throughout the turbulent period of its growth to maturity was due almost entirely to the efforts of one man, ably backed by a dedicated staff. That man was Trenchard and he it was who laid the firm foundations upon which the R.A.F. was built.

The solidity of the foundations was to be proved in World War II when the bare bones of an organisation devised in peace, with no experience to fall back upon, successfully withstood the imposition of a vast expansion without any major structural alterations.

The soundness of the doctrine of a separate air power as distinct from land and sea power was of course borne out by the resounding victory in the Battle of Britain. This doctrine enabled the planners to put first things first and to concentrate the inadequate resources on winning the air battle first.

By the end of the war the position of the R.A.F. as a separate service was unassailable. It is interesting to note that since that time the governments of several other nations likewise have granted independence to their own air forces.

# The Role of the Royal Air Force

The role of the Royal Air Force has recently been re-defined by the British Government. It is the primary task of the Royal Air Force to build up the V-bomber force which is the main contribution the United Kingdom can make toward deterring a potential aggressor armed with nuclear weapons. Should the deterrent fail, the function of the bomber force is, in conjunction with our allies, to make counteraction in war decisive in the shortest time, and to contribute powerfully to the defence of the United Kingdom against attack by sea and air and to the support of the allied front in Europe.

It is also necessary for the Royal Air Force to deploy an efficient fighter force backed by a highly developed control and reporting system for the direct defence of the United Kingdom.

The role of the overseas commands of the Royal Air Force is described in greater detail below. The 2nd Tactical Air Force in Germany is the main British contribution to N.A.T.O., and the Middle East and Far Eastern Air Forces provide for the day-to-day defence of our varied interests in those areas. They also maintain the base organisation to operate reinforcements of bomber and fighter squadrons and transport aircraft which the mobility of air power can provide at short notice.

In the fulfilment of its role both for its hot war and its cold war tasks the Royal Air Force has developed the fullest possible co-operation with the other Services.

**The world well remembers the Royal Air Force's gallant victory over the *Luftwaffe* in the Battle of Britain. But the RAF's triumph in Britain's desperate hour was not won solely by fighter pilots. Since 1918, because such British leaders as Churchill, Smuts, and Trenchard championed air power as distinct from land and sea power, the RAF has held equal status with the Army and the Navy. In the Battle of Britain the RAF vindicated the vision of these leaders by skillfully concentrating inadequate resources to win the air battle and by completing a vast expansion without major structural alterations. The British Isles, densely populated and anchored forbiddingly close to Europe, have become even more dependent on air power in the age of jet speeds and nuclear destruction. Wing Commander M. H. Le Bas, a member of the staff of the School of Land/Air Warfare, describes the RAF today. The RAF bases its offensive and defensive planning on the reality of the United Kingdom's vulnerability to nuclear attack. It regards as its primary task the build-up of the V-bomber force to deter a potential aggressor or to render decisive counter action. Recognizing that air defense depends on warning and that air retaliation depends on dispersal of offensive forces, the RAF's air strategy embraces the wide-flung Commonwealth and the sprawling base structure of NATO.**

# Organisation and Tasks

To fulfil its role, the R.A.F. is organised in the United Kingdom on a functional basis. Bomber Command, Fighter Command, Coastal Command, and Transport Command are the operational formations. These are supported by commands responsible for flying training, technical training, maintenance, and reserves. The functions of all these commands are explained in their titles with the exception of the last two. Maintenance Command is responsible for the supply of all items of equipment from complete aircraft to airmen's clothing and also for aircraft repair. Home Command, as well as dealing with the training of reserves, is responsible for the Air Training Corps—a voluntary organisation of youths who will later be inducted into the Service either as regulars or to complete National Service—and for providing parent facilities for units that would otherwise have to be administered directly by the Air Ministry.

Overseas, excluding Germany for the present, the R.A.F. is organised on a geographical basis, the commanders being responsible for all types of operations carried out in the areas of their responsibility. The Middle East Air Force with headquarters at Cyprus has a sphere of interest stretching from the Mediterranean to South Africa and from Malta to the Indian Ocean. Some overlapping occurs in the Mediterranean with the various N.A.T.O. commands in that area, notably in Malta where the R.A.F. is responsible for the air defence of this important N.A.T.O. base.

In the Far East the R.A.F.'s sphere of interest covers the area from Ceylon, through South East Asia to Hong Kong on the coast of China. Headquarters of the Far East Air Force is situated at Singapore.

*Bomber Command.*

The R.A.F. War Manual states, very simply: "Since the basic strategy of air power must be offensive, the bomber will be its primary agent." The layman, with his vision sometimes clouded or obscured by events such as the Battle of Britain, is apt to lose sight of this basic truth. It is safe to say, however, that those responsible for handling the affairs of the R.A.F. have never lost sight of it. In the past, allowing for the initiative which is always on the side of the aggressor, it may have been necessary to concentrate on the defensive to allow a breathing space in which to build up the offensive power. Those days are over; the offensive power must now be there and ready to strike from the outset.

It has been argued that, the United Kingdom being a member of N.A.T.O., the R.A.F. should concentrate its limited resources on building fighters or guided missiles both for its own defence and for the defence of N.A.T.O. nations with insufficient productive capacity to provide their own. Responsible men in this country, however, have never had any illusions that 100 per cent effectiveness in air defence of these islands could be provided at present or in the foreseeable future. Moreover the unpalatable truth is that only a small number of thermo-nuclear bombs are necessary to wipe out the British Isles for all time. The United Kingdom is the ideal target for such weapons.

A strong bomber force is essential not only as a deterrent against aggression and as a means to strike back in our own defence and in support of our allies should the deterrent fail, but also to reinforce and obtain respect for British views in the councils of the world. The truth is that the British have never accepted the role of a second-rate power to which they would surely be relegated in the absence of some force behind their arguments.

The scientists have now provided extremely effective weapons of destruction. The R.A.F. is just now beginning to introduce into its Bomber Command the vehicle to carry the weapons and thus enable it to perform its present tasks of reducing the weight of air and land attack on Western Europe, including the United Kingdom, and of countering and containing any threat to Britain's sea communications. The vehicle is the first of the so-called V-bombers, the Vickers Valiant, a 4-engined jet bomber of conventional design. It will be followed into service by more advanced types, two of which have been developed, the delta-wing Avro Vulcan and the crescent-wing Handley Page Victor. In the development of more than one type of advanced medium bomber, the R.A.F. has been justified by wartime experience, when its most successful 4-engined bomber, the Lancaster, was developed from an earlier twin-engined version which might well never have been developed had it been decided prematurely to concentrate upon a single type.

Since the war Bomber Command has been going through a lengthy period of transition from a piston-engine force to an all-jet force and from a visual-bombing to a blind-bombing force. The Canberra, a twin-jet bomber of relatively short range, is presently the main equipment, and with this aircraft the Command can hardly be said to possess a truly strategic capability. This can only come about when the Command is re-equipped with the new V-bombers.

*Fighter Command.*

Fighter Command has been an all-jet force since 1948. Until very recently, it is true, this jet force has consisted of day fighters whose basic designs were the result of Air Ministry specifications laid down early in the last war. In the last few months, after disappointing delays, the Command has begun to re-equip with a first-class modern fighter of British design, the Hawker Hunter. Prior to this, the most modern fighters operating in the Command have been a relatively small number of North American F.86E aircraft built and provided by Canada and the U.S. under the Military Aid programme. Even so our fighters have been fully able to deal with any offensive threat a potential aggressor was capable of mounting at the time.

There are several reasons for the delays in the arrival of the new fighters: some were the result of deliberate policy; and others, such as the failure of the early marks of the Supermarine Swift to meet performance expectations, were unforeseen. Some of the problems encountered are discussed later.

Fighter Command's task is to provide for the air defence of the United Kingdom and the defence of coastal shipping within its radar cover. The problems this raises are too well known to need much emphasis. Probably the best that can be hoped for as far ahead as can be seen is to make it as difficult as possible for a potential enemy to attack the United Kingdom; to aim at a pitch of efficiency to ensure that the enemy cannot penetrate the defences without suffering heavy losses; to cause him to think twice. All this to be achieved without devoting too many resources to an organisation which at best may never provide complete protection and, if it attempted to do so, might fatally weaken the striking force.

Basically the problem of providing an efficient air defence resolves itself into one of obtaining sufficient radar warning. How Britain's geographical situation affects this problem is best left for later consideration.

Operational control of anti-aircraft gun defences has always been vested in Fighter Command on the principle that there can only be one air defence commander. Recently the British Government has decided to disband the anti-aircraft gun defence of the United Kingdom because it can no longer be regarded as effective against the high-flying bomber. Operation of the surface-to-air guided missile will be the responsibility of the R.A.F. and in the United Kingdom this responsibility will be borne by Fighter Com-

*Until recently, Fighter Command's day fighters were those built to specifications laid down early in World War II. The Gloster Meteor (top), the only Allied jet aircraft to operate in World War II, has served the RAF and several other air forces since 1943. Limited numbers of the famed F.86E Sabre (middle), built in Canada and supplied under the U.S. Military Aid program, are now in service with Fighter Command and with some squadrons of the 2nd Tactical Air Force in Germany. The popular de Havilland Vampire (bottom) was the first aircraft in Britain or America to exceed 500 mph by a good margin over a wide altitude range. The first Vampire flew in 1943; by 1951 thirteen different countries had put the Vampire into service. The RAF adopted fighter, night-fighter, and fighter-bomber versions of the Vampire. Also the naval version was the first jet aircraft to land and take off from the deck of an aircraft carrier. Although still in service with a few overseas squadrons of the RAF, Vampires are being replaced by Venom F.B.1's.*

mand. The days of the manned fighter are beginning to draw to a close, but people who should know do not foresee its complete disappearance for many years to come and certainly not before 1965.

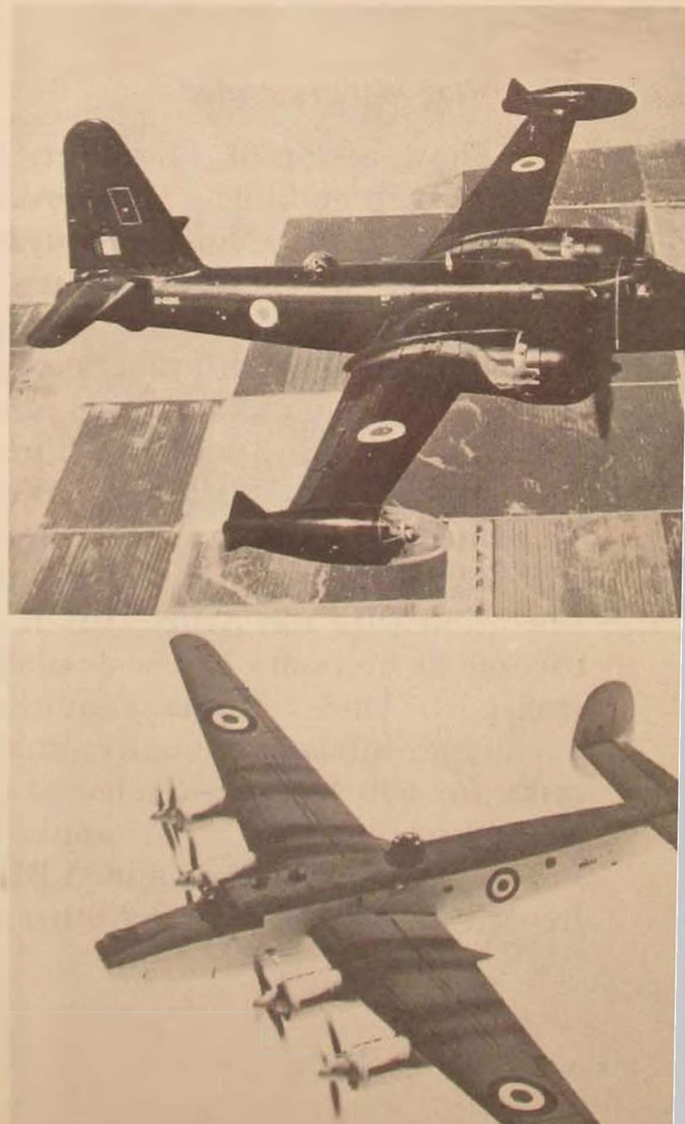
A new all-weather fighter, the Gloster Javelin, is about to be brought into service to replace the Gloster Meteor and de Havilland Vampire and Venom night fighters. In the future, great hopes are held for the most recent English Electric fighter, the so far unnamed P.1 which first flew in the summer of 1954 and has exceeded Mach 1 in straight and level flight.

*Although RAF Fighter Command has been an all-jet air force since 1948, only recently has this force been equipped with first-class, modern fighters. Three of England's newest fighters appear below. The de Havilland Venom N.F.2 (top right) is one of a series of Venoms developed from the Vampire and tailored to the new Ghost turbojet engine. The N.F.2, a two-seat night fighter carrying the latest airborne intercept radar, is in service with Fighter Command in place of the Vampire N.F.10. The Gloster Javelin F.(A.W.)1 (bottom left), the world's first twin-jet delta aircraft, is now in "super priority" production for the RAF. Powered by two Armstrong-Siddeley Sapphire turbojet engines, the Javelin carries a crew of two and the latest radar intercept equipment. The armament of the Javelin is reported to be four 30-mm. cannon, plus air-to-air missiles. In recent months Fighter Command has begun to re-equip with another modern fighter, the Hawker Hunter F.2 (below right). The Hunter is a single-seat interceptor, powered with an Armstrong-Siddeley Sapphire turbojet engine. Level-flight speed of Javelin and Hunter exceeds Mach 1.*

*Coastal Command.*

Coastal Command, which, were it not for tradition, might be more aptly named Maritime Command, is responsible for close co-operation with the Royal Navy in keeping the sea lanes open and denying their use to the enemy.

The Command is at present equipped with a mixed force of land-based aircraft—the Avro Shackleton and the Lockheed Neptune—and flying boats—the Short Sunderland. One of the unpleasant and inescapable facts which face those responsible for planning the defences of the United Kingdom is that this country relies for its very existence on the importation of vast quantities of food and raw materials, variously put at between 40 and 50 million tons a year. There does not appear to be any substitute to bringing these huge tonnages in by sea. This operation presupposes that command of the sea communications is not lost to the enemy. Today Coastal Command's main effort is devoted to devising ways and means of countering the main threat to this



*The principal duty of Coastal Command is to work with the Royal Navy to protect the sea lanes from blockade that would threaten the importing of the vast quantities of food and raw materials on which the United Kingdom depends for its existence. This task requires aircraft of maximum endurance, good maneuverability, and the ability to carry a varied and useful load of weapons. The Command is now equipped with two varieties of land-based aircraft, the U.S.-built Lockheed Neptune (top right) (U.S. Navy designation P2V-5), a long-range patrol bomber powered by 3250-hp Wright Turbo-Cyclone engines, and the Avro Shackleton (bottom), powered by four of the 2450-hp Rolls-Royce Griffon 57 piston engines.*

*In addition to land-based aircraft Coastal Command is equipped with a flying boat, the Short Sunderland (left). The Sunderland, famous for its World War II record on antisubmarine and convoy-escort duties, is also celebrated for its postwar activities in the British North Greenland Expedition and its role in the Korean War.*

country's sea communications, the submarine. At present the characteristics to be aimed for in anti-submarine aircraft would seem to be maximum endurance and good manoeuvrability, with the ability to carry a useful weapon load more important than sheer speed. Thus an aircraft of conventional design with a reasonable speed range and driven by either piston or turbo-prop engines is probably the most useful. Doubtless, however, the last has not yet been heard from the enthusiastic proponents of the flying boat.

*Transport Command.*

The function of Transport Command is the strategic movement of men and materials to overseas theatres and the provision of transport support for the Army by means of airborne operations, air transported operations, or air supply.

Since 1945 a policy of putting first things first, dictated not only by common sense but also by the economic situation, has depleted Transport Command to the point that it now consists of a relatively small number of Vickers Valetta and Handley Page Hastings aircraft. This force has been occupied with maintaining scheduled services to overseas commands, transportation of V.I.P.s, and keeping alive the techniques of transport support in co-operation with the Army. In an emergency it would be supplemented as necessary by the available resources of British civil air transport. Under normal conditions chartered civil aircraft fly a very large mileage annually on air trooping and air freighting tasks, for which it is intended to introduce modern aircraft such as the Viscount and the Britannia during the next few years.

A number of four-engined Blackburn Freighters, to be called Beverleys by the R.A.F., have been ordered, and the first of these will soon be in service with Transport Command. Recently a decision has been made to equip the Command with a number of De Havilland Comet II jet transport aircraft. With these aircraft the Command will be able to gain valuable experience in the operation of jet transports in readiness for the arrival of the Vickers 1000. The introduction of the latter type should enable the Command to provide true strategic mobility, not only for the Air Force but also for the Army's Strategic Reserve, so important a factor in countering outbreaks of the cold war.

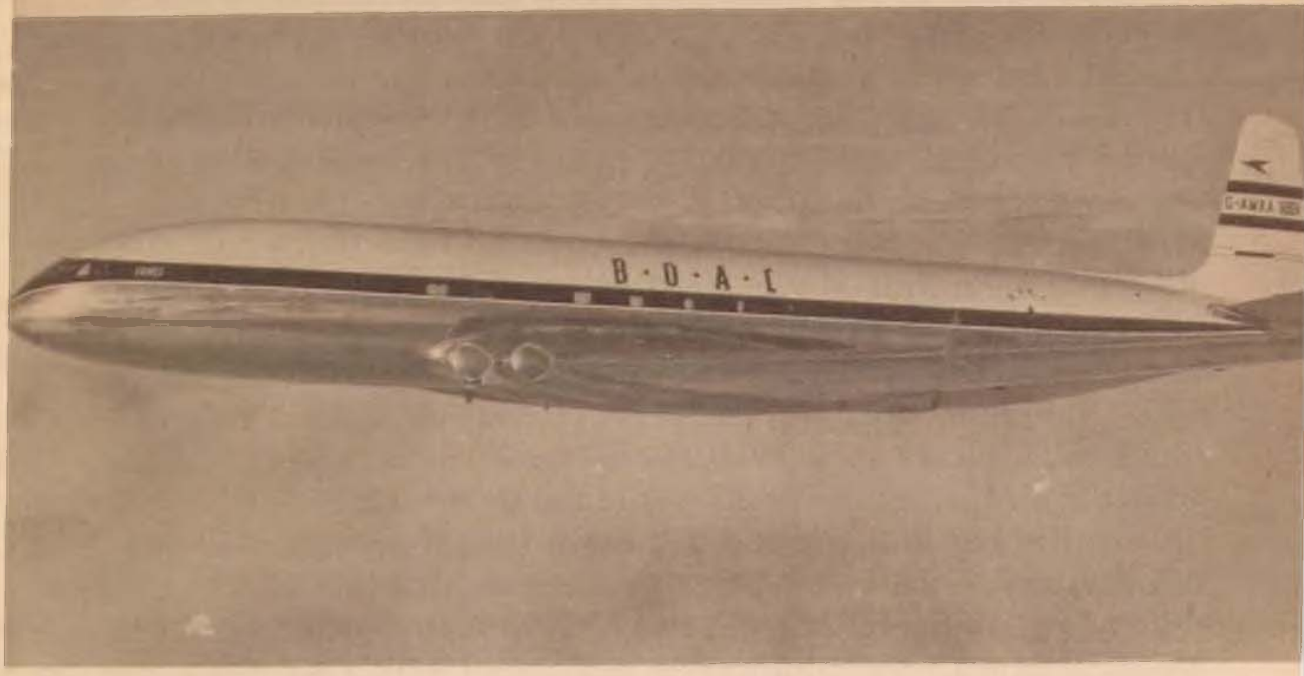
*Like most of the RAF, Transport Command has felt the stern pinch of Britain's postwar austerity. It now has a relatively small number of aircraft, and chartered civil aircraft perform many of its functions. Recently Transport Command has ordered a number of four-engine Blackburn Beverley C.1 freighters (right), which will soon be in service. The Beverley, with a payload of 29,000 pounds, has a range of 1300 miles. The fuselage is designed to permit vehicles to drive in through the twin doors at the rear. At present the mainstays of Transport Command are the long-range Handley-Page Hastings (below) and the twin-engine Vickers Valetta (below, right). Hastings transports participated in the Berlin Airlift in 1949. Coastal Command also uses a version of the Hastings for daily weather reconnaissance flights over the North Atlantic.*



*Despite limitations on its expansion since the close of World War II, Transport Command looks forward to the introduction into service of England's newest designs in the transport field. During the next few years Transport Command expects to acquire such modern turbo-propelled craft as the Bristol Britannia (above) and the Vickers Viscount (left) to carry out air trooping and air freighting duties which are now handled by chartered civilian aircraft. The Britannia, a long-range transport with four Bristol Proteus turboprop engines, can attain a maximum speed of 400 mph. The civil version, the Britannia 100, which is now in production for British Overseas Airways, can fly 3000 miles at 350 mph. The Viscount is a medium-range transport, powered by four 1530 ehp turboprops, with a maximum speed of 370 mph. The civil version, now on order for at least eight airlines, can accommodate between 40 and 48 passengers.*

### *Reconnaissance.*

No review, however brief, of the Royal Air Force can be complete without reference to the supremely important task of reconnaissance. It has been estimated that about 80 per cent of all usable intelligence in the last war was obtained from photographic reconnaissance. The successful outcome of all other types of air operations will depend in the first instance upon adequate reconnaissance and nothing but the best available type of aircraft can




*Transport Command also looks forward to integration of the newest designs in jet transport and expects soon to be able to provide true strategic mobility for both the Air Force and the Army. In anticipation of the Vickers 1000 (top), the prototype of which is now under construction, Transport Command has ordered a number of de Havilland Comet II jet transport aircraft (below). The Comet II, a derivative of the first turbojet airliner to be awarded a certificate of airworthiness, has a range of 2600 miles at 500 mph and will cruise at 40,000 feet. The Vickers 1000 is a transport version of the Vickers Valiant B.1, a long-range jet medium bomber now in quantity production for RAF Bomber Command. The V.1000 will be powered by four Rolls-Royce Conway jet engines of 11,500 pounds static thrust each.*

be considered suitable for the job. Whether this country could ever afford to design and produce an aircraft with reconnaissance specifically in mind is doubtful, but of the new aircraft about to be introduced the earliest versions will undoubtedly include some specially modified to carry out photographic reconnaissance.

In the U.K. at present the reconnaissance force forms part of Bomber Command and consists of English Electric Canberra aircraft. Allocation of priorities to photographic reconnaissance tasks is vested in a special inter-service committee in the Air Ministry.

*Overseas Commands.*

The 2nd Tactical Air Force in Germany is the British component of the 2nd Allied Tactical Air Force which also consists of Belgian and Netherlands units. This force is the R.A.F.'s major contribution to N.A.T.O. Its main task is to carry out operations in furtherance of the theatre air plan, and its secondary task to take part in joint land/air operations with Northern Army Group. The Command is at present equipped with the majority of the F.86E aircraft provided by Canada and the U.S.A., with De Havilland Venoms, Meteor all-weather fighters, Canberras and Meteors for reconnaissance, and Canberra bombers. Canberra interdictors will join the Command this Summer.

The main function of Middle East Force is the development of bases within its area to enable the R.A.F. to expand and utilise to the full extent its flexibility in time of war. Of course the Command has other functions, and it is presently engaged in redeployment consequent upon evacuation of the Suez Canal Zone. In Kenya it is assisting the Army to subdue terrorism.

In the Far East the R.A.F.'s main task at present is support of the Army in the fight against the Communists in Malaya. This is a truly joint operation, and the Air Force is providing both offensive and transport support in that area. This Command also includes air headquarters at Hong Kong, consisting chiefly of a fighter force for air defence of that base.

*Re-equipment Problems.*

Considerable disappointment has been experienced in the R.A.F. with the delays in delivery of new aircraft. Until the arrival in recent months of the Hunter in Fighter Command, all the operational aircraft in service were variants of aircraft produced from specifications issued in the last war. The most modern aircraft, the Canberra, was designed as far back as 1944.

At the end of the last war, two choices were open to the R.A.F. The first was to follow the traditional, safe policy of re-equipment in short steps by introducing new aircraft at comparatively short intervals. The second choice was to carry on with obsolescent aircraft and to concentrate the very limited research and design capacity on producing radically new types of aircraft which could not come into service for a considerable time—about ten years. The decision was made to follow the second course, and it is not difficult to see why.

Looking back to the time immediately after the last war, it was inconceivable to most people that the world would be in a fit state to wage another major war for many years to come. Moreover Great Britain emerged from the last war virtually a pauper. She had literally to export or die, and the greater part of the nation's resources in manpower, technical "know how" and raw materials was devoted to the export programme. By the same token the amount of money likely to be forthcoming for the Services, judging by wartime standards, would be strictly limited. Thus the decision to follow a "leap-frog" policy as opposed to one of short steps can be seen for what it was: a calculated risk based on a reasonable assumption reinforced by hard economic facts.

The result of this policy has been the obvious one that the R.A.F. has missed a whole generation of aircraft. It is now admitted that the problem facing aircraft designers who were called upon to solve intricate aerodynamical problems without enough experience to fall back upon was not sufficiently appreciated at the time. Neither were their problems alleviated by the decision to carry out supersonic research in unmanned instead of manned aircraft. Thus the policy of "super-priority" for military aircraft put into force after the Korean outbreak found an aircraft industry unable to take full advantage of its priority for lack of the requisite experience. Recently the British Government has decided on a policy of short steps in the introduction of new aircraft.

## Influence of Geography on Air Strategy and Tactics

In an article of this scope it is obviously not possible to do full justice to a subject about which much has been written by far abler pens. Nor is it the intention to become involved in a fruitless discussion of the difference between strategy and tactics. Suffice it to state some basic geographical facts and show how they might influence the offensive and defensive thinking of the R.A.F.

The British Isles are located off the northwest coast of Europe, the distance separating the two being a little over 20 miles at the narrowest point. The British Isles also lie at the centre, though not of course the geographical centre, of the Commonwealth. A glance at the map will show that the countries and colonies which comprise the Commonwealth are strung around the world and round the continent of Eurasia. These two facts, in some ways conflicting, have coloured British strategic thinking for centuries.

A vociferous minority of "Empire firsters" would have the

United Kingdom extricate herself from all European commitments and dedicate herself to the single aim of strengthening Commonwealth economic and, presumably, military ties. Unfortunately these people overlook the lessons of history and deny the facts of geography. In the past, England has always opposed the emergence of a single dominating power in Europe if only because of the menace such an occurrence would be to her own economic position. In all the European wars in which she has been embroiled she fought for one over-riding principle, the maintenance of the so-called balance of power. However much she may have wished it, therefore, England was never able to divorce herself from Europe.

Since the 1914-18 War Great Britain has been irrevocably wedded to European commitments but for a different reason. The planner's nightmare since that time has been a vision of the northwest coast of Europe occupied by a hostile power in possession of a strong air force. This nightmare became a reality in World War II but fortunately was not taken to its logical conclusion by an enemy who did not fully understand the use of air power.

The reason for this nightmare is not hard to see. Air defence depends upon radar warning and precious little radar warning could be obtained on aircraft operating from the other side of the English Channel. Today the problem is more complicated. The potential enemy is still in Europe, but the greatly increased speed of modern thermo-nuclear weapon carriers means that much more radar warning is necessary. Time is of the essence; time to intercept or time in which to order off one's own retaliatory force. Improving the organisation and increasing the efficiency of the equipment will reduce these times by only a certain minimum. The United Kingdom must buy more time with space. The frontiers with the potential enemy must be pushed and held as far away from these islands as possible. This cannot be done in Europe without allies.

As mentioned earlier, the R.A.F. can no longer hope to defend the United Kingdom by adopting a purely defensive strategy. In fact this was never so, since maintenance of the offensive has always been the over-riding consideration in formulating an air strategy. The British Isles, which have been likened to an enormous aircraft carrier firmly anchored off the coast of Europe, are not, by their very smallness and the consequent concentration of their industry and population, an ideal place from which to conduct a modern strategic offensive. The Commonwealth offers the space necessary for dispersion and at the same time, by menacing the enemy from all quarters of the globe, forces him to spread his defences. Of course the mounting of an air offensive from world-wide bases presupposes well-prepared bases and adequate air transport.

The Commonwealth air bases, particularly in the Far East, have an important role in the strategy and tactics of the cold war. Outbreaks in this war may well have to be countered by conventional forces, and the ability to deploy these forces rapidly by air transport may make the difference between victory and stalemate or worse.

Probably sufficient has been said on the subject of air strategy to show that national strategy and air strategy are now one and the same. The unalterable facts of geography dictate the strategy that must be adopted. Whereas in the past Great Britain's strategy has been based on sea power, so today it is based on air power. Air strategy has become the dominant strategy.

## N.A.T.O. Obligations

The R.A.F.'s N.A.T.O. obligations follow naturally from British strategical considerations. Had N.A.T.O. never been conceived, Britain would have been forced to enter into some other alliance for self-preservation, if for no other reason.

By far the greatest R.A.F. contribution to N.A.T.O. is the Tactical Air Force based in the British Zone of Germany. Numerically the R.A.F. 2nd Tactical Air Force is the strongest single N.A.T.O. tactical air force in Europe.

Although no R.A.F. forces are deployed in either Allied Forces Northern or Southern Europe, there is R.A.F. representation on the Air Force staffs of these commands. The present Commander of Allied Air Forces Central Europe, Air Chief Marshal Sir Basil Embry, is one of the R.A.F.'s most distinguished officers, and he has as many British officers on his staff as there are on the staff of the Supreme Allied Commander Europe.

Coastal Command of the R.A.F. has also considerable N.A.T.O. obligations. The Commander-in-Chief of that Command, Air Chief Marshal Sir John Boothman of Schneider Trophy fame, also doubles as Air Commander-in-Chief, Eastern Atlantic. The operations of Coastal Command in the Atlantic are closely inter-related with the maritime air operations of the U.S.A., Canada, France, Belgium, and the Netherlands. The R.A.F., in consequence, is also represented on the staff of the Supreme Allied Commander Atlantic at Norfolk, Virginia.

In less than the span of a man's life, the R.A.F. has grown from a few aeroplanes made of fabric, glue, and piano wire to become the dominant weapon of the British Services. World War II proved the soundness of the policies of those responsible for building up the strength of the R.A.F. Given the right equipment, it is up to the present generation of officers and men to prove that the faith of the country in the ability of the R.A.F. to do its job once more has not been misplaced.

*Royal Air Force School of Land/Air Warfare*

# Aircrew Training in the Atomic Age

BRIGADIER GENERAL CECIL E. COMBS

BEFORE World War II every tactical organization in the Army Air Corps was primarily a training organization. The formation of the GHQ Air Force was a first attempt to create an Air Force-in-being, with an instant potential for combat. However this was a very small organization, and its high level of experience was quickly dissipated in the expansion of 1940 and 1941. As the sense of emergency grew, that expansion very rapidly diluted available experience until few, if any, units possessed any real readiness for combat. Fortunately we had a cushion of space, provided by our geographical isolation, and a cushion of time provided by our allies, notably Great Britain. There was time enough, though it did not seem enough then, to train the new units to an acceptable degree of proficiency before they had to be committed to action.

It is a commonplace statement that we no longer have either a cushion of time or of space. The increased range and speed of aircraft, and the vastly increased destructiveness of their armaments, have eliminated both. Not only will a future major war be fought immediately with the forces available on D-day, but also the ultimate decision will probably be achieved by those same forces. For these reasons the Air Force program is built on a requirement for combat readiness. All the 137 wings in the program are intended to be first line, with a real and instant readiness for specific combat tasks in accordance with established war plans. The only major element not specified in these plans is the actual date of D-day.

I do not mean to imply that our tactical units are not at all times engaged in training. They are constantly striving to increase the capabilities of their weapons and their crews in every way possible. Their training is designed to keep them in shape for battle. I do mean that their attention is focused on the job they would have to do in wartime and that their training is limited by the necessary assumption that any day may be D-day.

Unfortunately our first-line units are not immune to the turnover that must exist in the armed forces of a democratic country. They suffer their share of losses of highly skilled personnel. Replacement of these losses is a problem of real concern. It is a problem that is intensified by the increased complexity of the newer weapons systems. As the job has become more urgent it has also become more difficult. Every training problem sooner or later requires compromise between quantity production and quality production. It is one of the major tasks of the Air Training Command to produce pilots and observers, trained to established performance standards in sufficient quantity to meet the needs of the Air Force program. If quantity were the only problem, it would be simple to send these people directly into the major commands. If it were not for the D-day requirement of the major commands, qualitywise, these people eventually could be trained up to meet the requirements. The quality requirements of first-line crews in ADC, SAC, TAC, and overseas commands, however, can no longer be met by young graduates of our basic flying schools. If the Air Force possessed what might be called second-string units to which these young graduates could be assigned for further training and seasoning, it would be possible to create a pool of highly qualified replacements for the major commands. But here again all the Air Force combat units are first-line units. The creation of other units would require a further increase in the over-all size of the Air Force that at the moment hardly seems probable.

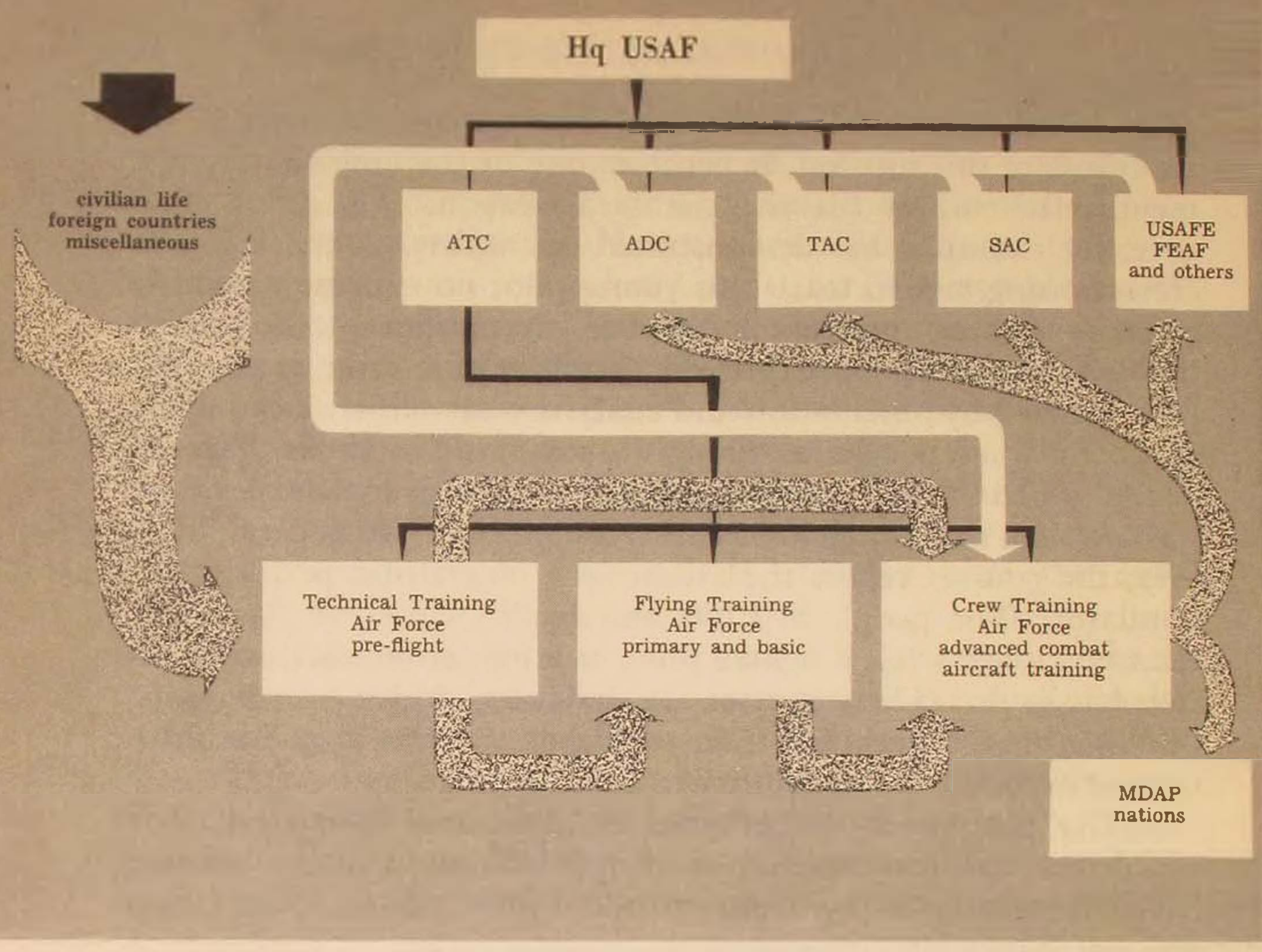
These considerations plus the needs of the Korean conflict led some three years ago to the creation of the Crew Training Air Force in the Air Training Command. Its purpose is to provide the realistic combat-type training which will qualify a newly rated

**When the Air Force established 137 wings as the minimum needed for the nation's security, it did so with the knowledge that this minimum force would have to bear the brunt of any future war. All wings must be first-line, combat-ready wings. With weapons systems becoming increasingly complex and with new wings being formed at a time when the world situation would not allow the gutting of operational wings to provide cadres for the new wings, Air Training Command stepped into the breach by extending its training to include crew training. In contrast to the old system whereby the pilot, navigator, or bombardier received realistic combat training only after assignment to an operational unit, Air Training Command now develops a combat-capable crew which with very little additional training in the tactical unit can be brought to combat readiness. Brigadier General Cecil E. Combs, Deputy Commander, Crew Training Air Force, describes the new program.**

pilot or observer to fill a crew position in a combat cockpit. As we translate this mission, it becomes one of teaching the aircrew member to employ his airplane as a weapon. The pilot graduate, for example, has demonstrated his ability to fly. It is the crew-training task to teach this young pilot how to use a combat airplane—fighter, interceptor, bomber, or transport—to do a combat job, a combat job expressed in terms of specific goals. We have learned by observation and analysis what skills we can teach in about what period of time. In some instances we have of necessity had to turn out combat crews whose over-all experience was less than that which we considered optimum. In general, however, the courses reflect the attainment of realistic performance standards. The people at Luke and Nellis Air Force Bases, for example, know what a fighter pilot in a fighter-bomber organization has to do. Their courses are designed to give him practice in doing these things, and their standards of performance require that he demonstrate his ability to do these things.

The analysis of the progress of thousands of students has enabled us to form a pretty good approximation of the average curve of learning of the average student under these realistic conditions. By evaluating demonstrated performance against progress through each course, we have been able to arrive at what we think are realistic quality goals. The guiding principle has been one of seeking a balance between those things which a student can learn quickly in a training situation and those other things which he can only eventually learn in the combat organization to which he is assigned. Admittedly this balance is a matter of professional opinion. As our people express it, it represents the difference between a "combat-capable" crew and a "combat-ready" crew. The objective—this combat-capable crew—is a graduate who knows his own capacities and limitations and those of his airplane and who can with very little additional indoctrination in the tactical organization fill a combat-ready cockpit job.

It must be obvious that effectiveness in meeting this objective is sometimes difficult to measure. For one thing the standards themselves may from time to time be either too high or too low. This can only be settled by constant review between the staff and bases conducting crew training and the commands that receive the graduates. As new weapons systems or new experience with old systems result in new tactical methods and capabilities, these things must be made known to us and immediately reflected in our courses. Every new situation requires a new compromise between the degree of excellence we would like to set as a standard




*The student pipeline into CrewTAF flows from civilian life to Technical Training Air Force for pre-flight training and then through Flying Training Air Force for primary and basic flying training. The pipeline includes nonrated Air Force applicants for flying training as well as trainees from nations in the Mutual Defense Assistance Pact. Students also come directly from major operational air commands for transition or refresher training in the most modern combat aircraft or for training in advanced survival techniques. Selected Army, Navy, and Marine officers also attend the survival courses. CrewTAF graduates are assigned to the operational commands, and foreign students return for duty in their own military forces.*

and the demands of an Air Force program that the cockpits be filled. The time factor, for reasons both of economy and of program balance, is inescapable, and always limiting.

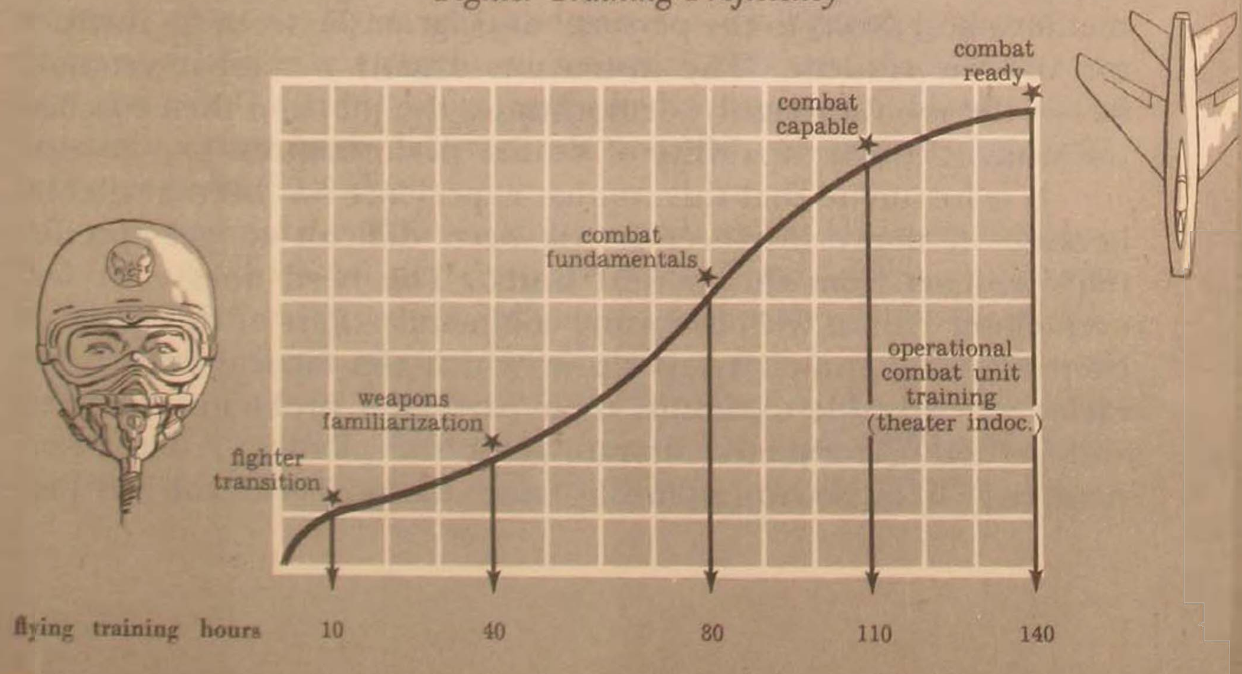
The other difficulty in evaluating our effectiveness springs from the fact that the ability of the graduate crews takes some time to show itself. Students in a controlled training situation can be evaluated. For instance, Luke and Nellis can give a man 110 hours of jet fighter time in a specified course, and he can demonstrate the skills that he has learned. In this same period of time they cannot, unfortunately, give him the judgment that comes only from years of experience. Consequently tactical squadron commanders find that it takes them a considerable amount of time to discover the strengths and weaknesses of these graduates, especially as their performance is not only a matter of flying skill but also one of maturity as officers. A close liaison is maintained with the tactical units and major command headquarters in order to solicit criticism of the results of our training.

The only way to deal with all of these problems involving professional judgment is to use people with adequate professional experience. There is no magic in the training methods of the Training Command. The basic training technique is one of

*The "student curve of learning" illustrates the measure of student proficiency against flying training hours. The phases of training proficiency shown are the most realistic that can be designed along the curve. The transition phase is the minimum amount of flying training normally provided in the basic operation of the aircraft as a vehicle. Transition is followed by weapons familiarization with the operational systems of the aircraft: sights, guns, radar equipment, bombs, rockets, etc. The student will have operated the systems in an aircraft or synthetic training device but not sufficiently to attain a specific level of proficiency. During the combat-fundamentals phase he is given enough practice to reach and demonstrate a specified degree of proficiency in all phases of use of the aircraft as a weapon. To become "combat capable" he must next repeatedly practice with real equipment in training situations closely paralleling the operational job to which he will be assigned. Theater and unit indoctrination training in an operational combat unit finalizes his training to the state of combat readiness. Identical definitions describe comparable phases of training in the interceptor curve of learning.*

## Student Curve of Learning

*Fighter Training Proficiency*



## Instructor Selection

Standard instructor qualifications are established for each crew training course of instruction. For example, the following are the requirements for an instructor to be assigned to the Fighter Training Complex:

**Mandatory:**

*Flying time:*

750 hours, including:

500 hours in jet-type aircraft, and

100 hours in the aircraft of instruction

**Desired, but not mandatory:**

*Special training:*

(1) Graduation from the advanced flying school of the course of instruction

(2) Graduation from a Central Instructor Course

(3) Graduation from the Fighter Weapons Instructor School

*Personal characteristics:*

(1) Ability to speak distinctly and express clearly

(2) Maturity of judgment and judicious responsibility

(3) Desire to be an instructor

*Combat Background*

demonstrating the job that has to be done. This requires a corps of instructors who have a great deal of tactical experience. While maximum use is made of all types of training aids, the training methods boil down to the personal association between an instructor and the student. The instructor, usually a combat veteran, knows the job thoroughly, demonstrates the job, and then coaches the student into a capability of similar performance.

It is fortunate that this combat experience has been available because in many instances it has been difficult to get specific requirements from the tactical units. The need does exist for even closer liaison with the using commands. Part of this gap has been filled by annual symposia in which the tactical experts in each field assemble to discuss their particular problems. As new and higher performance aircraft enter the picture, it has been necessary likewise to establish close liaison with the testing agencies. At the moment ATC is involved in the development of training methods for the F-100, F-101, and F-102, after a long period of collaboration with the testing agencies in the development of these airplanes. This liaison will continue, because one has never truly got the bugs out of an airplane until it has been subjected to the rapid rate of operation that only a training situation can generate in peacetime. For the same reasons the integration of a new aircraft forces a periodic reconsideration of its tactical development as we become better acquainted with its capabilities and limitations.

This is a general picture of the place of crew training in the Training Command. There are other ways in which Air Training Command could organize to accomplish this mission but the important thing is the mission and not the organization. Now perhaps a better idea of the way in which the mission is being accomplished may be given through a description of the bases themselves, their physical resources, and their typical courses of training.

## Some Physical Characteristics

The nine crew training stations conduct thirty-five major courses of instruction. With a near constant load of 2000 students, these courses yield 18,000 graduates a year, an annual production of 6000 pilots and observers for aircrews, 1800 instructor pilots, instrument pilots, and senior officers, 1200 aircraft controllers, and 9000 special-weapons and advanced-survival students. Aircrew courses last from two and one-half to four and one-half months.

The bases cover nearly 8 million acres, including 6 million acres of open country, desert, and mountain ranges maintained for firing and bombing ranges and maneuver areas and another million and a half acres for advanced survival training. These ranges are the performance laboratories for the development of the trainee's individual skill.

Approximately 1600 aircraft are assigned to the crew training mission, of which 90 per cent are jets. They include over 500 first-line fighters, approximately 150 bombers and 28 transports, some 255 interceptors, over 500 two-place jet trainers, and about 200 support aircraft for rescue, target towing, and administrative flights. Of the total assets of approximately one billion dollars, 60 per cent is invested in aircraft, which provide 700,000 flying

*An F-84 makes a firing pass on the ground gunnery range at Luke AFB. CrewTAF maintains six million acres of ranges over open country for practice of strafing, bombing, rocketry, special weapons delivery, and combat tactics, an area larger than New Jersey, Rhode Island, and Delaware combined. Daily over these vast areas aircrews practice the maneuvers and firing that train a combat-ready Air Force.*

hours annually. This flying time is greatly supplemented by the almost constant operation of 132 flight simulators.

The crew training mission requires more than 40,000 men: 3500 officers, 32,000 airmen, and 5000 civilians. About 1600 of the assigned personnel are instructors, who are supplemented by more than 200 highly qualified training supervisors. The experience of our instructors is extremely high. Almost all are combat veterans, many of them veterans of both World War II and the Korean War.

Instructor proficiency may be illustrated by the performance of teams from the crew training bases in the annual Air Force-wide gunnery and interceptor meets. Last year the fighter-bomber team from Nellis and the interceptor team from Moody won the Air Force championships. Some complaints have been noted from the tactical units at competing against the "pros," but most feel that they want to compete against the best, and that the Air Force should profit from setting the highest possible standard of weapons proficiency. To accomplish this and still make the competitions as fair as possible, ATC this year decided to eliminate from the meets the instructors in the Fighter Weapons Instructor School and the Interceptor Weapons Instructor School. Even so, our teams outscored last year's teams in this year's intracommand meets, in which Luke AFB earned the right to represent ATC in the Special Weapons Meet, Nellis in the Day Fighter Meet, and Perrin in the Interceptor Meet.

The number of instructors required in various aspects of the crew training programs varies according to the degree of personalized instruction required. Experience has shown that high-quality flight-line instruction in our fighter programs (F-84 and F-86) can be given to three students by one instructor but that interceptor flight training (F-86D, F-89D, and F-94C) requires one instructor for two students. For conventional bomber (B-29) and transport (C-119) flight training one instructor can give quality training to two crews, but for jet bomber flying training (B-47 and B-57) one instructor is required for each crew. Academic or ground school classes are usually limited to 20 students per instructor for maximum effectiveness.

Operating costs of the crew training bases are $216 million annually, of which 33 per cent is expended for student instructional purposes, such as aircraft fuel, ammunition, training aids and equipment, school supplies, and salaries of instructors and supervisors. Another 33 per cent is devoted to the maintenance of aircraft employed in aircrew training and 14 per cent to the maintenance of runways, grounds, and buildings. The per-student cost of the average aircrew flying course of instruction, counting the salary received by the student while attending, is about $20,000. This does not include such major items as the initial cost of the aircraft or its depreciation.

The crew training resources of ATC also constitute a stand-by reinforcement for emergency, when our firepower becomes available to augment Air Defense Command, Strategic Air Command, and other operational commands. Since the crew-training bases are equipped with first-line combat aircraft manned by experienced, combat-wise instructors, their power to reinforce other commands in time of emergency is not inconsiderable. A great part of the training dollar is thus ready for direct use in national defense.

## Crew Training Functions

The aircrew training functions are divided into three "complexes" in which fighter, interceptor, and bomber and transport training is conducted. The Fighter Complex stemmed from an urgent need for current combat-ready fighter pilots for replacements in combat units committed to the Korean War. Nellis Air

Force Base was selected to train graduates of basic single-engine schools and a limited number of experienced pilots in the employment of first-line fighter aircraft as weapons. As the tempo of operations increased in Korea, Luke Air Force Base was added, and when during the same time the USAF assumed the training of the major portion of fighter pilots of foreign units obligated to NATO, a third base, Laughlin Air Force Base, completed the complex. The Interceptor Complex also has three bases, Tyndall, Perrin, and Moody, for training in employment of the F-86D, the F-89D, and the F-94C. The Bomber and Transport Complex operates on two bases, McConnell and Randolph, to train pilots and other aircrew members in the multi-engine B-47, B-57, B-29, and C-119 aircraft. Its courses fulfill the two essential training requirements of assisting a major air command in converting its operational units to new model equipment or of providing transition training in combat-type equipment for newly graduated pilots.

### *The Fighter Complex*

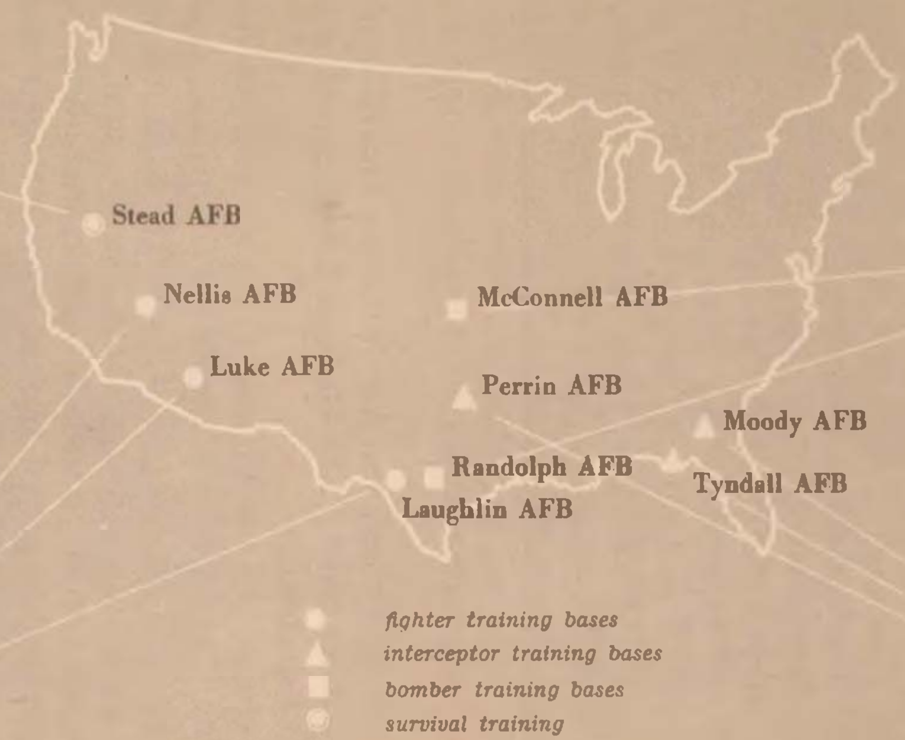
Since the beginning of fighter combat training the objective of all courses has been to provide maximum training utilizing first-line fighter aircraft, consistent with the number of aircraft available and the number of pilots required to be trained. Originally each base within the complex was to conduct a straight-through course in first-line fighter aircraft, which included all phases of fighter gunnery. Enough fighter aircraft were not available, and an air-to-air gunnery range for one of the bases was not obtainable, so that the plan had to be modified. Nellis Air Force Base continued to operate with F-86's according to the original plan, but at Laughlin and Luke the effort has been made to produce qualified fighter pilots while utilizing two different aircraft. At the present time four courses are taught to meet requirements established by USAF. Two courses provide 80 hours of flying training in 60 days. One combines T-33 flying with the F-86 and the other the T-33 with the F-84. The other two courses provide 110 hours of flying training in first-line fighters in addition to 40 hours pre-combat training in the T-33. These straight-through courses are 120 days long, with entries every ten days in all courses.

Selection of students for each of the four courses is in accord with USAF policies as to each pilot's status and with his eventual destination upon completion of his training. The F-86 and F-84 straight-through courses are restricted to USAF students who will fill cockpit positions in USAF tactical units. The 80-hour F-86

# Training Functions of Crew Training Air Force

*Crew Training Air Force Bases*

Advanced aircrew survival courses are conducted at Stead AFB.




### The Bomber and Transport Training Complex

Training in the B-57, B-29, and C-119 is conducted at Randolph AFB. The CrewTAF Central Instructor Course is also located there as well as special weapons delivery courses provided for USAF aircrews and instructors. Training in the B-47 is given at McConnell AFB.

### The Fighter Training Complex

Fighter training in the F-86 Sabrejet, as well as training research and development using the F-100 Super Sabre, is conducted at Nellis AFB. The USAF Fighter Weapons School is also located at Nellis. Training in the F-84E and G Thunderjet and the F-84F Thunderstreak is given at Luke AFB. Preliminary gunnery aircrew training in the T-33, the two-place version of the F-80, is conducted at Laughlin AFB.

### The Interceptor Training Complex

Training of interceptor crews for the two-place F-89D Scorpion and the F-94C Starfire is assigned to Moody AFB. Moody also conducts the USAF Interceptor Weapons Instructor School for the F-89D and the F-94C, in addition to the USAF Instrument Pilot Instructor School. Perrin AFB and Tyndall AFB are the locations for training in the F-86D, the single-place interceptor version of the Sabrejet. The USAF Aircraft Controller School, as well as the F-86D USAF Interceptor Weapons Instructor School, is also located at Tyndall AFB.

### The F-86 Straight-Through Curriculum

**I. Flying Training**

*Total hours: 427*

1. Briefing — 175
2. Flying — *T-33* *F-86* 110
   - a. Orientation and instruments — *10*
     - (1) Field orientation — 1
     - (2) Instruments — 9
   - b. Tactical training — *100*
     - (1) Transition (1 hour night) — 11
     - (2) Formation (1 hour night) — 8
     - (3) Air-to-ground gunnery — 23
     - (4) Air-to-air gunnery — 36
     - (5) Tactics — 22
3. Critique — 127
4. Synthetic instrument trainer (C-11) — 15

**II. Academic Training**

*Total hours: 140*

1. Aircraft general — 20
2. Armament and fighter gunnery — 24
3. Tactical operations — 10
4. Physiological indoctrination — 2
5. Celestial navigation — 10
6. Aircrew special weapons training — 64
7. Flying safety — 10

course was developed for Air National Guard students who will return to their units. The 80-hour F-84E course is normally filled by NATO students.

All courses of the Fighter Complex contain five basic phases of training: (1) *transition*, including acrobatics; (2) *tactical formation flying;* (3) *air-to-ground gunnery,* with all fighter weapons systems, including guns, rockets, bombs, and special weapons; (4) *air-to-air gunnery;* and (5) *tactics,* including missions requiring search and attack of typical enemy targets such as airfields, railroads, gun emplacements, and convoys. Tactics also includes fighter-versus-fighter practice with the gun camera in simulated air combat.

### *The Interceptor Complex*

Although conducted in dissimilar aircraft, the training programs for the interceptor crews are all quite similar in teaching basic radar intercept techniques. In the two-place F-94C and F-89D, the radar is operated by the radar observer, while in the F-86D the pilot not only flies the aircraft but also functions as radar observer. As the interceptor mission is all-weather, the pilot must be exceptionally well qualified to fly instruments. The steering information furnished by the radar and the computer is displayed to the pilot on a radar scope which is itself also a flight instrument. This indicated steering information must be acted on immediately, accurately, and sensitively to ensure centering the aircraft's firepower on the target.

For the necessary degree of instrument flying proficiency, the initial stage of interceptor training stresses instrument procedures and techniques of weather flying. After ten days of ground training the pilot student practices his acquired academic knowledge for 18 hours in the C-11 trainer and 26 hours of instrument flying in the T-33. In the F-94C and F-89D programs the observer also receives the academic portion of this training and then joins his pilot to complete the course as a team.

The second phase of training transitions the aircrew to their aircraft. This is followed by a basic radar interceptions phase, with practice in simple interceptions against T-33 targets. Many practice interceptions are necessary, particularly in the F-86D, to learn to follow directions of the GCI controller, interpret the airborne radar presentations, and make a successful run on the target. The student then progresses from single to multiple target interceptions against T-33 and B-29 aircraft. Ultimately the actual operation of the air defense system is simulated for him. He flies scramble missions against high-speed targets that employ evasive action and deception.

*A fighter instructor at Nellis AFB explains a ground gunnery pattern. The training features small student groups and individual instruction. Since most of the combat aircraft used for training lack space for an instructor, the student is completely on his own once he begins to roll down the runway. Before he is allowed to take off, his instructor must be certain that he is able to execute all maneuvers correctly and without accident on his initial trial and that he understands all routine and emergency procedures he may have to perform. All the student's subsequent communication with his instructor, who is flying in a separate aircraft in formation, is by radio. This kind of training requires the utmost in teaching skill to ensure the student's successful performance.*

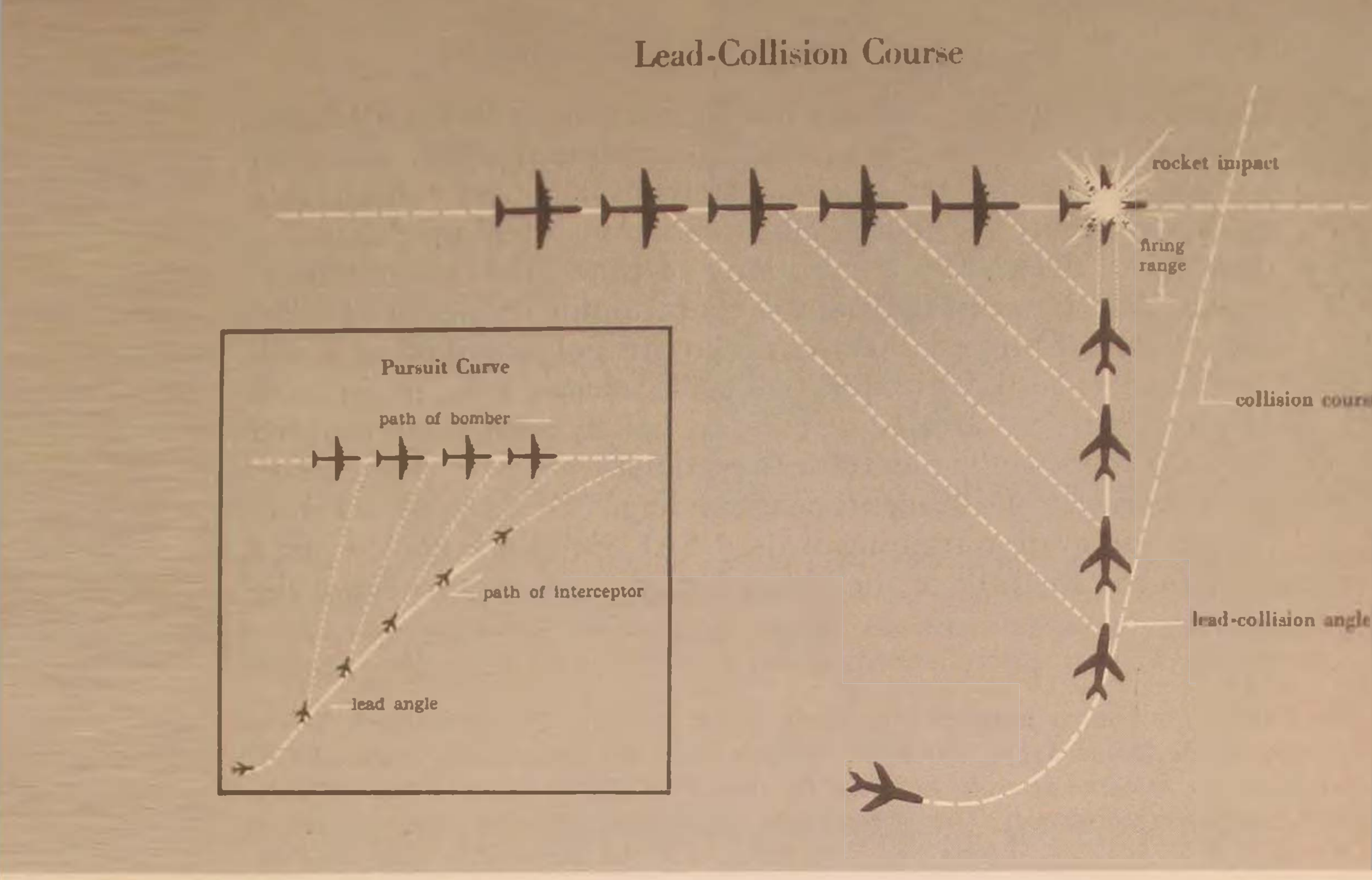
The final phase of training presents exercises in making radar contact with and firing rockets on a radar-reflective towed target. After four and a half months and some 100 hours of flying, the crew leaves for assignment to Air Defense Command or to one of the overseas commands.

It is in the interceptor training that the most difficult compromises have recently been made between unyielding quantitative demands and desirable quality standards. During FY 1956 the increased need for interceptor pilots in Air Defense Command has resulted in a shortening of these courses. The graduate will be thoroughly schooled in the airplane and in the basic interception techniques; his proficiency, however, especially against high-flying fast multiple targets, will leave much to be desired. Faced with a compromise of this kind, the mission of crew training becomes one of providing the maximum capability possible to the required quota of students in the specified amount of time.

### *The Bomber and Transport Complex*

Four courses are conducted in this area, three in bombardment aircraft and one in transports. McConnell Air Force Base is the home of the B-47 program, which opened in 1951 with the beginning of the conversion program of the Strategic Air Command from B-29's to B-50's to B-47's. Since then McConnell has

*F-84 cockpit procedure (left). Instructors initiate students in their aircraft by means of a trainer. To conserve flying hours flight simulators are also used (right). Constructed to simulate a specific aircraft both in cockpit design and flight characteristics, they enable the trainee to fly an entire mission on the ground. Aircrews are thus familiarized with emergencies too dangerous to be practiced in flight. Simulators available or programmed for crew training are the B-47, the C-119, the F-86D, the F-84F, the F-89D, the F-100, the F-101, and the F-102.*



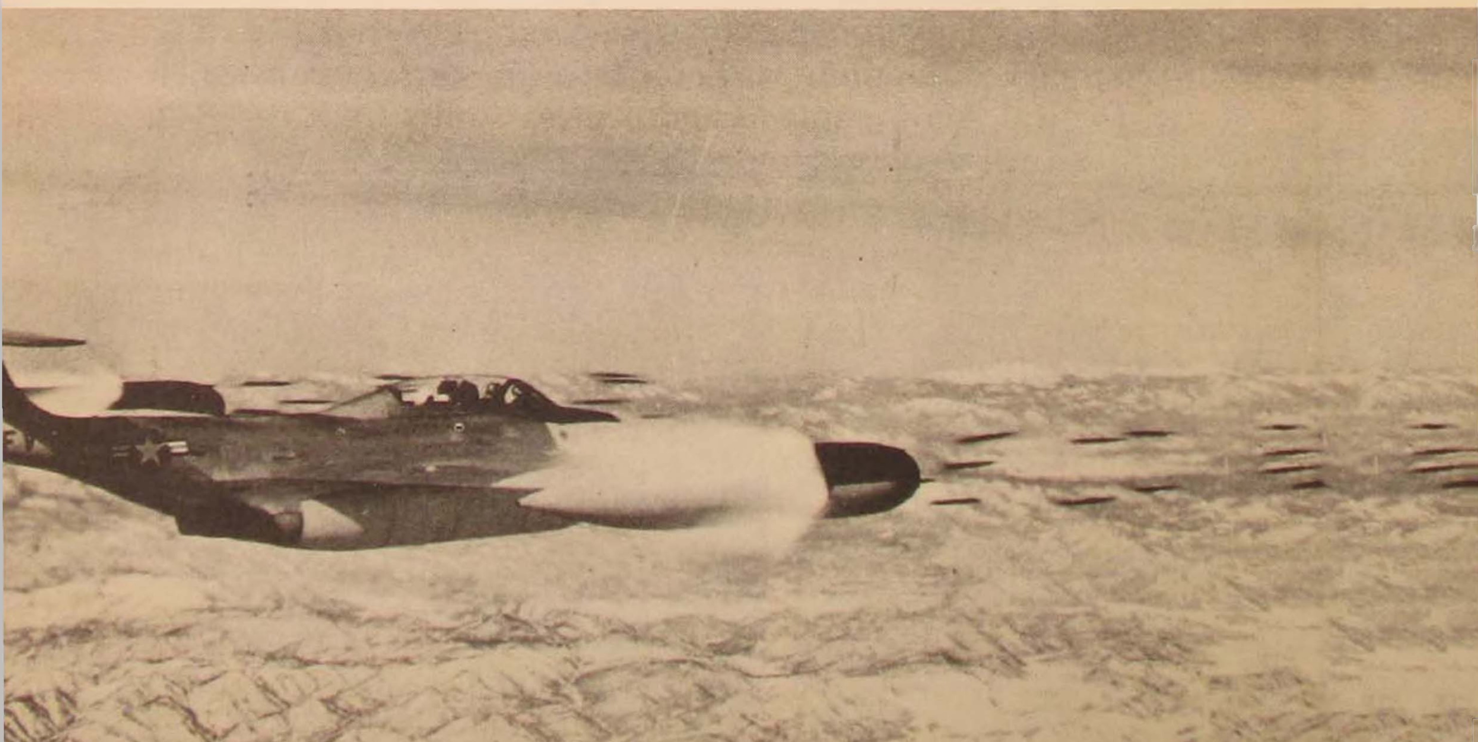

*Considerable practice is required to interpret the airborne radar presentation of a bogie and make a successful run on the target. These interceptions are of the lead-collision type rather than of the old pursuit-curve kind of World War II. The lead-collision interception differs from the curve of pursuit in that at only one time on any one pass is the lead on the target correct for a hit. At that instant the computer automatically fires a selected number of rockets in a modified salvo. After the firing signal appears on the pilot's radarscope, he executes a pull-out. The flight paths of interceptor and target cross at very close range.*

converted over 1000 Strategic Air Command crews to B-47's. The B-57 program at Randolph Air Force Base supports the conversion of the Tactical Air Command and overseas units from the B-26 to the B-57. Also at Randolph, B-29's are used for four-engine transition training. The transport program is transition training, using the C-119 to train crews in the type of aircraft they will operate upon assignment to troop carrier units. Four-engine transition training in the C-54 will be instituted at Randolph in April 1956 to prepare crew members for heavy transport units.

The Medium Bomb, Jet (B-47) training course is an eight-week course designed to provide Strategic Air Command with a pilot/co-pilot crew fully familiar with the B-47, its systems, and correct operating procedures for it. A four-week period of academics precedes 40 hours of flying instruction during 10 flight lessons. Graduates are completely qualified to operate the B-47 under all conditions of flight, and since the crews usually have considerable prior experience in bombardment aviation, their up-grading to combat readiness takes a minimum of time in their tactical organization. Three additional weeks of training in special weapons are added for aircrew members who are not qualified as bomb commanders. All B-47 observers get academic training in most of the specialized areas, but they do not fly with their assigned crew during the 40-hour transition course.

Aircrew B-47 students also undergo 17 days of survival, escape, and evasion training at the USAF Survival School at Stead AFB in the foothills of the Sierra Nevadas, where they learn the

*An F-89D fires a salvo from its armament of 104 rockets. The F-86D interceptor version of the famed Sabre, the F-94C Starfire, and the fantastically armed F-89D Scorpion, all first-line aircraft, are used by CrewTAF's Interceptor Training Complex in training aircrews. The present-day interceptor, called a night fighter in World War II, has come a long way since the days of the Beau-fighter and the P-61. Today's interceptors are jets, carrying air-to-air rockets as armament. They are controlled initially by a ground control intercept station and are vectored to the target area by the interceptor controller. When the airborne radar "sees" the "bogie," control of the interception is taken over by the aircrew on the airborne radar. In tactical operations it is probable that the interceptor pilot would never actually and visually see his target. After the target is located, the interceptor is flown by steering data provided by a computer. When the interceptor reaches an optimum position, the computer automatically fires the rockets. Interceptions are normally carried out from one side of the target to present a larger target area to the rocket salvo and to avoid the tail-cone armament of the bomber.*

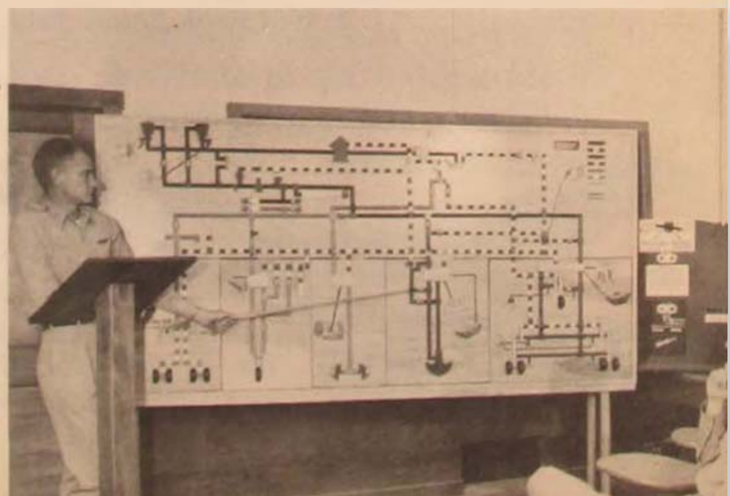


*Night sortie. A B-57 training mission heads into the sunset. The B-57 student puts in 25 hours flying time in the aircraft, preceded by 25 hours in the T-33. For the first B-57 transition lesson an instructor flies a chase B-57 to assist the student in adopting correct procedures. Except for a second solo mission the student pilot is accompanied by his observer on the remaining seven lessons, four of which are performed at night. Three night profile missions, which simulate all typical characteristics of a combat sortie, emphasize SHORAN bombing, with results determined by radar bomb scoring.*

fundamentals of tactical movement, camouflage, and the medical aspects of survival, the improvisation of survival equipment, the use of communications gear, and methods of aerial recovery. The course culminates in a 9-day survival trek in the Plumas National Forest of the High Sierras. Other aircrew trainees have survival training at their school bases.

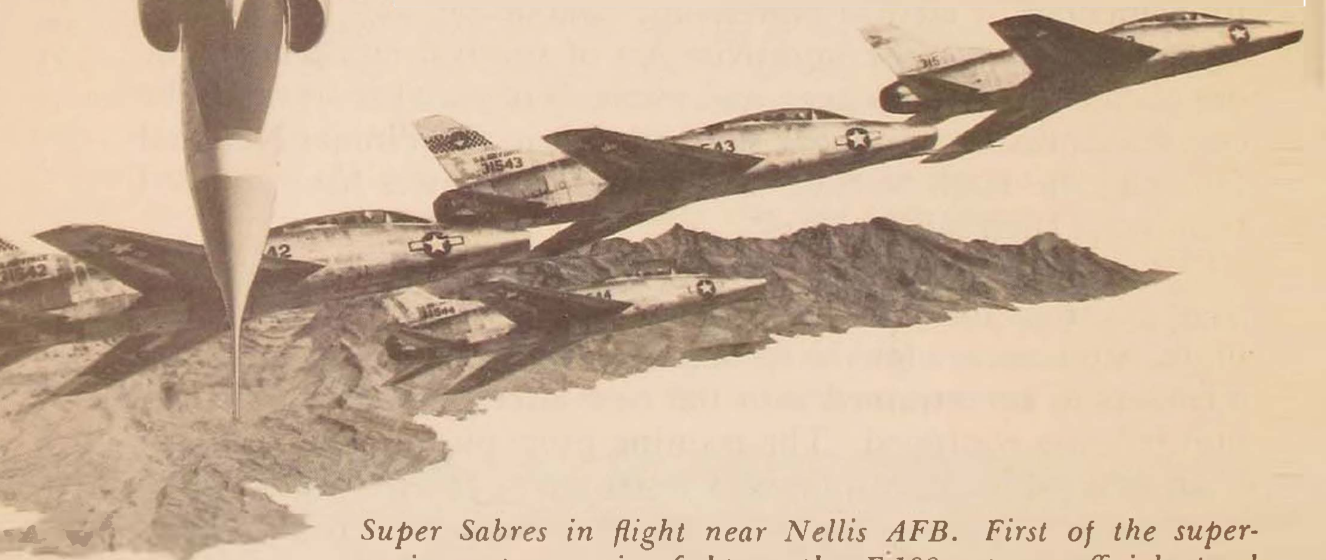
The Light Bomb, Jet (B-57) training course is a conversion program from the B-26 for Tactical Air Command and overseas units. Students are for the most part already trained combat crew members to be retrained into the new aircraft with which their unit is being equipped. The training program provides 25 hours of supervised jet transition and instruments in the T-33 and 25 hours of aircrew transition in the B-57. The T-33 flying training, together with B-57 academic training, takes up the first six weeks.

*The hydraulics system of the C-119. Specially fabricated training devices show the student what to do and what happens inside his airplane when he does it.*

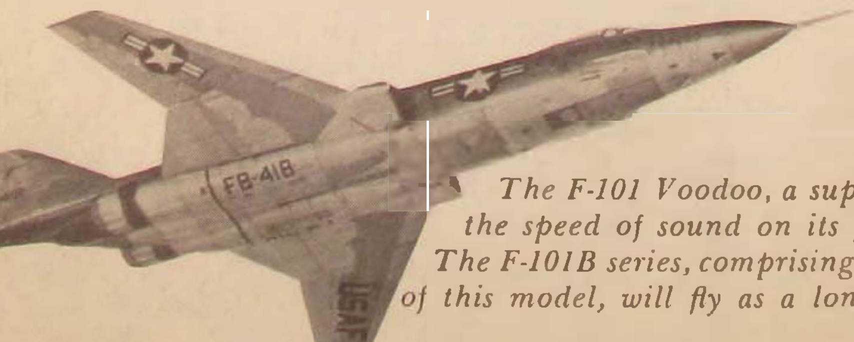


# First of the Century Series

*The F-102A delta-wing interceptor flew 20 December 1954. Speed, supersonic; ceiling, stratosphere.*



*Super Sabres in flight near Nellis AFB. First of the supersonic century series fighters, the F-100 set an official speed record for operational aircraft of 822.15 mph on 20 August 1955. Designed as an "air superiority" fighter, the F-100 has a ceiling over 50,000 feet and a range over 1000 miles. It is armed with 20mm guns. First flight date was 25 May 1953.*



*The F-101 Voodoo, a supersonic escort fighter, exceeded the speed of sound on its first flight, 29 September 1954. The F-101B series, comprising most of the production aircraft of this model, will fly as a long-range, two-place interceptor.*

One month on special weapons, basic survival, and B-57 flying training for both the pilot and the observer completes the course.

The Medium Transport Transition (C-119) course gives transition training in tactical equipment to newly graduated pilots but is not intended to qualify them as aircraft commanders. During the six-week program students receive 40 hours of flying training plus academic instruction in the aircraft, its equipment, and crew duties. No actual troop carrier missions are flown, but indoctrination in transport doctrine is given in academic training.

The Four-Engine Transition Training (B-29) is a 40-hour, 7-week course for recent pilot graduates who are to be assigned throughout the USAF to units requiring crew members for four-engine aircraft. Another similar B-29 transition course trains experienced pilots as potential aircraft commanders and pilots for further transition training in KC-97 aircraft and subsequent assignment to the Strategic Air Command in aerial refueling units.

## Crew Training With Century Series Aircraft

The F-100 Super Sabre Jet fighter is already being employed at Nellis Air Force Base for instructor training and training research and development. Soon the F-100 and F-101 fighter and interceptor and the F-102 delta wing interceptor will come into the regular combat aircrew courses for student training. With the century series aircraft we are entering a new training era with foreseeable, but as yet indefinable, training problems. Some of these problems, which we have been studying for over a year, are as follows:

(1) *Student training capability.* With certain flight characteristics of the century series aircraft more critical than those of previous jet aircraft, it is obvious that the margin for pilot error has become smaller, regardless of the simplicity of operation. As a result we do not now feel that the basic flying school graduate possesses adequate flying experience to qualify immediately for combat training in these aircraft. Since a transition vehicle of higher performance than the T-33 is needed to prepare the student for his century series training and no high-performance trainers are anticipated, current fighter or interceptor aircraft will be used to bridge this gap. Of course if two-place training versions of these aircraft become available, this concept may be changed.

(2) *Aircraft training capability.* A number of training problems are anticipated in this area that are typical of all new aircraft:

the limited experience of personnel, the high failure rate of aircraft parts, inadequate support of engines and parts, repeated aircraft groundings for technical order compliance, and frequent failures of systems associated with the new equipment and aircraft. In the past these conditions have inevitably resulted in low or extremely fluctuating utilization rates during initial years of operation. These problems are real; and they usually require outside help from Air Materiel Command. Our only approach to them is to try to foresee them and to keep our thinking and planning flexible.

Another major consideration is the suitability of the aircraft to perform the mission. Not all models will permit all the gunnery and bombing phases of fighter-weapons training that are considered necessary in producing a versatile fighter pilot. Finally, because of the cost of operation of the new aircraft, it appears to be more economical to provide basic fighter-gunnery training and tactics in present types before training in the century series.

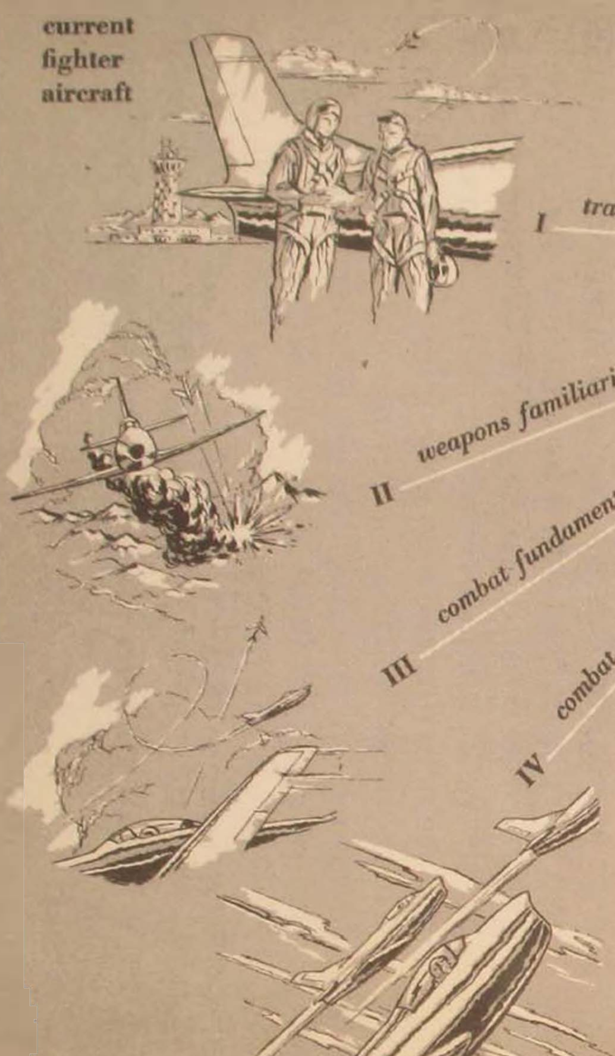
Our studies therefore indicate that it is most practicable to program a minimum acceptable amount of training hours in the new aircraft combined with continued use of present first-line fighters and interceptors. As the utilization rate of the new aircraft improves, as it always does, the program would shift a greater amount of time to be provided each student compatible with flying-hour and mission capability. This progress can be expected to continue until we have achieved the ultimate rate of utilization and can conduct the entire course with the new aircraft.

(3) *Quality of training.* At the present time the training standard of the optimum-quality course is geared to produce a combat-capable pilot with all the versatility that he will be expected to display in a tactical unit. Several years of experience have indicated that approximately 110 flying hours are required to produce a combat-capable fighter pilot and 80 flying hours to produce a combat-capable interceptor pilot. If we were perfectionists, and all people in the training business must guard against this extreme, and if economy of time and money were not essential, it would be possible to design a course to satisfy every conceivable training requirement. For example, combat flying training could reach 180 hours per course and require 8 to 9 months. This is obviously unrealistic. Considering the average term of active service of the average reserve officer as about four years, such a course would seriously reduce the time he could be used effectively in a combat unit. On the other hand an extremely short course that required the combat unit to engage in extensive individual

# Four-Phase, Four-Stage Fighter Training Concept

course training phases

current fighter aircraft



I transition (10 hrs)

II weapons familiarization (30 hrs)

III combat fundamentals (40 hrs)

IV combat capable (20 hrs)

course implementation stages

| a | b | c | d |
|---|---|---|---|
| 1 | 1 | 1 | |
| 2 | 2 | 2 | |
| 3 | 3 | | |
| 4 | | | |
| 5 | 4 | 3 | 1 |
| | 5 | 4 | 2 |
| | | 5 | 3 |
| | | | 4 |

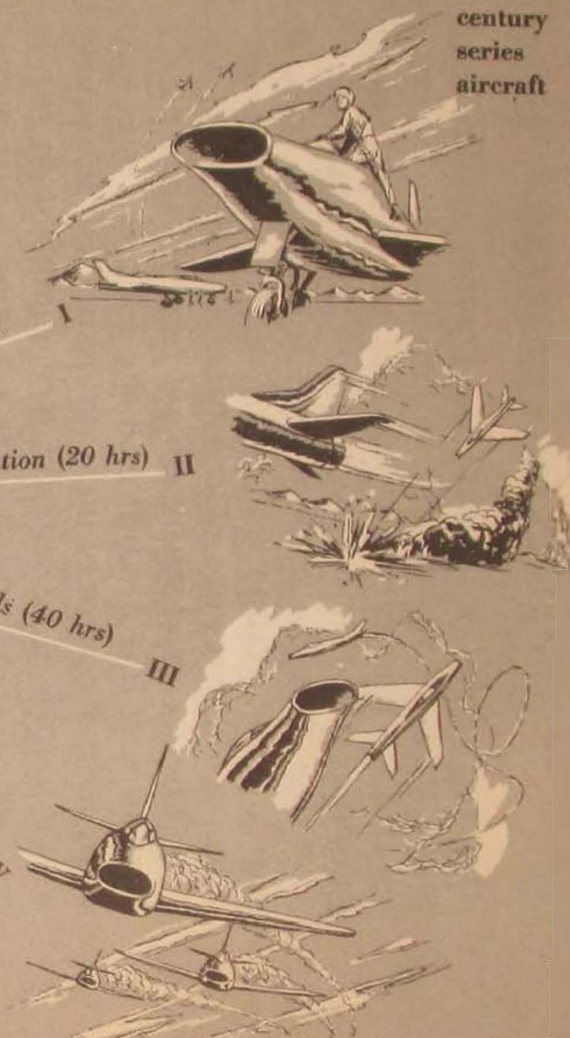
summary

| | | | | |
|---|---|---|---|---|
| current | 100 hrs | 80 hrs | 40 hrs | |
| century | 10 hrs | 30 hrs | 70 hrs | 110 hrs |

**Note:** Course training hours include 10 instrument training hours in T-33 aircraft.

course training phases

century series aircraft



I transition (10 hrs)

II weapons familiarization (20 hrs)

III combat fundamentals (40 hrs)

IV combat capable (40 hrs)

**Example:** During stage A the student is given, in consecutive order, all four phases of his training in the current aircraft. After this training is completed, he undergoes additional Phase I training in the century series aircraft.

training would jeopardize the combat readiness of our tactical units severely and would be equally unrealistic. We have been guided by the consideration that we should concentrate on the training that can be rapidly absorbed and intensively applied, knowing that the combat unit will always have the burden of carrying the graduate through the maturing process which only time or the pressure of combat can provide.

These considerations have resulted in a plan to use both a current first-line aircraft and the century series aircraft in a 110-hour fighter course of 90 training days. This course will produce a graduate who is initially well qualified in the fighter arts on an F-86 or F-84 and who has a good familiarity with the new plane. With minimum supervision he should rapidly be able to transfer his abilities on the old type to the new. As the capability of the century-series aircraft and its course flying hours increase concurrently, then during this flexible progression the amount of training to be provided in existing fighter aircraft will be the difference between century-series flying hours and the tactical course hours, which remain constant. This phasing in of century-series flying time is illustrated in the diagram of its four-stage implementation planned for the fighter program. The same considerations have led to a similar plan for phasing in century-series interceptors. These plans are admittedly compromises, but necessary ones, and no other plan promises to keep up with the demands of the Air Force program.

It should be clear by now that crew training has two major problem areas that are probably common to the entire Air Force—one is personnel, the other materiel. To accomplish the crew training mission there are two indispensables—experienced instructors and available flying hours. Our instructor experience is high at present, but we lose an instructor after a three-year tour and he is eagerly grabbed by a tactical unit. There is no similar eagerness in return to release to us experienced pilots for instructor duty. Consequently we are forced to train many of our own replacement instructors, sometimes using basic school graduates. This process must not be permitted to go too far, or a sort of inbreeding will inevitably lower the standards of the training and the product. And as crew training ceases to be rigorous and realistic, its major reason for being loses validity. A healthy rotation both in and out is the answer and deserves more emphasis from USAF and more recognition from the major commands.

The materiel problem is magnified by the variety of types of aircraft involved and by the phasing in of new aircraft. A controlled training operation does permit the attainment of utilization rates generally much higher than those achieved in tactical organizations. It is a type of operation ideally suited to specialized maintenance methods which have been adopted, generally along the lines of SAC's maintenance system. Even so, our aircraft have to be completely ready for combat-type operations, and the distinction between AOCP and ANFE* is usually a meaningless one as far as we are concerned. We are well manned in maintenance at present, but like the rest of the Air Force we suffer certain severe specialist shortages, especially in the higher electronic skills. The only way we have been able to live with these shortages has been through energetic on-the-job training. This problem may worsen in the future, but there are encouraging signs that despite the increasing complexity of electronics gear operationally, there will be improved reliability and simplicity of maintenance. We devoutly hope this will be true.

I cannot discuss the crew-training operation without expressing a tremendous admiration for the job that the maintenance people and instructors are doing. The pace of operations is terrific—500 jet hours a day, for example, at Luke or Nellis. The

*[AOCP: Aircraft out of commission awaiting parts. ANFE: Aircraft not fully equipped.—Ed.]

*Flight-line activity backs up intense flying training schedules. Aircraft take off from runways with almost unbelievable frequency. At Nellis Air Force Base, the world's busiest airdrome, jet fighters land or take off every 20 seconds of the working day. Parallel runways alleviate the traffic load. Total aircraft resources of the crew training program exceed 1600 airplanes, 90 per cent of them jets.*

pressure on the people is similar to that of actual wartime operations.

I must also express, for all of us associated with them, an unqualified respect for our students. There was a time not so many years ago when most of us would have questioned seriously the ability of new pilots to cope with modern high-performance jets. The performance of these young officers has in every way exceeded the demands put upon them. I personally feel that we may even be unduly conservative in our approach to the century series. We must, however, make every effort to safeguard lives and planes. Our major accident and fatality rate is understandably higher than the rest of the Air Force. In 1954, however, it was about half the 1953 rate, and 1955 shows further improvement. This improvement must continue, and therefore, regardless of the abilities of our young pilots, we must continue to improve methods, supervision, and standards. I am confident that our new pilots will meet the demands of the future, but the job of training them is a highly specialized job and requires a large investment of experience. This very expensive training job is militarily sound only if it provides a high-quality product to the combat units. The entire Air Training Command is dedicated to the support of this investment, because of a strong conviction as to the vital significance of the crew-training mission in maintaining the wings of the Air Force at the required standard of combat readiness in this atomic age.

*Headquarters, Crew Training Air Force*

## THE SEARCH FOR THE SHAPE OF ATOMIC WAR

### *In Exercises the Army and Air Force Test New Doctrine, Tactics, and Weapons*

A Quarterly Review Staff Study

A constant problem facing the jet-age strategist is the need to keep pace with the jet-age scientist in maintaining a modern, up-to-date air force as our first line of defense and as the major deterrent to world-wide Communist aggression. As science continues to add newer, faster, or fantastically more destructive weapons to our air arsenal, the strategist must come up with new concepts and doctrines for using the weapons. Once such concepts are evolved they must be tested, implemented by operational techniques and tactics, and all of this must be taught to those trained in the technical use of the weapons. For the best, most modern weapons that science may devise will be of little use if commanders and operators lack the understanding of the pertinent doctrine and concepts.

As the scientist has had to test and prove the new weapon, so must the strategist prove the validity of his latest strategic concepts and test proficiency in the weapon's use. This must be done quickly or the strategist will become hopelessly out of pace with science. Since the outcome of a future war likely will be decided within a few days, our air arsenal must be provided with the latest, proven doctrines, tactics, and weapons if we are to survive.

General Dwight D. Eisenhower, writing in the *Military Review* in September 1946, commented on preparation for future war:

> Time has been of the essence in warfare but never was it more essential than in our most recent war. With the introduction of atomic and electronic war and the astounding advance being made almost hourly in aerial warfare, the tempo is increasing in geometric progression. If war comes to us again the fact seems inescapable that we will not have time to train units before we are faced with the final issue of defeat or victory. Certainly it would be unconscionable to gamble on a fortuitous recurrence of the time to prepare bought by the blood of our allies in 1917 and 1942.

Despite scientific testing and theorizing it is in combat that weapons, doctrine, and techniques receive the most exacting evaluation. In conventional wars of attrition the factors of time and distance permitted an almost orderly wartime adjustment to change. But when the jet-atomic age ruled out such a wartime-evolutionary process, the scientist and strategist had to look for another method of proving weapons, techniques, and doctrine before D-day. The answer was found in an increased use of *field* or *command post* exercises. Both of these have become the principal means of a testing and evaluation program for weapons, doctrine, and techniques in the post-World War II period.

## Types of Exercises

THERE are two types of field exercises or maneuvers. In one the troops and armament and the airmen and aircraft of only one side are actually present. Those of the other side are imaginary or are represented by only a skeleton force. In the second type of field exercise both friendly and aggressor forces are actually employed. Both sides are allowed freedom of action within predetermined limitations. An umpire system is used to evaluate play and monitor its development.

Field exercises may be large or small. They may involve a single bomber crew solving a navigational problem, including air refueling and dropping a "bomb" under simulated combat conditions, or an entire Air Force command participating in a joint exercise with the Army and Navy.

Often a field exercise can be superimposed on a routine activity. For example, the routine movement of a Strategic Air Command bomber wing to a new base affords logistics and communications planners an opportunity to develop and execute a realistic combat exercise to test new concepts without special expenditure of funds. But all field exercises or maneuvers cannot be adapted to such situations. If particular features of a weapon are questionable or a theory of tactical doctrine is a subject of inquiry, the field operation may be especially tailored to simulate the combat condition under which the weapon or doctrine may be best evaluated.

Where it is merely theory or a current or revised concept that is being tested the command post exercise is generally used. The command post exercise does not employ units in the field. It is often labeled a "paper war" or a "map maneuver." Through a detailed battle scenario realistic combat situations are established. The participating players are given information relating to troops, logistical dispositions and procedures, troop and station

**Exercise SAGE BRUSH, the largest peacetime field exercise held in the United States since World War II, has focused public attention on the efforts of the Army and the Air Force to prepare for a possible future atomic war. Since the revolution in both air and land warfare brought about by the advent of nuclear weapons and supersonic aircraft has left us without battle-tested strategies and tactics to meet these new weapons, planners looked into the future in writing the scenario for Exercise SAGE BRUSH. In this changing environment it is generally recognized that the only valid tests of doctrine, strategy, and tactics for the future are the field and command post exercises. Such exercises have become the principal means of a testing and evaluation program to aid peacetime adjustment to change. The Editors of the *Quarterly Review* examine this program and its effect on preparedness for a future in which nuclear weapons may change the shape of war. Information on Exercise SNOWBIRD and LOGEX 55 came from final maneuver reports of the Alaskan Air Command and Office, Chief of Army Field Forces. Photographs of Troop Carrier operations in Exercise SNOWBIRD are from the Eighteenth Air Force.**

lists, operations and administrative orders, standard operating procedures, and similar information that would be known if an actual combat operation were in progress. Special situations are introduced at various intervals in the play of the scenario to get player reaction and to evaluate understanding of doctrine. Such situations might include surprise chemical attacks, guerrilla activity, atomic attacks, etc. As in the field exercise, an umpire system evaluates play and monitors the development of the command post exercise.

Since one of the primary purposes of the command post exercise is to test newly proposed or radically different concepts, both planners and players accept the new concept without reservation, subordinating previous knowledge, experience, and personal ideas to a true and complete portrayal of this concept as written and interpreted. While no field units are employed, an exercise of this type is not necessarily a small operation. Several thousand men may take part in a "paper war."

A field or command post exercise is usually initiated by directive from higher authority. The directive includes information basic to the planning of the particular exercise—the type of exercise, the ground situation, air missions, target types and priorities, chain of command, and the tactical principle to be stressed. The directive also establishes the purpose, duration, and scope of the exercise.

Both the field and command post exercises can serve their purpose of proving, training, and evaluating only if the scenario is carefully and realistically prepared, if it is carefully monitored by umpires, if it is carried out forcefully and enthusiastically as one complete operation, and if it is ended with a comprehensive and well-planned critique. The over-all value of the exercise will vary directly with the realism according to which the combat conditions are simulated.

The key part of a scenario is the *general situation*. Here are stated the facts known or assumed to be known to both the friendly and aggressor forces, facts that would be known if the exercise was really a combat situation. Thus the participant is able to assume his place in the exercise with a logical background for the action that will proceed from the *initial situation*.

The scenario for the initial situation is written so that its solution will properly set the exercise in motion along the devised lines. The statement of the initial situation is logical, brief, and as simple as possible. Yet it includes all the information needed to solve the situation accurately. It must be presented in such a way that the element of surprise will not be eliminated. The initial situation concludes with a message, an order, or a statement of a particular enemy threat or action that forces the commander to make a decision, execute a decision that has been made, or do both.

In most instances solving the initial situation will not provide all the action necessary to evaluate fully a theory or revised concept or to train the participating players. Further training and testing is accomplished by introducing situations that are logical developments of the initial situation. These may be generally termed *concurrent situations*.

The nature of the concurrent situation is such that it can provide the training or testing it calls for without introducing an entirely new situation into the exercise. It is merely superimposed on one or more of the major situations. For example, a unit in the play of the exercise is told that the aggressor has knocked out the primary communications system, forcing the unit to demonstrate its proficiency in using an alternate system. Thus the training requirement is accomplished without material interference with the situation in progress.

Each situation in the play of the exercise must have at least one *requirement* and one *solution*. The requirements are for the use of unit leaders and their staffs participating in the exercise. They indicate what is expected of the participants. The solution for each requirement, as prepared by the planner, establishes a standard by which the efficiency of any unit playing the exercise can be measured—it is not an absolute. Almost any requirement will have more than one logical solution.

A field or command post exercise consists of several closely related phases: a troop or player orientation, a situation or situations, and a critique. Each phase has a definite objective and varies in importance with relation to the exercise as a whole. Each phase is assigned a running time consistent with its importance to the entire exercise. Thus the running time of the combined phases equals the specified running time of the exercise.

In either the field or the command post exercise the play is controlled by a group of umpires under a chief umpire. Participants are completely orientated to the general situation, including the identification or marking of friendly and aggressor aircraft, personnel, and vehicles, the methods of enemy representation, safety and ground rules, etc. It is especially important that the participants fully understand that missions will be carried out and decisions made according to the doctrine or concepts established for the particular exercise.

When an exercise has progressed to its logical conclusion or has reached a point where it would be of no further benefit to continue, the chief umpire notifies the exercise commander to assemble his players for a critique. The chief umpire conducts the critique, beginning with a brief outline of the purpose of the exercise, the initial situation, and the developments of the exercise as it progressed. Successful and well-executed actions and decisions are praised. Poorly executed actions are criticized. Both favorable and unfavorable comments are illustrated or supported by reference to specific actions or situations. In discussing an error or faulty judgment the possible consequences in actual combat are explained and a logical solution suggested. The entire critique is limited to the major concepts, doctrine, training, or weapons or weapons system that the exercise was designed to illustrate. It ends with a summary stating whether or not the purpose of the exercise has been accomplished or how well the doctrines and concepts have stood up under test.

From the number of field and command post exercises held by the military services in 1955, we have selected one to illustrate each type—LOGEX 55 for the command post exercise and Exercise SNOWBIRD for the field exercise. Both exercises will be examined from two levels: (1) the operational level, and (2) the planning level.

Of these two levels the first, or operational level, is of least concern, since it deals with techniques and equipment. The problems on this level may be numerous and it is of course necessary to discover them. But because they are more readily apparent, they are identified and corrected almost automatically. It is at the planning level that the ultimate value of an exercise is truly measured. And since a future war of any size will require a great deal of joint Army-Air Force action, it is very necessary that these two services, by participating in peacetime in joint exercises such as LOGEX and SNOWBIRD, should develop doctrines, strategies, and tactics that are mutually supporting. Do these two exercises, as planned and played, reflect disparities between views of the Army and the Air Force—or between commands in the Air Force—on the nature of atomic war or on doctrinal issues—disparities that as yet have been unrecognized or unreconciled by our military planners?

## Command Post Exercise: LOGEX 55

LOGEX, a command post exercise, is held annually under the direction of the Office, Chief Army Field Forces, Fort Monroe, Virginia. The responsibility for planning and conducting the exercise rotates among the Army Technical Services. LOGEX 55, held at Fort Lee, Virginia, from 2 to 7 May 1955, involved more than 5000 student officers, technical and administrative school umpires, and support personnel. In a six-day hypothetical battle it tested the ability of student officers to keep a hypothetical field army of 400,000 men fighting under all the pressures of modern war and to evaluate new concepts of logistical support. Guided missile attacks, guerrilla raids, atomic explosions, and a powerful aggressor army were tossed in the path of the players. Umpires both above and below the established chain of command controlled and directed the exercise.

When the Army requested Air Force participation in LOGEX 55 the stated purpose of the exercise was to train students in the advanced classes of the Army technical and administrative service schools, presumably in currently accepted doctrine and concepts. As planning progressed it became apparent that the Army wanted primarily to test the feasibility of new ground force logistic doctrine and organization within a theater of operations. The new concept of logistic support was designed to relieve the combat commander from many logistic responsibilities held in the past and to provide new methods to speed the flow of supplies and services.

But these concepts had been molded only in accordance with the Army's own capabilities and patterns of operations. In some cases they conflicted with joint regulations and mutual agreements. And the fact that the chosen "Theater of Operations" was an extremely limited geographical area placed the Air Force in the position of having to tailor its organization and operations to a pattern established by the Army rather than functioning on a coequal basis.

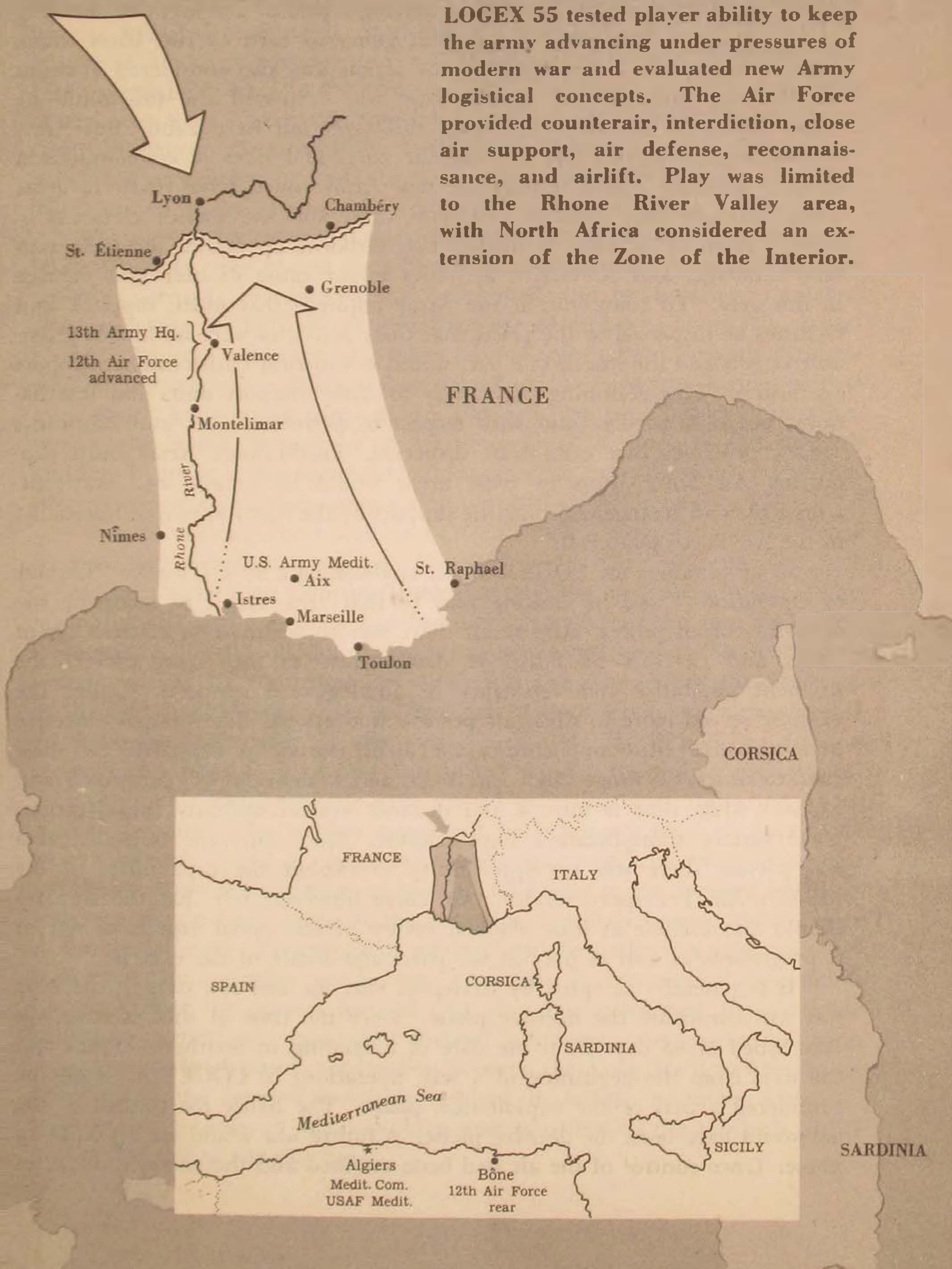
The Air Force had five general objectives in participating in LOGEX 55: (1) to provide Air Force participation in accord with Air Force doctrine, capabilities, and limitations; (2) to provide integrated and coordinated actions between Army and Air Force for interservice support, to make known Air Force logistical support requirements to the Army, and to carry out Air Force missions and functions; (3) to cooperate with the Army to initiate a feeling of understanding and confidence; (4) to associate Air Force officers with those of the other services to gain a clearer understanding of surface-force problems; and (5) to provide a possible supplement to instruction presented by Air Force representatives at Army Technical Service and administrative schools. Actually the Air Force portion of the exercise was intended to develop interservice mutual support between the Army and the Air Force. There was no attempt to make any play between Air Force units, except that necessary between air terminals and control centers to develop and control airlift and aeromedical evacuation.

The "Theater of Operations" for LOGEX 55, established some eight months before the exercise was played, was an area approximately 90 miles wide and 120 miles deep in Southern France, designated the Western Mediterranean Theater of Operations, with North Africa an extension of the Zone of Interior. This area had been played in previous LOGEX's during the past five or six years. The time of the play was D plus 63, counting from the date of the landing in Southern France. The date from the beginning of the war was approximately D plus 630. The Army concept presupposed that a United States Tenth Field Army had broken out of Normandy. In the exercise the United States Thirteenth Field Army was to come up the Rhone River Valley and link up with the Tenth Army at Lyon. The scenario also called for Free French Forces to attack from the area north of the Pyrenees. Since a test was being made of new Army logistical concepts, difficulties would have arisen in placing a support command in Normandy in addition to the one in the exercise area. Therefore the United States Tenth Field Army was changed to an Allied Army not requiring U.S. support. This Army had no part in the exercise except to serve as the other prong in the eventual link-up at Lyon. The Air Force was to provide counterair, interdiction, close air support, air defense, reconnaissance, aeromedical evacuation, and theater airlift operations.

This latest LOGEX marked the first time that the Air Force had been represented in the early planning phase of the exercise. But the representation still came too late to coordinate the selection of an objective area, although at Air Force suggestion a few changes were made in the theater concept. For example, the theater was enlarged somewhat to permit the deployment of tactical air forces throughout the Mediterranean. Air Force units were deployed in Spain, North Africa, and the Mediterranean islands, as well as in the objective area (Southern France), to reduce their vulnerability to nuclear attack. The Air Force suggested that a European Command, regarded as having been in existence prior to aggressor actions, be established and relocated in North Africa. The Commander of the European Command could then direct and coordinate the efforts of the various military forces in seeking the common objective of reoccupying Europe. This suggestion was not accepted, although a unified command headquarters was moved

# Concept of Operations - LOGEX 55

**The LOGEX 55 scenario stipulated that the U.S. Thirteenth Field Army had landed in Southern France and was moving up the Rhone Valley to meet an Allied army from the north at Lyon. LOGEX 55 tested player ability to keep the army advancing under pressures of modern war and evaluated new Army logistical concepts. The Air Force provided counterair, interdiction, close air support, air defense, reconnaissance, and airlift. Play was limited to the Rhone River Valley area, with North Africa considered an extension of the Zone of the Interior.**



to North Africa along with theater air force and theater navy. Theater army remained in Southern France to coordinate actions of field army and support command.

Air Force tactical units in the objective area included three flights of fighter-interceptors on separate bases, and a squadron of reconnaissance aircraft on still another base. Since the Air Force is dependent upon the Army for a considerable amount of its logistic support, it attempted to test the flexibility of Army support action by moving a part of a fighter-bomber wing to the objective area with a squadron going to each of two bases where fighter-interceptors were located. This action was also considered a means of reducing vulnerability. If one base was destroyed the loss could be "absorbed" and the Air Force could still carry out its mission. But Army support concentrations left the rear air bases and lines of communication open to guerrilla attack. Under the new Army concept the rearward areas would contain only lines of communication and the service elements to operate them. The Army recognizes that airborne operations, guerrilla warfare, sabotage, and subversive activities might cause disaster and damage in this area. To counteract it the Army required that units, supplies, and facilities be dispersed to the point that these activities were no longer profitable targets and the loss of one part would not disrupt entire combat support operations. This reasoning may apply to Army support units and installations, but it is hardly valid with respect to petroleum, oil, and lubricants (POL) pipelines that cannot be dispersed. Furthermore Army units supporting Air Force units in these areas would be remote and scattered. Under such an arrangement, logistic support by the Army appeared unreliable to the Air Force planners.

Army planners for LOGEX 55, in establishing a 90 x 120 mile "Theater of Operations," and in limiting play to that area, failed to recognize the flexibility of air power. As a result there was no adequate or efficient use of airlift and LOGEX 55 failed to demonstrate to the Army players the inherent flexibility and versatility of air logistical support. Rather the exercise served more to stress air power's limitations. The limited objective area provided little opportunity for airlift forces to capitalize on their characteristics of range and speed in aerial delivery of personnel and logistics when time is limited and distance and accessibility considerations make surface transportation impracticable. Since only the objective area was played, there was no opportunity to exploit the capabilities of the Military Air Transport Service. Air Force observers felt that the scenario should also include at least a token review of the global aspects of war as it progressed, as well as play in the particular locale of the exercise.

It is generally accepted by strategists that the first few days of the next war will constitute the decisive phase. Since the time of this exercise was established at 63 days from the date of a landing in Southern France and 630 days from the beginning of a war, operations in LOGEX 55 might be considered a part of the exploitation phase. The battle for control of the air would have been the decisive phase. A future war would see no build-up phase. Once control of the air had been attained and the enemy's air forces in-being were destroyed, it is questionable if an exploitation phase, as played in LOGEX 55, would be required. Also, at D plus 630 it was practically impossible to present the benefits derived from a Strategic Air Command bombardment of the aggressor's heartland.

The Air Force provided a staff of 38 officers and 10 airmen to guide the Air Force play of LOGEX 55. This staff was the largest Air Force participation in any LOGEX, not only in numbers but also in Air Force command representation. Such representation enabled more Air Force personnel to acquire knowledge of Army organization, procedures, and doctrine. The scheme of Air Force participation in LOGEX 55 was to send representatives from operational areas and instructors from Air Force schools. Air Force officers who were students at the Army Medical Field Service School were used primarily in the medical evacuation and air terminal play. Some Engineer Aviation units were played by Army engineer officers from the advanced officer courses at the Engineer School, Fort Belvoir, Virginia.

Throughout the exercise it was difficult to generate play at the operational level. Umpires were placed both in top command roles, where interservice policy is normally coordinated and established, and in the lower unplayed echelons where the bulk of the actual routine of support is normally accomplished. Players found they were often passing information through channels without formulating policies and decisions or planning the action needed to provide the required support. In addition, the geographical limitation of play eliminated deployment of Air Force units in numbers and strength sufficient to generate any appreciable impact on the Army support capabilities. With few exceptions, there were no opportunities for interservice play.

Most of the Air Force staff at LOGEX 55 was assigned to airlift and aeromedical evacuation functions. This was due to the requirement to staff a Transport Movement Control Center, air terminal, and aeromedical evacuation units. These functions had been controversial in the past and since there was less likelihood that Army personnel would be familiar with these procedures, the Air Force planners decided to give them particular emphasis.

Inasmuch as all flights on the first day of the exercise were preplanned on the operations order in the scenario the Air Force honored routine requests even when they were not submitted through the proper communications channels. These requests were treated as emergencies and acted upon. Numerous requests for patient movement by helicopter in the coastal area were approved. Some of these movements were not true evacuations but were movements of patients so as to free bed spaces in the forward hospitals and to generate bed spaces in the receiving hospitals located to the rear in the coastal areas. This repeated sorting kept the patients moving in small hops rather than directly to the rear. Through the Aeromedical Evacuation Liaison Officer the players learned that they had consumed the available helicopter aeromedical capability without achieving true evacuation from front to rear. Inadequate coordination between the Army Medical Regulating Officers and the forward hospitals resulted in failure to move patients—represented by cards—to the airfields in time to utilize all the available airlift on the first day of the exercise.

Since LOGEX is a logistical command post exercise, using no troops in the field, tactical assumptions and situations introduced by the scenario must be all the more valid if the players and umpires are to derive full benefit from the exercise. Air Force representatives felt that the scenario for LOGEX 55 lacked realism in its treatment of tactical air capabilities and deployment, indicating Army misunderstanding of air power. Twice during the exercise the *concurrent situation* subjected friendly forces to atomic attack, once against port facilities at Marseille and the other against an armored division on the front line. Both bombings resulted in extensive damage and heavy casualties. But in the case of the Marseille bombing, the exercise was over before the full impact of the attack could possibly be felt. Participants at the operational level of the exercise derived some immediate training benefit from the attack, through having to reestablish communications and transportation facilities and providing medical care for disaster victims, but it is difficult to see what benefits could accrue to the planning levels. It was the opinion of the Chief Air Force Umpire that, throughout the exercise, logistics problems arising from such attacks were not sufficiently stressed. The question also arises as to the validity of any assumption that the aggressor would be able to employ nuclear weapons as late in the war as D plus 630.

The Chief Air Force Umpire at LOGEX 55 pointed out that although the USAF is not evaluating the Army's new ideas and concepts, the Air Force is interested in Army organization and support capabilities. Every effort should be made to assist the Army in developing realistic situations in the problem. LOGEX should be continued as an Army exercise with the USAF providing participation in line with Air Force doctrine, capabilities, and limitations and placing requirements on the Army for support of the Air Force.

The Army has announced that the locale of the next logistics exercise, LOGEX 56, has been tentatively established in Europe. It is to be played with two United States armies along a line near the Rhine River. A European Command and component headquarters will be located in northeast Spain. The play is to start at approximately D plus 240 from the beginning of the war. The advance will cover considerably more ground than in LOGEX 55. Air Force units may be deployed in the United Kingdom, Europe, and North Africa.

In such an arrangement for LOGEX 56 the question again arises regarding the validity of the time of the play of the exercise. While D plus 240 is a reduction from LOGEX 55's D plus 630, a decision should still be made regarding the decisive phase and considering the Army exercise as the exploitation phase. For LOGEX 56, as in LOGEX 55, there exists the questionable assumption by Army planners that an aggressor would be able to employ nuclear weapons as late in the war as D plus 240.

One of the recommendations of the Chief Air Force Umpire at the end of LOGEX 55 was that consideration should be given to changing the concept of a general war situation to one of a logistical exercise involving a peripheral war of limited scope. While the United States must be prepared to fight an all-out intercontinental war—to fail to be so prepared would be suicidal—the likelihood of a war of such proportions is becoming more and more remote. Conversely the threat of limited wars has apparently increased. It would seem profitable for the Army, Navy, and Air Force to engage in a logistical exercise involving a peripheral war of limited scope in an area such as Thailand, Malaya, Burma, Indo-China, Indonesia, or Korea. A problem played in such an area would require more and better logistics planning, since neither resources nor an elaborate transportation network would be available as they were in LOGEX 55 and in the proposed LOGEX 56 European area.

## Field Exercise: SNOWBIRD

SNOWBIRD, one of a series of cold-weather, joint Air Force-Army *field exercises* actually employing both friendly and "enemy," or aggressor, forces in the play of the exercise, was held in Alaska from 10 January to 10 February 1955. The exercise was initiated by the Alaskan Command (Alaskan Air Command and United States Army Alaska) and directed by the Commander, Alaskan Air Command.

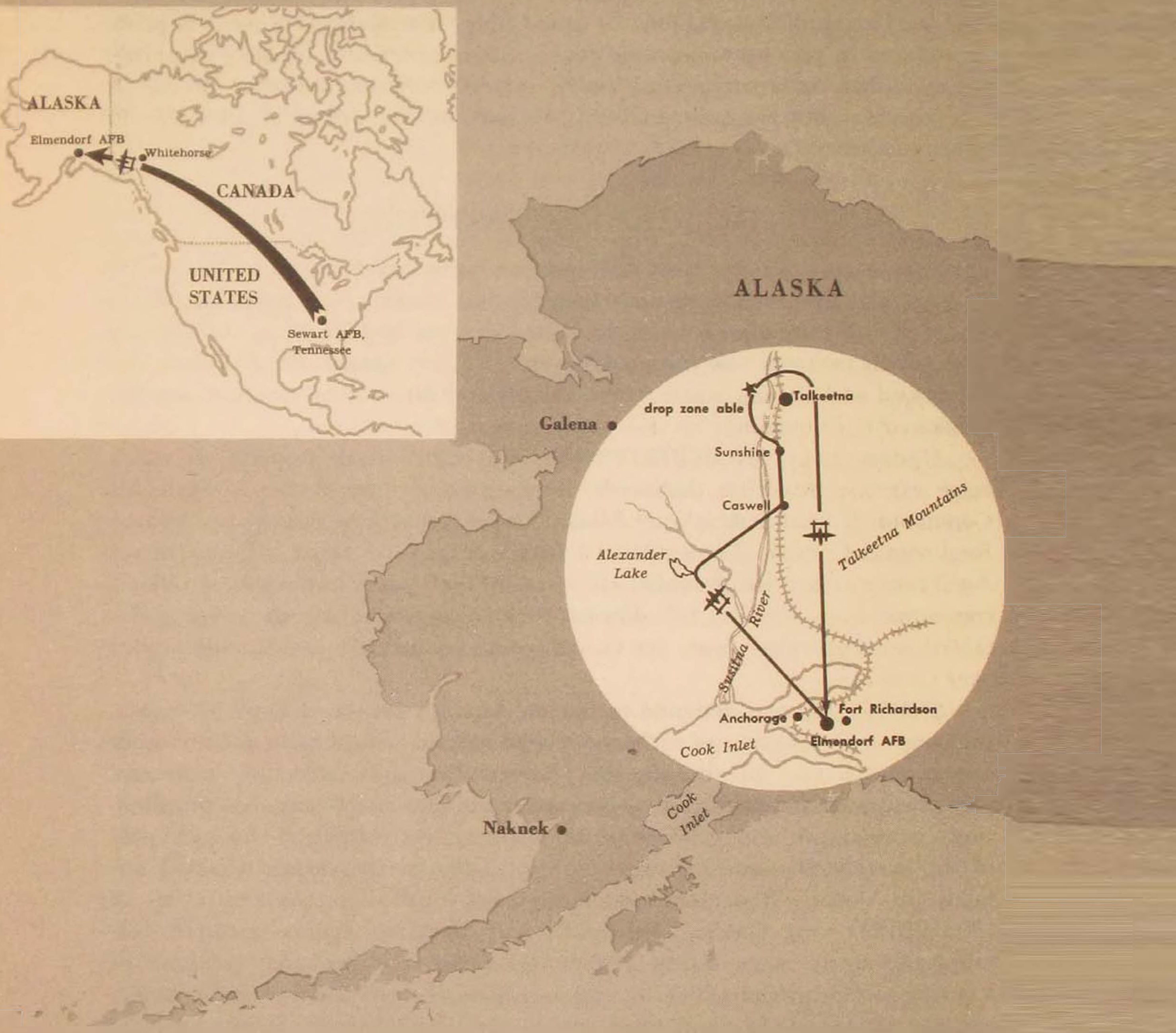
Operationally, SNOWBIRD was a joint effort in all respects. It was a large exercise involving thousands of officers and men of the Alaskan Air Command, United States Army Alaska, and a completely equipped Airborne Regimental Combat Team airlifted from the United States. The Military Air Transport Service provided air weather, air rescue, and airways and air communications service. In addition the Royal Canadian Air Force maintained and operated bases in Canada and cooperated in clearing flights over Canada.

SNOWBIRD was designed to test the total air-ground defense of Alaska, the combat effectiveness of airborne troops in cold weather, the cold-weather operating efficiency of aircraft, the practicability of constructing snow-compacted runways for tactical air operations, and the effectiveness of coordination between air and ground units. The general situation for the play of the exercise showed that aggressor forces had seized certain isolated airfields in Alaska. The areas under aggressor control at the beginning of SNOWBIRD were Galena, Talkeetna, and Naknek. Aggressor forces, battalion-size units, were holding these areas for the probable purpose of securing airfields from which to stage missions against other areas in Alaska and against targets in the United States. For the maneuver it was assumed that the USAF had gained air superiority over the Alaskan area.

The scope of Exercise SNOWBIRD included the movement of an Airborne Regimental Combat Team, 3000 men with their field equipment, vehicles, and weapons, some 3200 miles from Sewart Air Force Base, Tennessee, to Alaska; the commitment of this force in a tactical problem in Alaska; and the return of this organization to its home base.

While it contributed to the exercise, the actual movement of the Airborne Regimental Combat Team from the Zone of Interior to participate in

# Concept of Operations - SNOWBIRD




**According to the scenario for Exercise SNOWBIRD, aggressor forces had seized isolated areas in the vicinities of Galena, Talkeetna, and Naknek, Alaska, for the probable purpose of securing nearby airfields from which to stage missions against Alaskan bases and against targets in the United States. The aggressors, played by Alaska-based units, were to be dislodged by an Airborne Regimental Combat Team that had been airlifted from Tennessee (see inset) and were operating from Elmendorf AFB. These friendly forces were airlifted to Talkeetna to secure an airhead, construct a snow-compacted runway, and defend the airstrip against aggressor forces moving overland from Fort Richardson (see enlarged area). Operations at Galena were canceled by bad weather. Time and economic limitations canceled the Naknek phase.**

SNOWBIRD and the return of the Team upon completion of the operation was not considered a part of SNOWBIRD. This portion was considered an administrative and training maneuver of the Eighteenth Air Force and the Tactical Air Command, and was called TACAIR 55-3. Thus we had an example of one field exercise being superimposed upon and growing out of the requirements of another field exercise. The mission of the Eighteenth Air Force was to train in arctic operations, survival, and rescue, after arrival in Alaska but before participating in SNOWBIRD. Once the exercise was under way the transport units of the Eighteenth Air Force were placed under the control of the Commander, Alaskan Air Command for the duration of SNOWBIRD.

The original SNOWBIRD scenario showed three specific situations and called for the exercise to be conducted in three consecutive phases, each with its own D-day. The problem in Phase I called for one Battalion Combat Team to conduct an airborne assault at Galena on D-day to reduce the aggressor holdings and to prepare the airfield there for arrival of reinforcements. On D plus 2 the other two battalions of the Airborne Regimental Combat Team would be airlanded at Galena to destroy aggressor resistance. Phase I was scheduled to end on D plus 3.

In Phase II the scenario showed a requirement for the construction of a snow-compacted runway in virgin territory to increase the operational effectiveness and capability of the Alaskan Air Command. To achieve this one Battalion Combat Team would be paradropped on D-day in the vicinity of Talkeetna, Alaska, to secure the area selected for the airstrip and to defend the area against aggressor attacks. The Battalion Combat Team would be reinforced by a company of airborne engineers who would begin the construction of the snow-compacted runway. On D plus 2 the remainder of the Airborne Regimental Combat Team would be airlanded on the new snowstrip at Talkeetna to reinforce the assault battalion. Engineer Aviation forces were to accompany the reinforcements to assist in completing the snowstrip so that fighter aircraft could be accommodated.

Aggressor forces for Phase II consisted of two battalions proceeding from Fort Richardson approximately 60 miles overland to the Talkeetna area to reduce the friendly hold and disrupt the construction of the runway. Phase II was to end on D plus 4.

The situation in Phase III called for an aggressor force of one battalion to be in control of King Salmon Airfield and surrounding territory at Naknek. The mission of the friendly force: using one Battalion Combat Team, dislodge the aggressor and recapture the airfield. On D plus 2 the remainder of the Airborne Regimental Combat Team would be airlanded at King Salmon Airfield to reinforce the friendly assault force and to destroy the aggressors. Phase III was to end on D plus 3.

For all three phases of Exercise SNOWBIRD aggressor forces were selected from organizations stationed in Alaska under the control of the Commanding General, United States Army Alaska. For Phase I, one Battalion Combat Team would be prepositioned at Galena, Alaska. For Phase

II, two battalions would proceed overland from Fort Richardson to Talkeetna. For Phase III, one battalion would be prepositioned at King Salmon Airfield.

All three phases of the exercise could not be carried out. Phase III was canceled before the exercise got under way because it would extend SNOWBIRD beyond the 30-day time limit established for Tactical Air Command forces to be in Alaska and would also cause an extension of the number of flying hours allocated to SNOWBIRD.

Phase I of SNOWBIRD, calling for an airborne assault on Galena, was postponed 24 hours from the scheduled 24 January D-date and then canceled entirely when it developed that weather conditions en route to Galena were not favorable for formation flying under the peacetime operational standards in effect.

Phase II, beginning with the paradrop at Talkeetna, got under way on 28 January at 0900 hours. Less than seven hours later 110 troop carrier sorties had been flown, 107 of them effective. Two battalion combat teams had been delivered to the Talkeetna area along with 131.1 tons of equipment. In addition 12 friendly and 9 aggressor armed reconnaissance sorties were flown. On D plus 1 a third battalion combat team was delivered, adding 515 men and 86.3 tons of equipment to the force at Talkeetna. The same day 16 armed reconnaissance sorties were flown in support of friendly forces and 2 in support of the aggressors. Action on D plus 3 was limited to armed reconnaissance sorties, 28 for the friendly forces and 17 in support of the aggressors. On 31 January 14 C-119 sorties were flown to resupply friendly forces with 51.5 tons of equipment. Air strikes for both friendly and aggressor forces were furnished by units under the Alaskan Air Command.

Construction of the snow-compacted runway was designed to be a part of Phase II. The scenario called for work to begin on D-day by Army units. Since much of the equipment planned for use was not air transportable, a considerable amount of prepositioning was necessary. The equipment included eight bulldozers; three road graders; ten drags, disc harrow, and pneumatic-tired rollers; and two pulvimixers, used to mix and heat snow so that it could be compressed to a hard surface. By D plus 2 a 6000-by-100-foot snowstrip was to be ready. On D-day the free air temperatures were abnormally high and the heavy equipment used in snow compaction broke through the subsurface. But on D plus 3, 3500 feet of runway was declared operational and a C-47 made a test landing. The strip was not considered safe for heavier aircraft. By D plus 12 the temperatures had dropped and the subgrade stabilized to a degree that the runway was thought capable of supporting C-124 aircraft. No test landings were made.

Final reports of Exercise SNOWBIRD from the Alaskan Air Command indicate that observers there felt the exercise had been successful from the standpoint of meeting its objectives. But the weather situation modified the results. Abnormally high temperatures prevented aircraft and personnel from being subjected to prolonged periods of extreme cold. Thus a question remains concerning the degree of operational capability that could be expected when temperatures drop to -20°F. or below.

A FIELD exercise such as SNOWBIRD is the closest approach to the actual combat condition and as such constitutes the basic method of testing, training, and evaluating in peacetime. But it must be realistically planned and realistically carried out. During World War II the consensus of overseas commanders was that men sent overseas from training bases had not been taught how to fly and fight as hard as they would have to do in actual combat. They had been trained to fly and fight safely. When these men reached the combat theaters they had to undergo further training because the training in the U.S. did not nearly simulate normal combat conditions.

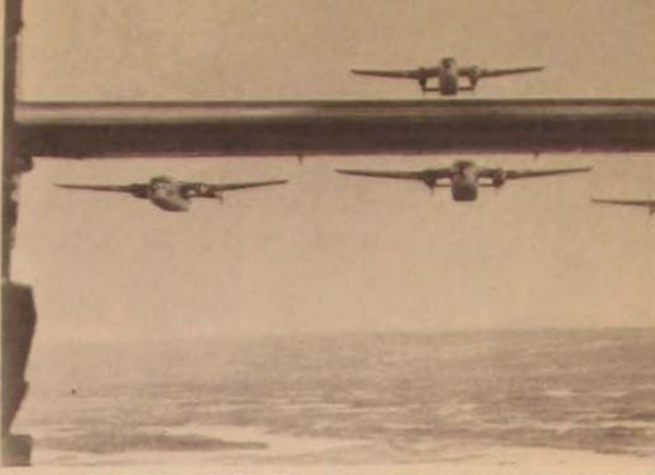
Had normal combat conditions been simulated in SNOWBIRD, Phase I, the airborne assault on Galena, would not have been canceled. The troop transports would have gone through the mountain pass, or over it, despite the rather hazardous weather conditions during the day. Or the troops would have made a night drop when the weather was more favorable. But early in the exercise it had been determined that peacetime operational restrictions would be in effect during the play of the exercise. It is true that greater emphasis on training under more rigidly simulated combat conditions might increase the risks of accidents during peacetime, but such training would decrease the accidents and casualties in a combat theater in time of war.

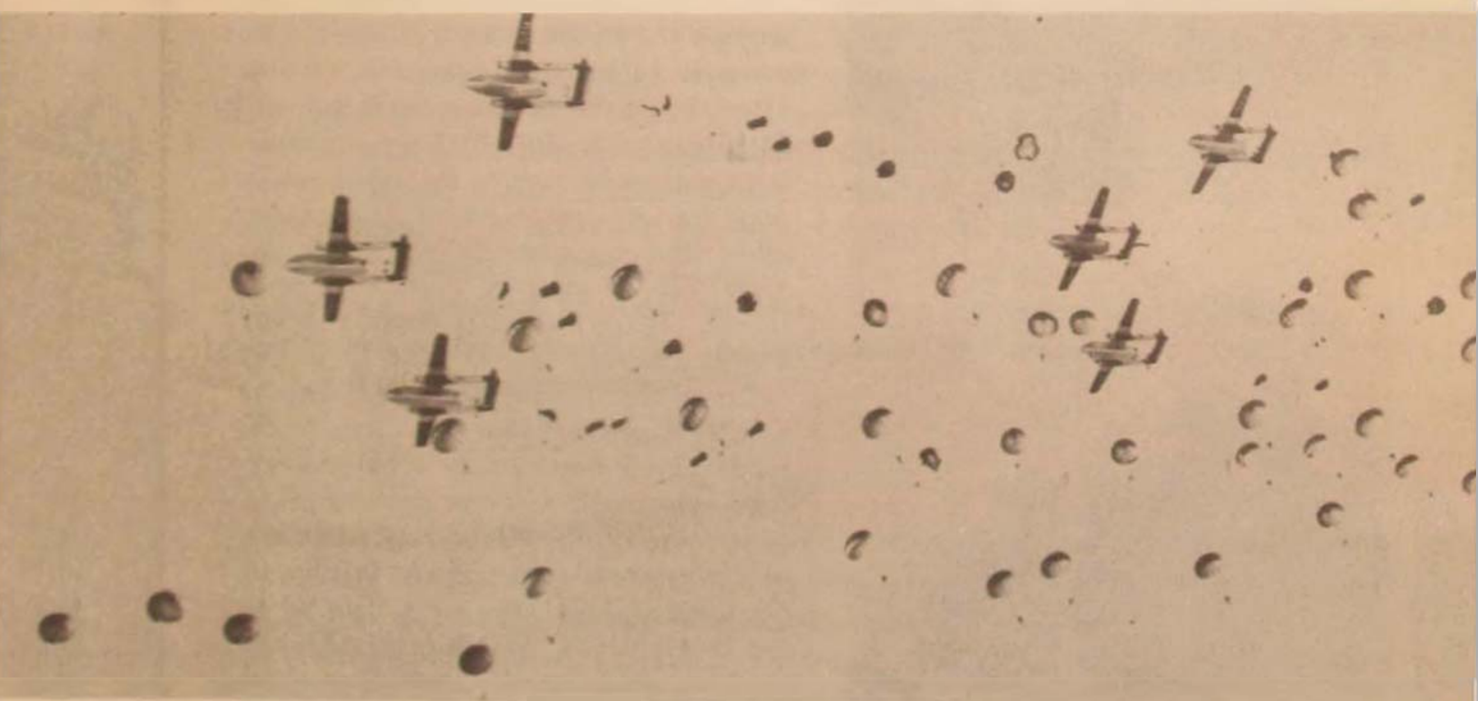
While SNOWBIRD was a joint exercise from the operational standpoint, the planning staff included only those participating agencies assigned to Alaska. Some months before SNOWBIRD was played, representatives of Tactical Air Command, Eighteenth Air Force, and Army airborne forces had developed a new concept for airborne operations that eliminated requirements for formation flying in delivering troops to airheads. The new concept calls for "spoke" missions in which a small number of aircraft converge on a drop zone from different directions at a specified drop time. Since it eliminates the need for formation flying, this technique is not greatly affected by bad weather and does not require the maneuvering of large numbers of aircraft. Thus adverse weather in all probability would not have caused the cancellation of the airborne assault on Galena had a representative of the Tactical Air Command or the Eighteenth Air Force, acquainted with the latest techniques, been asked to participate on the SNOWBIRD planning staff.

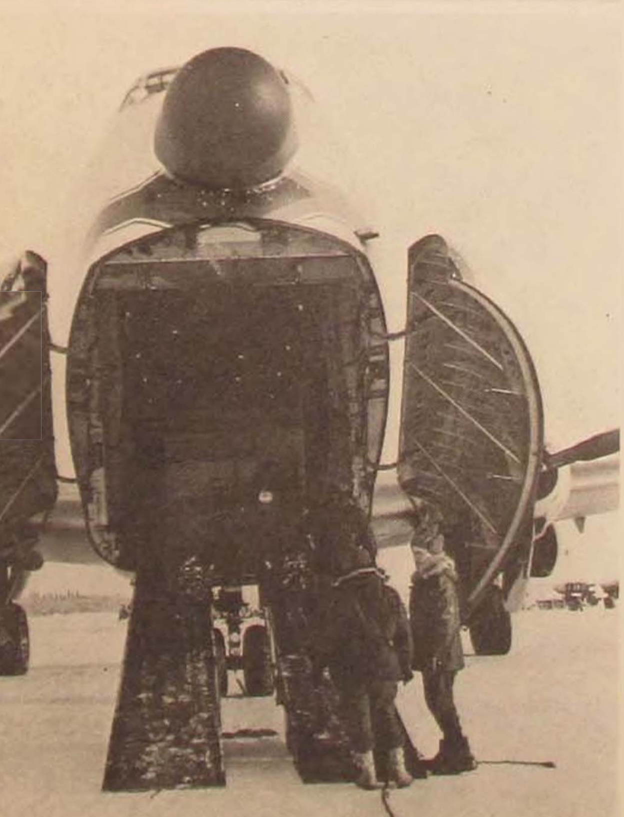
In its final maneuver report on Exercise SNOWBIRD the Alaskan Air Command advised planners of similar exercises to consider the operating capabilities of current troop carrier aircraft in establishing drop zones and maneuver areas. By locating drop zones in the same general weather area as the base of departure and establishing maneuver areas so as to permit low-altitude formation operations from the base of departure, it was felt that weather would have less influence on the outcome of an exercise. The report pointed out that long-range efforts at relatively high altitudes, caused by Alaska's mountainous terrain and variable weather, resulted to some extent in the cancellation of Phase I.

*Parked on the flight line at Elmendorf Air Force Base in Alaska (top) are some of the 100 C-119 Flying Boxcars of the Eighteenth Air Force's 314th and 456th Troop Carrier Wings that participated in Exercise SNOWBIRD early this year. These aircraft, plus a few giant C-124 Globemasters, airlifted 3000 paratroopers and their field equipment, vehicles, and weapons, 3200 miles from Sewart AFB, Tennessee, to Elmendorf to assist on the "friendly" side of the Alaskan maneuver and to demonstrate Troop Carrier's capability for airlifting large numbers of troops to reinforce remote garrisons. At Elmendorf, base of departure for operations against aggressor forces, ground crews supervise the loading (above, left) of heavy-drop equipment into a C-119. The supplies were later dropped in support of paratroopers who had made an airborne attack at Talkeetna. During the four-day operation at Talkeetna C-119's flew over 200 sorties, delivering 3000 men and over 250 tons of equipment.*

*Exercise SNOWBIRD's Phase II, the Talkeetna operation, got under way at 0900 hours on 28 January 1955. C-119's left the base of departure, Elmendorf AFB, flying over desolate Alaskan tundra and mountains (top) en route to Talkeetna, carrying Arctic-equipped paratroopers (right) of the 11th Airborne Division. The objective was to establish an airhead at Talkeetna and to defend it against an aggressor force moving overland from Fort Richardson, some 60 miles to the south. In seven hours on the first day, two battalion combat teams along with 131.1 tons of equipment had been airdropped in the objective area. On D plus 1 a third battalion combat team was added to the "friendly" force at Talkeetna (below). Subsequent airlift activities during the four-day operation were limited to resupply missions for the 3000-man force.*







*Once on the ground at Talkeetna, airborne engineers of the 11th Airborne Division use tractors and other equipment to build a snow-compacted runway on the frozen tundra (above). The scenario called for work to begin just after the initial landing on D-day. By D plus two a 6000-by-100-foot snowstrip was to be ready. But abnormally high free-air temperatures delayed the effort and not until D plus three was 3500 feet of runway declared operational. Tests proved it could support a C-47 aircraft. By D plus 12 it was believed that the surface could support a C-124 aircraft—but no tests were made. Since much of the snow-compaction equipment was not air transportable, it had to be prepositioned in the objective area. Paratroopers injured in the drop at Talkeetna were airlifted to the hospital at Elmendorf AFB by C-124's. An injured paratrooper (left) is taken on board a C-124 via the belly elevator. When SNOWBIRD was completed, equipment (below) and men were loaded in Eighteenth Air Force aircraft for the long flight to Tennessee.*

A certain lack of realism in one respect is evident in this analysis of SNOWBIRD by the Alaskan Air Command. Surely a potential enemy would not establish himself in force at points where he knows that the U.S. could easily launch a successful counteroffensive. Also a scenario tailored to an ideal condition merely to give our combat forces practice may provide basic training but certainly it does not serve to test full combat potential.

Further evidence of lack of realistic planning was found in the concept of operations for Exercise SNOWBIRD. There was a broad assumption that the aggressor was able to control certain remote areas in Alaska and to support troops located in these areas. The support of isolated ground forces would require that the aggressor have air superiority. Troops and equipment cannot effectively be moved overland for any great distance in Alaska in summer or winter. Offensive and defensive operations, say the strategists, will be by air and air alone. During the play of Exercise SNOWBIRD friendly forces used Elmendorf Air Force Base for their departure base. If the aggressor had the air superiority to establish his airheads in the remote areas in the first place, a base such as Elmendorf would become a high-priority target and would probably be untenable. Had this joint exercise been jointly planned, Elmendorf would probably have been but one of several departure bases. The new technique of flying "spoke" missions precludes the necessity of massing large numbers of troops and aircraft at one airfield where they would be an ideal target for a high-yield weapon. It would have been much more realistic to take advantage of the flexibility offered by the new airborne operations concept and disperse to other bases such as Ladd and Eielson, if it was necessary to operate from the combat zone at all. In true combat conditions the bases of departure generally would be located outside the combat zone.

The lack of realism in SNOWBIRD planning was further emphasized by the assumption that friendly forces controlled the air over Alaska. Of course such an assumption was necessary for the play of the exercise once it started with the enemy already entrenched. But the question arises as to how an aggressor got there in the first place. If we are to test the defense of Alaska, then it should be against the background of a realistic situation and one that is likely to occur.

## Critique

An analysis of LOGEX 55 and SNOWBIRD must reflect the often-voiced opinion that strategy is apt to become less scientific—in the sense of being less analytical and less precise—and therefore more fallible the higher one progresses up the ladder of problem solving and decision. The analysis also reveals that there are substantial differences in operational techniques and doctrine within the Air Force itself as well as between the Air Force and the Army.

As both exercises progressed, those at the operational level were generally able to recognize and work out to mutual satisfaction the problems growing out of differences in technique. But doctrinal differences are unreconcilable once the exercises are set in motion, since such differences have become an intimate part of the scenario. Often conflicts in doctrine are not apparent until the exercise has been played and evaluated. Thus it remains for those at the planning level to study previous exercises in an attempt to close any doctrinal gaps before a new exercise is planned.

Many joint Army-Air Force exercises have been planned and played since World War II. In this ten-year period it seems reasonable to assume that the services should have solved the problem of arriving at joint answers in matters of doctrine as well as in routine operations. Evidence points the other way. Indications are that once an exercise is played it is forgotten. Succeeding exercises continue to point up the same unresolved, intraservice and interservice doctrinal disparities. If this trend persists the entire maneuver program may be invalidated for any purpose other than lower-echelon training.

Even more disturbing is the evidence that there is a higher level of doctrine which most exercises simply ignore in the originating directives and in the planning by assuming that the old way is still the best way. This applies to the bedrock level of doctrine and concept: what is the nature of atomic war? What will atomic weapons force in the way of radical changes in deployment, in lines of communications, in the nature of air and ground operations? Will an atomic war still have the old, familiar phases of build-up, decision, and exploitation or has the whole time-phasing of war been altered by an entirely new rate of destruction curve from area weapons? The Air Force feels strongly that these are the great realities of the atomic age and that all planning must start from these premises. The Army, while making certain tactical and logistic concessions to the big bomb, apparently feels that the change in warfare will not be nearly as sweeping as the Air Force thinks. Consequently when the two services come together in a joint exercise, they sometimes find that they not only differ in detail, but they are fighting two different kinds of war.

One of the most ambitious field exercises ever played in this country, Exercise SAGE BRUSH, is now under way in the vicinity of Camp Polk, Louisiana. The joint Army-Air Force exercise is being played by a force of some 140,000 officers and men of the Tactical Air Command and the Continental Army Command. No attempt was made in the planning stage to pattern the exercise as a whole after existing situations. Rather, the scenario was based upon actions of the type to be expected in a possible future major conflict. Pre-maneuver accounts indicated that in SAGE BRUSH every effort was made to resolve technical and doctrinal difference through a joint planning staff before the exercise got under way. This is an encouraging sign, and it will be interesting to watch the development of this exercise and future exercises to see if the services succeed in solving their doctrinal differences. The stakes are too enormous to be left to chance or to osmosis.

*Air University Quarterly Review*

# In My Opinion...

## TECHNOLOGY AND MILITARY MEN

Colonel O. G. Haywood, USAFR

We live in an age of technological marvels. We have become so accustomed in our daily life to the products of this technology—our telephone, our automobile, our television set—that we forget how great has become our dependence on scientists and engineers. Most dependent of all is our military establishment, for the weapons of modern war press hard upon the frontiers of human knowledge.

This is not new. War machines of all ages have been the advanced products of their times. The difference in recent years is that the weapons of war have become so complex and so expensive and their performance so fantastic that we have tended to think in terms of machines instead of men. Admiral Strauss, Chairman of the Atomic Energy Commission, recently stated: "Technology has become the backbone of our national strength." To many this statement connotes a national dependence on machines. But technology really means technical knowledge, not the products of this knowledge. Machines do not create our national strength. This strength lies in the people who plan the technological marvels, who develop and manufacture them, who maintain them, who operate them.

I am not making an idle distinction. The budget requirements of the three services are presented annually to the Congress. There is page after page of statistics and supporting data on wings and tanks and ships and research and development of weapons, a few pages on numbers of men required, and nothing on quality—the Ph.D.'s in science and engineering, the skilled maintenance, the executive talents needed to use these advanced weapons effectively. Yet in any technological society it is quality not quantity that counts.

The priceless ingredient of the military establishment is not its B-52's or its supercarriers; it is its men. Only men plan; only men manage; only men fight. As we look to the future at what technology means to the services, we should focus our attention not on the machines but on the men.

The advance of technology will continue, and at an ever-increasing rate. Lord Kelvin said, some hundred years ago: "One really does not know anything about a phenomenon until he can describe it with numbers." Ability to describe the laws of nature with numbers is dependent on ability to observe and measure, which in turn is dependent on ability to make instruments. The better we can make instruments, the more we can learn of the laws of nature; and the more we know of the laws of nature, the better we can make instruments. It is a snowball reaction. The more technology advances, the faster it can move farther into the unknown.

The expansion of military electronics is a striking example of dependence on technological advances. Government purchases of electronic equipment in 1941 totaled $25,000,000. They totaled $2,300,000,000 in 1954—about a hundredfold increase in 13 years.

Electronics has given man an entirely new tool, the means for rapid handling of information—for acquiring, transmitting, processing, storing, and redisplaying information to the human senses or for control of machines. This is all our television does, or airways communications, or a missile guidance system. The intercontinental ballistic missile has received much publicity recently. Even the analysis as to whether such a weapon is feasible would be impossible without electronic high-speed computers. The development of such weapons and their operational use will require these electronic computers. And so will the evaluation of strategies for their employment.

One of the most difficult tasks facing military leaders of the future is the evaluation of the tactical and strategic usefulness of weapons that have not yet been built. Weapons of modern war are as expensive as they are fantastic. The Nation cannot afford to develop all the weapons that are possible. Even more critical, the engineering power of the Nation's industry, vast as it is, has not the capacity to engineer all possible weapons. The military worth of such weapons must be evaluated in advance, by men who combine understanding of technology and military operations. Their decisions will determine the strategy of future war, for the weapons are so powerful and so inflexible that they dominate the strategy of their employment. The only question is: What is the role of career military personnel in making these decisions?

There has always been a problem as to what functions of the national defense should be assigned to military personnel, and corollary thereto what types of individuals and equipments are needed in the military establishment. The ability to read and write was not required of the early Roman officers; Greek scholars accompanied the Roman leaders in the field to keep the records and handle the logistics. Revolutionary French armies prior to Napoleon did not have horses for their field artillery. The French artillery commander had to negotiate with farmers to move his guns to the battlefield. A civilian professional engineer was assigned to each German engineer battalion of World War II to assist with more complicated engineering analyses.

Yet all these army commanders did their own strategic and operational planning. One of the most important functions of the management of any organization is long-range planning. For the peacetime military establishment, this function overshadows all others, since the present value of the services is their ability to wage future war. The primary function in peacetime is long-range planning of the weapons to be developed and of the type and quality of men needed to maintain and fight these weapons. Such planning has become more and more technical, and those making these military decisions must have an understanding of the technical significance of their decisions.

Industry has faced a similar problem in recent years with the rapid advance of technology. The result in industry has been that more and more engineers are going to management because they are needed in management more than ever before. No industrial concern can afford to develop all the ideas which might turn into new products. Engineers competent to evaluate the technical difficulties of engineering and production and the worth of the product in a technological society must be a part of the management team that accepts or rejects the idea. No company can afford to have personnel policies which do not attract engineers. Men who understand both engineering and engineers must participate in the development and review of personnel policies. No company can afford to say that its engineers competent to do research and development are too valuable to be assigned to other work, for they are so valuable to the functioning as a whole that some must be assigned broad management responsibilities.

The military is trending in the opposite direction. The path to advancement is not through scientific and engineering experience and understanding. There is little place for technical men on the military "management team," yet military technology is inherently a part of the team's decisions. If the top management of a company in technical industry were to make its decisions without the full participation of the research and engineering official, how long could that company hope to remain competitive? Yet technical plans and decisions, governing annual expenditures for scientific research and engineering development greater than all of industry's expenditures combined, are being made by the Armed Services without top-level participation of career technical men.

It is true that the need for technical competence is greatest at the level of the working engineer, that such competence becomes less essential in the higher positions of management, that technical competence is not a requisite for every member of the management team, and that many technically competent men have little to offer to top-management decisions. Industry has found that only one out of three engineers can be developed for management positions. But it is equally true that some individuals with technical competence must participate at all levels of management decision and that for individuals who possess the other attributes of managers no degree of technical knowledge can be too much.

This statement is the antithesis of the belief of many senior officers—that technical people should be used only as staff advisers within the area of their technical specialty. Technical competence is often a handicap. I have personally acted on the strength of this conviction. I satisfied the academic requirements for my Doctor of Science degree in 1940, after the normal award date. The degree was mailed to me overseas the following year. There was no military record of the award. In the belief that such a degree would be a handicap in time of war, I did not notify the War Department until six years later.

I know of other officers who have had technical qualifications removed from their official records, because they felt they were a handicap to good assignments and thus advancement. In fact the official Air Force policy at one time made officers attending civilian universities ineligible for promotion. This was absurd, that those selected for advanced training because of their intellectual aptitudes should be penalized through such selection.

The services and the Nation face a great problem—the need for technical understanding in the military management team. The need will become even greater as technology continues its relentless advance. Consultants, part-time scientific advisers, study committees, and study contracts are valuable, but these cannot replace career military and civilian personnel. On the contrary they create an even greater need, for individuals within the career military establishment must integrate the thoughts and work of these advisers and committees into the military management team.

The solution of this problem is difficult. The services have lost their competitiveness with industry and other segments of the U. S. economy—first in salary, then in benefits, and now in individual security. The differential is most striking in the types of men who are most scarce in the services—highly-trained professional men. The one-hundred-dollar-per-month bonus has not solved the problem of attracting and retaining sufficient medical officers. Such a panacea will not attract large numbers of scientists and engineers, though it would be a step in the direction of increased recognition for those with advanced qualifications, just as flight pay recognizes the skill as well as the hazard of aircrew personnel.

There is urgent need for steps to increase the attractiveness of technical careers in the services. But more pressing is the need for recognition that the problem does exist. The situation will become progressively worse until the problem is faced and tackled. Then it will be solved. For it is imperative to all our citizens and to the industry which is competing for the same trained men, that the military services have their share of highly-qualified technical men in order that the Nation may have the efficient military power it needs for survival.

*Waltham, Massachusetts*

One of the brightest strands in the history of United States air power is the long struggle to develop strategic air power. The *Quarterly Review* has attempted to trace the major lineaments of this story—the growth of strategic air doctrine and the subsequent development of the aircraft to implement the doctrine. The *Quarterly Review* Staff wishes to extend grateful acknowledgment to those who have so generously assisted in the preparation and review of the material:

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# The Strategic Bomber

*A Quarterly Review Staff Monograph*

OVER 140 years ago a German inventor proposed dropping fire bombs from an airship powered with oars manned by "small men of light weight." This idea, novel and quite at variance with the technology of the time, was one of the first visualizations of strategic employment of air force. Nearly 100 years passed before the first bomb was dropped from an airplane. Even then it was a fairground stunt in San Francisco in January 1911. The bomb was a piece of gaspipe filled with black powder. The airplane was only slightly more complicated.

Less than four years later, only weeks after the outbreak of World War I, the German Air Force bombed Compiegne in France, and in November 1914 three English Avros flew over 250 miles into Germany to bomb the Friedrichshafen Zeppelin works. By September 1915 European army commanders had begun to coordinate their ground strategy with bombing operations. In 1916 the first night bombing mission was flown. And as the war continued aerial photography and air direction of artillery fire became commonplace.

By the time the United States entered World War I on 6 April 1917, the airplane had already become much more than merely the "eyes" of the army. Its offensive possibilities as a weapon of war had been tested and proved, but not fully developed. It remained for two Signal Corps officers to envision and demonstrate the airplane's strategic potential.

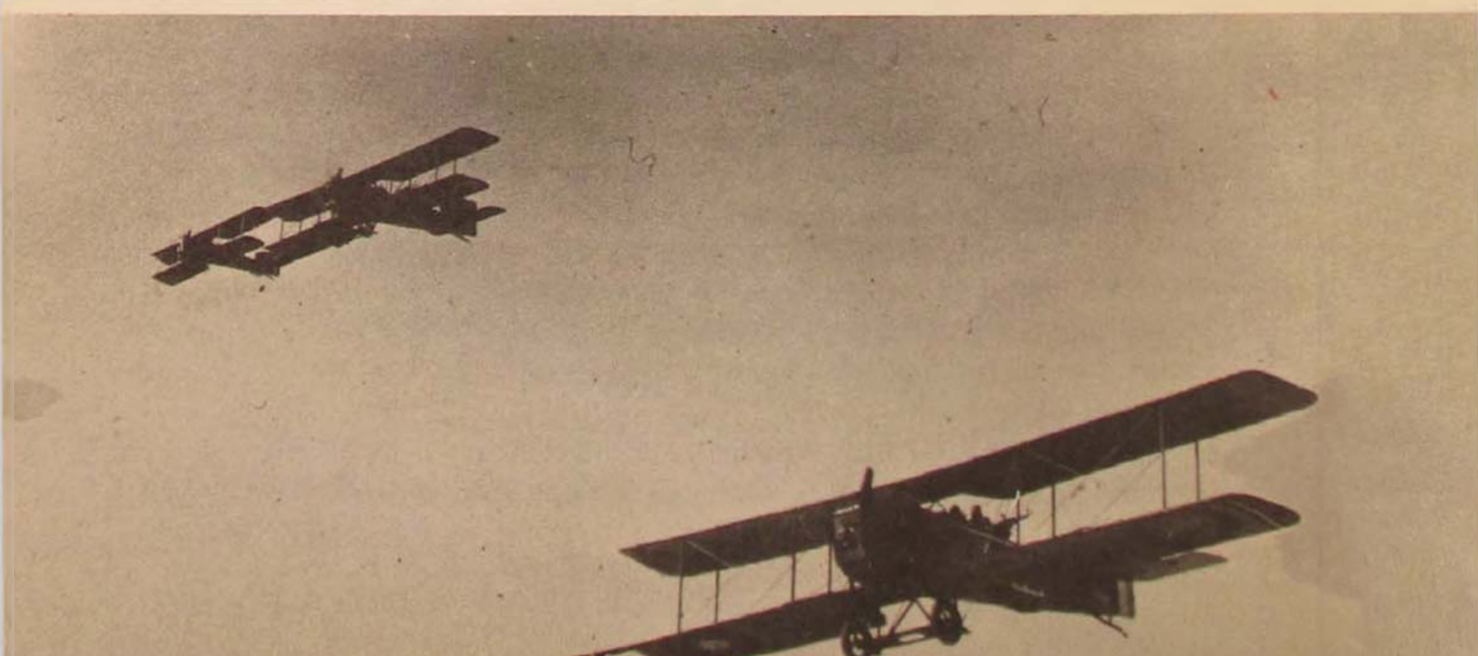
Lt. Col. Edgar S. Gorrell, Officer in Charge of Strategical Aviation for the AEF in December 1917, was the AEF's foremost planner of strategic bombardment. On 28 November 1917 he submitted to the Chief of Air Service a proposal for a strategic bombing campaign. This was approved and adopted, although the war ended before extensive strategic bombing operations could be initiated. Gorrell saw in the bomber a new means of reducing the enemy's will and ability to fight. What navies had for centuries done with the passive method of blockade he proposed to do with the positive action of bombing: deteriorate the effectiveness of the enemy's armies by crippling the industries that supplied the armies. He urged that the Allies match Germany's attempt to develop a strategic bombing force. He expounded the use of both day and night bombardment and the concentration of air forces against a single target on a single day. Not until World War II were these concepts fully accepted. Gorrell later concluded that the United States did not achieve true strategic bombing in World War I because too few bombers were produced and because the strategic concept lacked the support of GHQ.

Brigadier General Billy Mitchell, another Signal Corps officer, had been interested in military aviation since its inception and had followed its prog-

## World War I

**At the outbreak of World War I the United States lagged far behind in the development of military aviation. While European belligerents were deploying combat planes of a dozen specialized types, American air forces remained unready for a war in which air power was to play an integral part. A handful of flyers, a few small training fields, aircraft incapable of combat use, and an aviation industry still in its infancy were the meager beginnings. But by the war's end American air forces could boast an over-all strength of 190,000 men, more than 11,000 pilots, and more than 40 training fields at home and overseas. From early forays by a few volunteers, U.S. air strength grew to 45 combat squadrons, flying 35,000 hours over enemy territory and completing 150 bombing missions. By November 1918 aircraft industries had developed a productive capacity exceeding 20,000 planes a year, and American air power had reached a potential of formidable dimensions.**


*The British-designed de Havilland 4 (left), only American-built aircraft to see combat in WWI, was powered by the famous Liberty engine. Mainstay of A.E.F.'s bombing force, DH-4's and French-built Breguet 14's (below) took part in Billy Mitchell's massed air offensive in the St. Mihiel salient in September 1918.*



ress in the European war. Primarily a field commander rather than a planner, Mitchell's ideas on bombardment were not as "theoretical" as Gorrell's but they did go considerably beyond the prevailing Army concept of air action. In terms of the range and the bomb loads of the bombers of that day, his plan—proposed and sold to General Pershing—employed air power as a massed offensive force. It was a form of semi-strategic interdiction, designed to isolate portions of the battlefield and to throw the German troops off balance. Early in August 1918 Mitchell began to assemble a force of 1500 Allied combat planes of all types. When the ground forces moved out for their St. Mihiel offensive in September, Mitchell's air units struck ahead of them. In relays of 500 planes he hit the Germans on the St. Mihiel salient—first on one flank, then on the other, then on both. This was the world's first truly massed bombing campaign.

In the final days of World War I, during the Meuse-Argonne offensive, Mitchell's planes hit strategic targets, screened troop movements, scouted German territory, searched out machine-gun nests, shot down enemy balloons, and by engaging German fighters in combat, kept them from seriously hampering Allied troop and supply movements. As part of this offensive Mitchell, on 9 October, mounted what was described as the "most notable bombardment effort of the war." Employing a force of some 200 bombers escorted by over 100 pursuit planes and about 50 triplacers, Mitchell attacked and disorganized German army reserves gathered in the rear for a counterattack. Thirty-two tons of bombs were dropped during the strike, and later operations that day raised the total for the 24-hour period to 69 tons.

Contemporary opinion on the importance of this mission was expressed in an Associated Press release of 10 October 1918:

> The bombing squadrons which made up this air fleet probably represent the first definite American unit of major importance in the independent air forces which are being built up by the Entente powers. This navy of the air is to be expanded until no part of Germany is safe from the rain of bombs. It is a thing apart from the fighting, observation, and bombing squadrons attached to the various army corps. The work of the independent force is bombing munitions works, factories, cities, and other important centers far behind the German lines. It has been promised that eventually Berlin itself will know what an air raid means, and the whole great project is a direct answer to the German air attacks on helpless and unfortified British, French, and Belgian cities.

Although Germany's sudden collapse a month later made such attacks unnecessary, even the most surface-minded powers began to note the offensive power of the airplane. Yet it was not until nearly 25 years later—during World War II—that the bomber emerged as an effective accepted offensive weapon of prime strategic importance.

## Developing Bombardment Doctrine

World War I left the American people with a strong aversion to all things military. The huge conscripted American Army had been disbanded almost overnight in an attempt to return to "normalcy." The Washington Naval Conference of 1921-22 in like manner sought to reduce navies to impotence. And the economy-minded policies of the Coolidge Administration created an inhospitable atmosphere for military research and development.

## Mitchell vs. the Battleships

**During the early 1920's the decisiveness of aerial bombardment was the subject of heated controversy between proponents of air power and of sea power. Vulnerability of warships to air attack was the main issue. Air theorists, led by General Billy Mitchell, attempted to resolve the matter by a series of tests conducted in 1921 and again in 1923 under the joint direction of the Army and Navy. For three months airmen of both services trained for the ensuing trials. Using four captured prizes from the German imperial fleet, the tests began on 21 June 1921 nearly 100 miles off the Virginia capes. That day the submarine U-117 was sunk in 16 minutes. On 29 June a test was conducted to determine how effectively aircraft could locate approaching "enemy" ships. After a sea search in a test area of 25,000 square miles the U.S. battleship *Iowa* was intercepted in only one hour and 57 minutes. In July the destroyer G-102, the light cruiser *Frankfurt*, and the battleship *Ostfriesland* were subjected to air attack and effectively sunk. Sinkings of the *Alabama* in September and of two other old American battleships in 1923 provided further confirmation. From the brilliant success of aerial bombing in this test, a Joint Board of the Army and Navy concluded "that it has become imperative as a matter of national defense to provide for the maximum possible development of aviation in both the Army and Navy."**

*Bombing of the captured German light cruiser* Frankfurt *on 18 July 1921 was one of the more conclusive tests. That morning a joint Army-Navy air attack and then a Navy air attack effected superficial damage, but later in the day Army Martin MB-2 bombers dropped 11 bombs and sank the ship in 35 minutes. On one morning pass over the* Frankfurt *(left) a 300-lb. bomb was a dud. Below, a 600-pounder scores a hit during the afternoon attack. The most decisive test of all occurred three days later when seven of Gen. Mitchell's airplanes, each carrying a 2000-lb. bomb, made the huge German battleship* Ostfriesland *roll over and sink in 21½ minutes.*

*Serving to vindicate further Billy Mitchell's theories on the decisiveness of air bombardment, the effectiveness of air forces against sea forces was demonstrated again in September 1921 when the obsolete American battleship* Alabama *was subjected to air attack. A Martin MB-2 bomber hits the "crow's nest" of the once mighty battleship with a phosphorous bomb before sinking her with two 2000-pound bombs.*

Because the paltry defense budget had to stretch a long way, severe competition developed between the Army and the Navy. In its struggle for survival each service attempted to preempt the role and the missions of the other. It is small wonder the Navy reacted vigorously to Billy Mitchell's claims that battleships could be bombed out of existence. Similarly the War Department, under the leadership of infantry, artillery, and cavalry officers, developed a profound distaste for the small group of veteran airmen who had antagonized the General Staff by seeking to advance the airplane over the traditional military weapons.

In the decade following World War I General Billy Mitchell was almost a one-man show for air power. He made the United States air conscious. In his many speeches and voluminous writings, Mitchell used both rapier and bludgeon to drive his points home. As the father of American air doctrine, Mitchell is regarded as the USAF disciple, advocate, and counterpart of the RAF's Trenchard and Italy's Douhet.

To Mitchell air power was the basic military means of decision. He went far afield from the teachings of Napoleon, Clausewitz, and Jomini. His cardinal principles were that the airplane was essentially an offensive weapon and that the primary mission of aviation was to gain air ascendancy through offensive action. Mitchell asserted that victory in war required destruction of the enemy's power to wage war. Modern war, he claimed, must be aimed not only at the armed combatant in the field but also at the factory, the transportation and communications system, the natural resources, the farm, and even the civilian population.

This was the concept studied and taught at the Air Corps Tactical School, the center of the over-all development of air theory after 1926. Here instructors and students had been caught up by Mitchell's vision of air power. They had found it confirmed and extended in the writings of the Italian General Douhet, who foresaw in air power—especially strategic air power—the instrument of decision in future wars and frankly relegated armies and navies to the role of support and exploitation of the air decision. In their explorations and extensions of this new philosophy the instructors and students vigorously thrashed out the thorny problems of the nature of war, the employment of air power, and tactical doctrines for the various aspects of military aviation. The mission of the school was to stimulate thought, to develop new ideas, and to formulate a unified and consistent body of doctrine. Air Corps Tactical School instructors rendered yeoman service in giving definite and precise shape to the various American tenets of air doctrine that had existed in a nebulous form since 1918.

The Army General Staff and the War Department of the time were not in sympathy with these ambitious new concepts. The Army generals felt that their basic job was land warfare. Their battles were to be won by defeating the enemy army on the battlefield. From their standpoint the Army employed aviation for two purposes: to reconnoiter enemy positions and to support ground forces with highly maneuverable firepower. Any talk of strategic targets or air ascendancy was considered the theorizing of would-be "empire builders." This atmosphere of official disapproval forced airmen into covert methods of spreading the new air philosophy. Official doctrine or philosophy was that released by the Army Chief of Staff. The published studies of the theoreticians of the Air Corps Tactical School reflected unofficial views held by the faculty. While they constituted the basis of the continuing air doctrine, they were not always officially accepted nor were they always adopted by the air-minded elements of the public. To confuse the picture further, many of the new air concepts called for aircraft and for equipment that were not within range of the art of aircraft production at that time. For years air frames were limited by the meager horsepower of the existing engines, and frequently the theoreticians were merely theorizing about a desired ultimate.

The Air Corps Tactical School made its most significant and original contribution to air doctrine in developing the methodology of aerial warfare. Its instructors were able to resolve the dilemma resulting from two diametrically opposed concepts—the traditional United States policy of defense and the Mitchell-Douhet theory of attack. From 1926 on, the Air Corps Tactical School taught that the primary missions of military aviation were not the defeat of hostile craft in the air or the acquiring of intelligence information for the use of ground forces. Instead the school proposed that the real mission of air power was to eliminate the enemy's ability to wage war by neutralizing his air force and by destroying his vital centers. More than a decade was required for the appropriate doctrine to emerge in definite and detailed form.

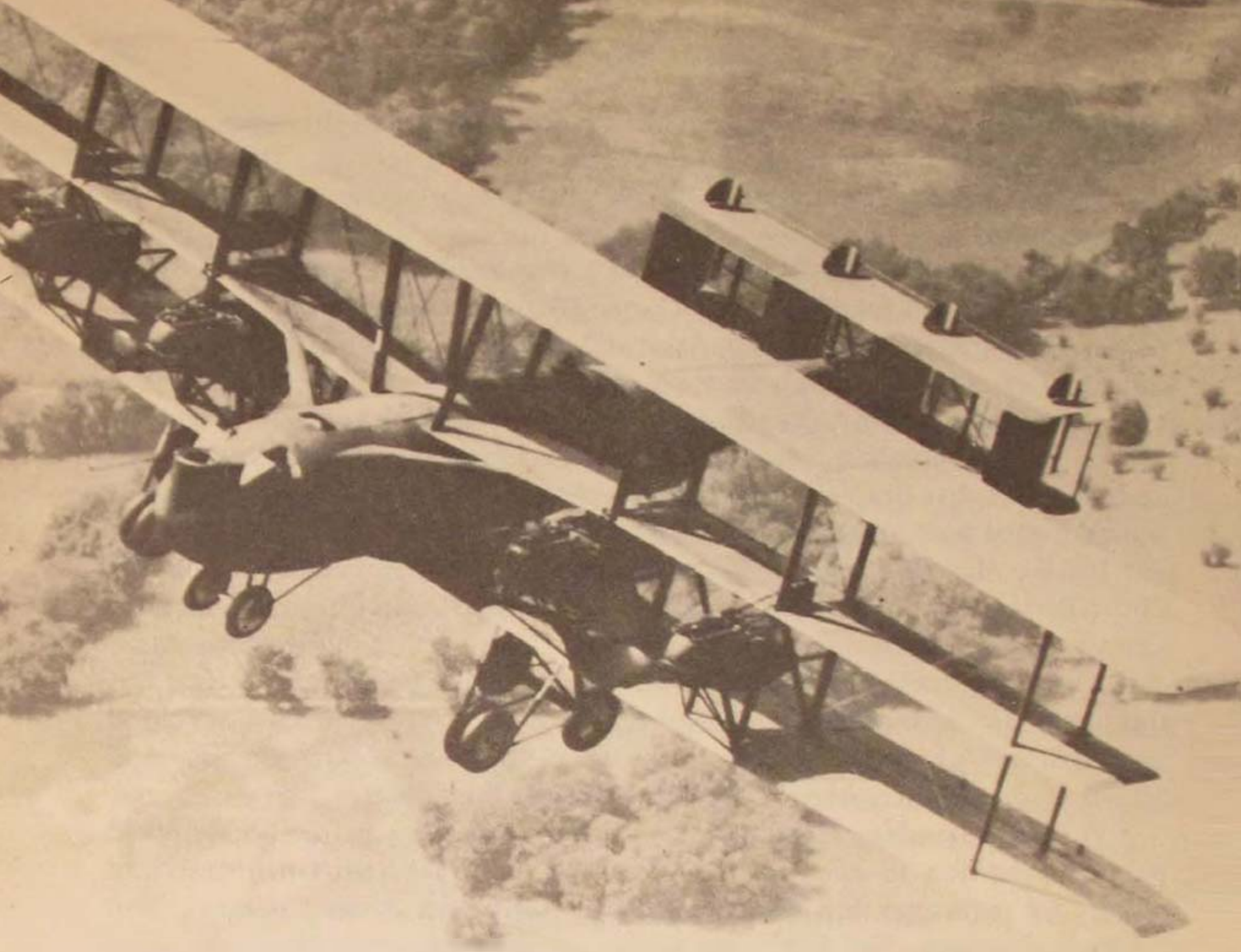
As early as 1920 the Air Service School (renamed the Air Service Tactical School in 1922 and finally the Air Corps Tactical School in 1926) held that bombardment constituted the fundamental arm of an air force. The seminal ideas had emerged in a single textbook first published in 1926 called *Employment of Combined Air Force* and later revised many times under the title *Air Force.* Strategic bombardment concepts gained momentum in the early 1930's, and the belief that strategic air power must be independent of tactical demands was expressed with greater emphasis and detail as the decade drew to a close.

During the 1930's the leading doctrinal concept nurtured by the Air Corps Tactical School was that of sustained, precision attacks by heavy bombers against the industrial structure of an enemy nation. Although this theory dated back to World War I, the faculty refined the concept and worked out the tactics for accomplishing the mission. In its development of precision bombardment of critical points of a specified target system, the Tactical School made another original contribution to air science.

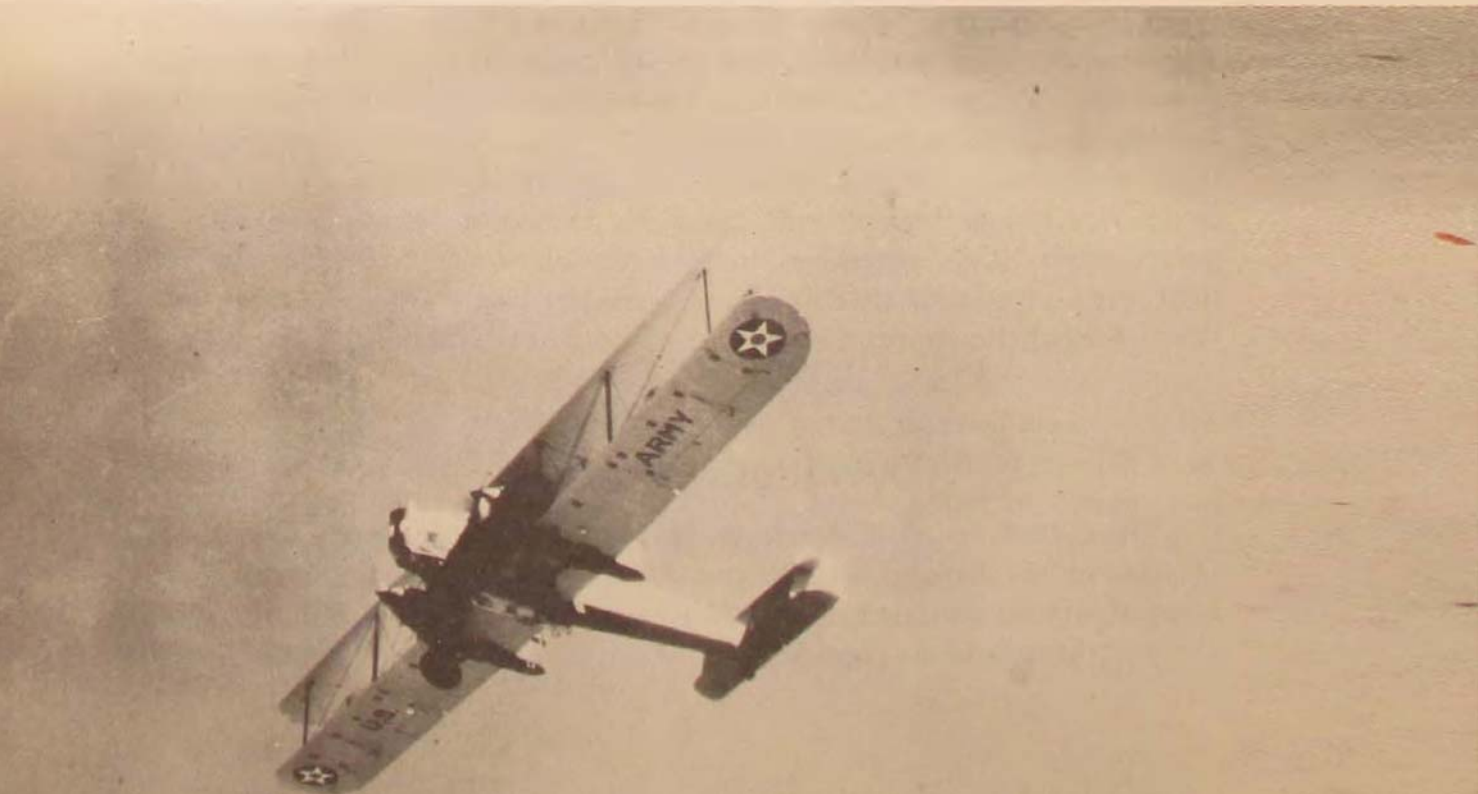
Precision bombing arose out of two divergent principles—widespread public opposition to mass civilian bombing and the traditional American respect for marksmanship. Tactical School instructors stressed selection and priority of targets. Gradually the school abandoned its earlier teaching of night bombing and turned to daylight operations as the principal tactic against industrial objectives. In 1930 the instructors held that bombers opposed by enemy fighters would have to be supported by pursuit aircraft. But within five years some bombardment enthusiasts believed that nothing could stop the bombers, that escorts were unnecessary. Air Corps designers emphasized speed, range, and altitude as defensive factors. While many officers continued to favor the idea of escort fighters there was little they could do about it at the time. Severe budget limitation dictated "first things first." The bombers were developed and pursuit aviation lagged behind. Largely because of this, the United States had no first-rate escort-fighter until the P-51 was available in quantity in 1943. The bombardment advocates pushed their theory hard, and by 1935 the precision concept had fully evolved. Its tactics emerged as high-altitude, daylight, formation bombing of vital pin-point targets. The system was further reinforced when the Norden bomb-sight was perfected in 1931 and the Sperry bombsight in 1933. Now the Air Corps needed the appropriate aircraft to test its doctrine.

## Developing the Bomber

From 1926 to 1936 development in aircraft performance was clearly inspired by the demands of doctrine. On the other hand, lag in the development of bomber models before 1936 retarded the growth of military aviation and the theories of its employment. Much of this delay in bomber develop-



*The development of the Barling triplane bomber, first flown in 1923, was a step toward realizing air bombardment doctrine. Although only one was built, this first "heavy" was the largest U.S. airplane built to that date. It had a service range of 335 miles. The Curtiss Condor B-2 (below), carrying a 2000-pound bomb slung under its belly, was the Air Corps' operational heavy bomber of the early 1930's.*




*The twin-engined B-9 developed by Boeing was the Air Corps' first all-metal monoplane bomber. A product of the 1931 bomber design competition, this model revolutionized U.S. airplane design. The low-wing B-9's two 600-hp engines powered it at a top speed of 173 mph. It carried a crew of four and a 1900-pound bomb load, had a service ceiling of 19,200 feet and a range of 1250 miles, and incorporated the retractable landing gear. The B-9 outdistanced all pursuit craft of its day.*

## Early Post-World War I Bombers

**Despite demobilization, small appropriations, and a marked emphasis on pursuit planes, the development of bombardment aircraft progressed significantly in the postwar years. The Martin GMB, first American-designed bomber, and its modification, the MB-2, supplanted the Handley-Page of World War I vintage. New heavy bomber types appeared in the Barling of 1923 and the Keystone B-1B of 1927. By the late 1920's Curtiss Condor B-2's and Keystone LB-6's were becoming the Air Corps' standard bombardment aircraft. In the early 1930's two innovations in airplane manufacture revolutionized bomber development. The advent of monoplane design and all-metal construction enhanced the possibilities for greater range, speed, bomb capacity, and serviceability. Other developments included trends toward the monocoque fuselage, enclosed cockpits, retractable landing gear, and air-cooled engines. Incorporated into the specifications of the bomber design competition of 1931, these new features found expression in its three important products— the Boeing B-9, the Martin B-10, and its derivative, the Martin B-12.**

*The Martin B-10 was another winner in the 1931 design competition. Equipped with two radial engines of 700 hp each, it was capable of 213 mph. Like the B-9 it featured retractable landing gear and was the first aircraft to incorporate enclosed cockpits for its crew. When the B-10 made its initial flight in 1932, it was regarded as the world's fastest and heaviest bomber. In 1934 a flight of B-10's completed the first nonstop hop between Alaska and the continental United States.*

ment stemmed from lack of equipment for conducting necessary engineering tests and studies. The impasse with the Navy over land-based bombardment was also inhibiting. The MacArthur-Pratt agreement (over the boundaries and areas of control between the Army and Navy in the defense of the United States from seaborne invasion) of 1931, limited the range of reconnaissance and bomber aircraft to the distance that a fast Navy unit could cruise in 24 hours at high speed. This was probably the single most damaging blow to the concept of strategic bombardment.

The National Advisory Committee for Aeronautics (NACA) was the chief aviation testing service. Wright Field was still in its infancy as the center of Air Corps technological advancement. Colleges and universities lacked the funds to engage in extensive aeronautical research. America's new aviation industry had to shoulder most of the responsibility for military aircraft design and development. But even the industry suffered serious inadequacies. Since few aeronautical engineers had had combat experience, they lacked analytical knowledge of the tactics of air warfare. The engineers were concerned primarily with building perfect flying aircraft and were antagonistic when the combat requisites established by Air Corps officers clashed with the best aerodynamic design. It took World War II to prove that the best weapons can be achieved only by active cooperation between the scientists and engineers and the strategists and tacticians.

The Air Corps Act of 1926 signalized the beginning of an intimate association between the Air Corps and the aircraft industry. The act provided for design competitions among manufacturers preliminary to drafting developmental contracts. It marked the beginning of the now-traditional policy that recognizes the contractor's right to amortize the experimental phase of an aircraft with income from later production orders. This policy has been a salient point in encouraging the aircraft industry to take many calculated risks which eventually have proved highly beneficial to the nation. The act also had the effect of shifting emphasis from experimental development to the procurement of standardized equipment.

Although many Air Corps officers were convinced that the heavy bomber was the basic weapon of air power, the War Department stubbornly resisted this concept. Sharp differences arose as early as 1928 over plans for bomber construction. Air Corps officers wanted to develop two models of bombardment aircraft. For day operations they wanted an aircraft with high speed, short range, considerable defensive power, and a small bomb load. For night operations they wanted an aircraft of minimum defensive strength to carry heavy bomb loads over greater distances. But the War Department, chiefly for reasons of economy, advocated a single model, an all-purpose bomber designed for missions in support of ground armies. The Navy Department was particularly critical of Air Corps efforts to develop and employ bombardment aircraft for coastal patrol. Throughout the 1920's high military circles in general deprecated the idea that heavy bombardment planes could be of large value in defending the United States.

By 1930 the future of the heavy bomber was still unpredictable. Its proponents, undismayed by adverse turns of events, continued to plan and recommend design changes. These Air Corps pioneers now sought to attain two main objectives—a long-range, high-altitude bomber with maximum bomb load and another aircraft for precision bombing from both high and low altitudes. But more than dogged determination was needed to bring results. By 1931, although 1800 planes had been authorized under the Act of 1926 and 1500 planes were actually in existence, only 39 were bombers. Still the Tactical School emphasized more firmly than ever that the keystone of air power was the long-range bomber.

As with all important new weapons the strategic bomber met with opposition to its use from legal and moral standpoints. A serious challenge to bombardment aviation was raised during the General Disarmament Conference at Geneva in 1932. Great Britain exerted pressure to have international law rewritten to abolish aerial bombing as a means of warfare. With the conference floundering in a morass of dissension, nothing came of the attempts to modify warfare by outlawing specific weapons.

When Franklin Roosevelt became President of the United States in 1933, the Navy acquired a staunch champion. He began immediately to build up naval strength to that authorized under the London Naval Treaty of 1930. But for years neither Roosevelt nor his cabinet paid much attention to the Army. Until 1937 the Air Corps was almost completely ignored. Following a conference with the President in 1935, General Billy Mitchell, who had noticed that the President's desk was covered with naval mementos, was quoted as saying, "I wish I could have seen one airplane in that collection."

Roosevelt's first Secretary of War, George H. Dern, was openly hostile to air power, denouncing the concept of destroying armies or populations by bombardment as the "phantasy of a dreamer." Dern warned Americans not "to purchase freedom with gadgets" but to adhere to traditional defense measures. This myopic perspective of the War Department was continued under Secretary Harry H. Woodring. Air Corps appropriations were scaled down consistently by the Budget Advisory Committee of the War Department and again by the Bureau of the Budget.

## Entering the Four-Engine Era

While military leaders were exhibiting small enthusiasm over military aviation in the years after World War I, the aircraft industry and the aviators were expanding their horizons. After 1925 all phases of aeronautics showed remarkable progress. Outstanding record-breaking flights were made by military and private pilots. Lindbergh's flight to Paris aroused public interest in aviation and stimulated technological developments. There was a steady extension of the effective range of aircraft. Air refueling experiments and instrument flying were demonstrated successfully. Commercial aviation expanded as public confidence grew in the new mode of transportation.

In the 1934 airmail controversy, adversity proved a blessing in disguise for the Air Corps. When President Roosevelt cancelled all mail contracts held by commercial airlines, he ordered the Air Corps to take over the airmail routes. Lack of proper equipment and inadequate ground services caused a series of crashes and the loss of twelve lives. Two special investigating bodies —the Baker Board and the Drum Board—unearthed the general inadequacies of U.S. military aviation. As a result General Headquarters Air Force was activated in 1935. While the GHQ Air Force plan did not satisfy ardent supporters of complete autonomy, it served as a stepping stone toward the ultimate objective.

As early as July 1933 the Air Materiel Center at Wright Field, in spite of all the hampering influences, had begun a secret preliminary engineering study to develop an ultra-long-range, multi-engine bomber able to carry a 2000-lb. bombload. This study eventually gave birth to such famous progeny as the B-17 and the B-29. The Chief of the Air Corps submitted the study to the War Department, emphasizing that the planes produced could be used to reinforce Hawaii and Panama, as well as defend both coasts of continental United States. In December 1933 the General Staff gave its approval and

*Development of the XB-15 marked the entrance of air power into the four-engine era. Built in 1935, this Boeing giant boasted a wingspan of 149 feet—7 feet longer than the B-29—and was the forerunner of the Flying Fortress model. Although the XB-15 proved to be too large for its four 1000-hp engines, it rendered long and useful service as a cargo plane until it was dismantled in 1945. The XB-19 (below) was the Army Air Corps' largest prewar bomber. Developed by Douglas and first flown in 1941, it had a range of 5200 miles. Like the XB-15 the size and weight of the XB-19 were far too great for the aerial power plants then in existence.*

recommended that budgetary provisions be authorized to cover it. In May 1934 the Chief of Staff authorized negotiation of contracts with the Boeing and Martin airplane companies for preliminary design and engineering data.

On 29 June 1935 the Boeing Company received a production contract to build Boeing Model 294, which was designated by the Army as the XB-15 (later redesignated as the XC-105). Since this airplane was about twice the size of any plane ever flown, the structural design and all the accessory equipment required exhaustive research and experimentation. Only one XB-15 was built. Completed in 1937, it was the first of the very-heavy or superbombers. It was followed in the spring of 1941 by Douglas Aircraft Corporation's XB-19, a bomber even larger than the XB-15. In both of these aircraft the specifications for the size and complexity of the airframe overreached the power of the engines then available. But engineering lessons learned from the building of the XB-15 and the XB-19 were invaluable in building the other strategic bombers that followed.

In 1934 the Army Air Corps announced an open design competition to American aircraft manufacturers for another new bomber. The specifications called for a multi-engined aircraft. When the bids were opened, all the competitors save one had interpreted "multi-engined" to mean the customary

*Boeing Model 299, grandparent of all the Flying Fortresses, effected a revolution in heavy bomber design. Designated the XB-17, the 299 design was begun in 1933 and the airplane flew on 28 July 1935. Powered by four Pratt & Whitney R-1690 750-hp engines, the 299 had a top speed of 236 mph, a ceiling of 24,620 feet, a range of 3010 miles, and a weight of 32,432 pounds. Its wings spanned 103¾ feet.*

two engines. Boeing Airplane Company had ventured into the new design realm of a sleek super-aircraft with four engines.

Boeing executives and engineers had already accomplished by 1934 a chain of successes in design pioneering for their transport planes, their B-9 twin-engined bomber, their pursuit planes, the P-26, the P-29, and the Navy XF7B-1. The company now staked its money, effort, and reputation on its Model 299, the prototype of the B-17 Flying Fortress.

Model 299 was a unique airplane in all respects. Every step undertaken by the builders and engineers was in the realm of pioneering. This early version of the "Flying Fortress" was the first airplane to combine extended range, great carrying capacity, and the speed of a pursuit plane. It represented an entirely new concept in aviation history and appeared to be the aircraft that could test the Air Corps Tactical School theories.

The Army contracted an experimental prototype of the 299 designated the XB-17. To build such a plane in the mid-1930's was an undertaking that challenged the best aeronautical engineering in America. But when the summer of 1935 came, the XB-17 was completed, and ground testing of all equipment proved satisfactory. On July 28 it took to the air and its performance surpassed even the dreams of its designers.

## Selling the Heavy Bomber

Developing the B-17 was only the first step. The heavy bomber had to win the acceptance of the Air Corps technical staff at Wright Field. On 20 August the XB-17 was flown from Seattle, Washington, to Dayton, Ohio—2100 miles—at an average speed of 252 miles an hour, setting a non-stop record for the distance. Air Corps officers were deeply impressed by the looks and the performance of the new aerial weapon, one of them reverently pronouncing the plane to be "an aerial battle cruiser." Extensive flight tests were performed by the manufacturer and by Wright Field specialists.

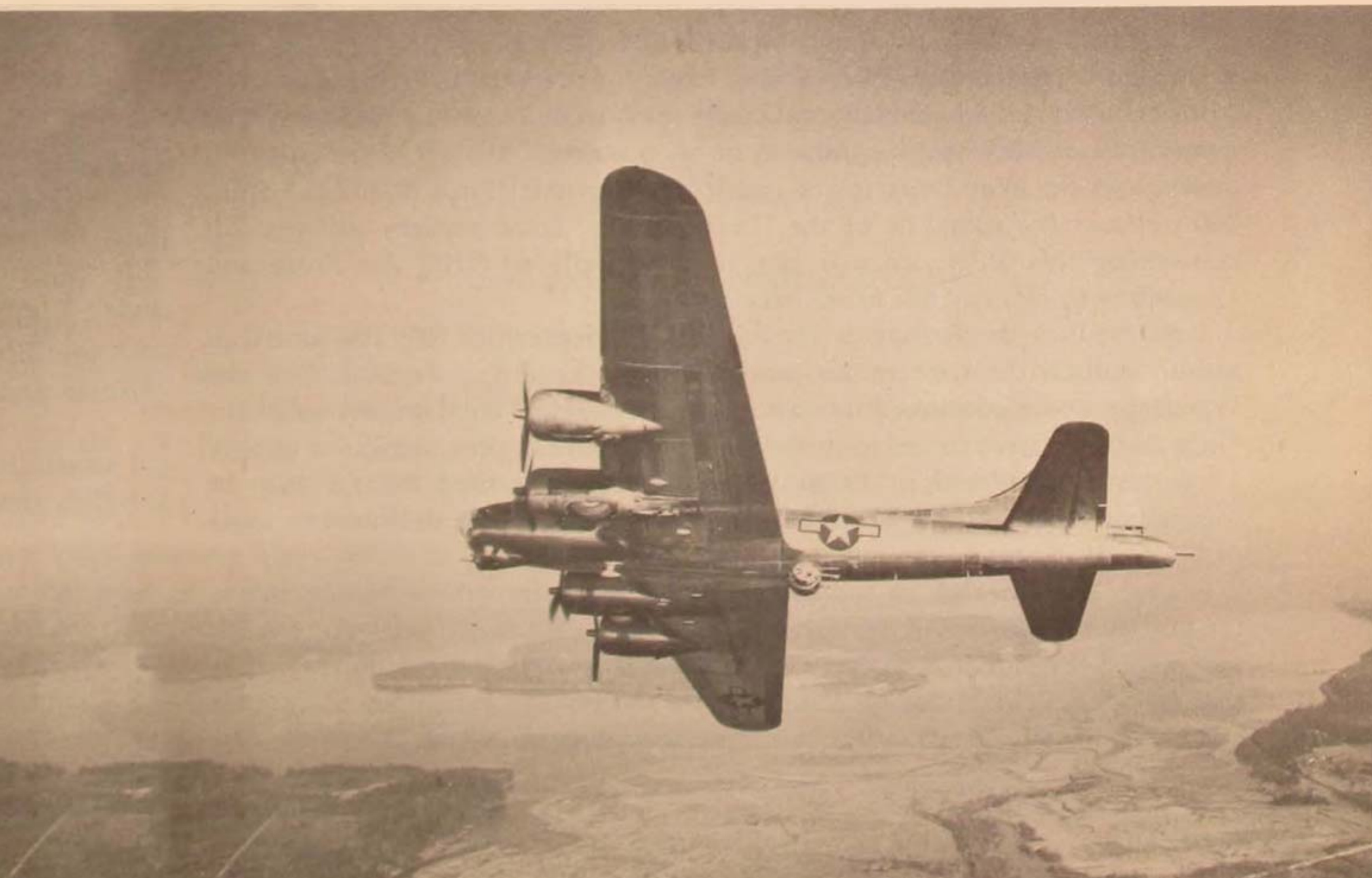
The climax of the flight tests came on 30 October 1935. Military leaders and several congressmen had been invited to witness the new Air Corps giant in flight. Years of hopes and dreams were in its making, and at last the moment had come to convince the military world that Billy Mitchell and his associates had not fought in vain. The future of American military aviation was in the mold. The XB-17 roared down the runway, started to climb, then stalled from a steep angle and crashed in flames. The plane had taken off with the locking pins still holding the elevators in horizontal position.

As a result of earlier flight tests the Air Corps had recommended the purchase of 65 B-17's for Fiscal Year 1936. Even after the crash the War Department was sufficiently impressed with the new bomber's potentialities to place a service order for 13 planes—to be designated as YB-17's. The YB-17 was practically identical to the XB-17, except for some modifications in the power plant, the landing gear, and the armament. The first flight test was held on 2 December 1936, and by August 1937 all thirteen planes had been delivered to the Air Corps.

## The Flying Fortress

**Prototype for all B-17 series, the pioneering design of Model 299 led progressively to more and more potent strategic bombers. Although basic design of the airplane changed little during its ten years of development, armament was increased and horsepower, range, and bomb load boosted. The YB-17A was the first bomber to employ turbosuperchargers, enabling it to operate at the above-20,000-foot heights demanded by the "high-altitude precision bombing" concept. By 1940 the B-17C was in production. This was the plane the RAF used against German ports in the initial substratospheric bombing raids of World War II. On hand before Pearl Harbor, the B-17E provided a tail-gun post; the F series of 1942 added greater bomb capacity. Evolution of the Boeing Flying Fortress culminated in the battle-proven B-17G, which became the main weapon of the Allies in the air war over Germany.**

*The YB-17A of 1937 (below) featured new supercharged 1000-hp engines but otherwise differed little from the B-17 prototype. Although only one was built, it served as the experimental series for later B-17 modifications. By the time the B-17E (top right) appeared in 1941, 1200-hp engines, streamlined gun turrets, and a redesigned empennage had been added. Over 400 changes were made in the E series to create the B-17G of 1943 (bottom right). Featuring a plexiglass nose and a chin turret operated by remote control, the improved G series had a top speed of 310 mph, a 30,000-foot ceiling, and a range of 2000 miles with a 4000-pound bomb load.*



Convincing Congress and the public of the need for a heavy bomber was not easy. The plane itself was too far ahead of the times. Americans were just getting used to thinking in terms of one or two-engined aircraft—and this one had four engines. Even the War Department was not prepared to accept such an advanced design. Army strategists continued to look upon any airplane merely as an appendage to ground operations. For their purposes a small plane was about as good as a large one. Army officials reasoned that an appropriation would buy more small planes than large ones—and big numbers were impressive in annual reports. With isolationism, pacifism, and economy popular themes among the voters, Congress was reluctant to appropriate vast sums for weapons of war.

An aggressive campaign was needed to demonstrate the capabilities of the heavy bomber to Congress and to the public. Officers and men of the 2nd Bomb Group took up the challenge. The new bombers made aviation history and laid the foundation for subsequent long-range flying accomplishments. They put the B-17 in the national spotlight and kept it there. Air Corps pilots, many who later flew their way to fame in World War II, put on air shows and broke record after record with the new bomber. Crews toured the country in B-17's so that everyone could see America's new technological miracle. No opportunity was lost to drive home the potentialities of the plane as an efficient defensive weapon. The record shows that the first 12 B-17's were flown 9293 hours and 1,000,000 miles, without a serious accident.

Spectacular flights to South America awoke the world to the possibilities of the Flying Fortress as a long-range bomber. One demonstration drawing major attention was a navigational exercise in which three B-17's intercepted the Italian liner *Rex* at sea during joint Army-Navy maneuvers in May 1938. The flight of B-17's located the ship over 600 miles from the coast, dropped a message on her deck, and returned, having proved the contention of Billy Mitchell that land-based planes could find and bomb battleships. The demonstration was not appreciated in all quarters. Almost immediately an order from the War Department restricted Army Air Corps flights to within 100 miles of the shoreline of the United States. Some mystery still prevails concerning this order, since it was given verbally to GHQ Air Force and apparently to this day has never been rescinded.

By the time the European war broke out in September 1939 the American public realized the tremendous possibilities of the Flying Fortress. But the War Department continued its apathetic policy toward bombardment aircraft. Only 29 B-17's were included in the 1938 procurement program and a meager 11 more were ordered in 1939. When Germany attacked Poland only 14 four-engine bombers (13 YB-17's and one XB-15) had been delivered to units of GHQ Air Force.

The Munich crisis of September 1938 was an important turning point for military aviation. On 28 September, the day after the Munich Agreement was signed, President Roosevelt announced to the nation's military leaders that he wanted to build up American air power. He called for an annual output of 10,000 aircraft, with an all-out maximum of 20,000. Roosevelt also instructed military leaders to prepare to enforce the Monroe Doctrine against Axis infiltration, subversion, or military pressure in the Western Hemisphere.

In response to the President's directive, the Air Corps Board drew up a special staff study, *The Air Corps Mission Under the Monroe Doctrine*, recommending the creation of a substantial force of long-range reconnaissance bombers as the best means of safeguarding the Americas against aggression. The new frame of reference supplied by Mr. Roosevelt gave fresh opportunity to expand air doctrine. Hemispheric defense called for an air operation that was tactically offensive in nature.

Hitler's *blitzkrieg* invasion of Poland on 1 September 1939 gave further impetus to the American armament program. Almost immediately the Air Corps sent observers to Europe to report on air tactics. Records of the Air Corps Tactical School show that it interpreted their reports as indicating that the *Luftwaffe* was operating in Poland with concepts similar to those expounded at the school.

The fall of France and the decision to build 50,000 airplanes changed the entire aviation picture overnight. New officials such as Secretary of War Henry L. Stimson and Army Chief of Staff General George C. Marshall, guided by the forceful recommendations of Deputy Chief of Staff for Air General H. H. Arnold, saw the necessity for building strong air forces around the heavy bomber. Until this time no plans had been approved that called for the exploitation of the airplane's great and unique flexibility as a weapon. Even as late as the autumn of 1940 Air Materiel Division proceeded cautiously when it let contracts to Boeing for 500 B-17's and to Consolidated for 500 B-24's. Though large by previous austere standards, these bomber contracts accounted for only two per cent of the President's proposed program. But the contracts did mark the beginning of the heavy-bomber production schedule of the Air Corps. Because most of the heavy bombers produced before Pearl Harbor were sent to the RAF, the Air Corps had on 7 December 1941 only 83 B-17's on bases in the continental United States and 31 at strategic outposts. Most of the B-17's overseas were not equipped for combat operations.

## Increasing Production

On 9 July 1941 President Roosevelt asked General Arnold for the logistical information needed to implement American air doctrine. This request resulted in the writing of the Air Corps' comprehensive war plan, designated "Project AWPD/1." Months before, the War Department had evolved its own detailed war plan, called "Rainbow No. 5." With the President's request in hand, General Arnold's air staff assumed a position of equality with Army and Navy staffs.

Project AWPD/1 is a unique historical document. Its principal authors were a committee headed by Colonel Harold L. George and composed of Lt. Colonel Kenneth N. Walker, Major Laurence S. Kuter, and Major Haywood S. Hansell—all former key instructors at the Air Corps Tactical School. Working under intense pressure these officers drew up in one week a remarkable staff study that specified exact target systems ideally suited for precision bombing and programmed the aircraft needed to accomplish the over-all strategy. Drawn in minute detail, Project AWPD/1 not only served as a blueprint but was actually executed almost to the letter in World War II. It followed the doctrinal concepts of the Air Corps Tactical School and tenaciously clung to the cardinal principle of daylight precision bombing, with no provision for fighter escort. The fulfillment of the Air Corps' plan was a task unequalled in military history. The gigantic undertaking required mobilization of the nation's industrial resources as well as its manpower.

When the United States Government reached the decision that thousands of additional bombers would be needed, Boeing pooled its engineering and manufacturing data with other leading aircraft companies in an all-out joint production effort. The program was energetically undertaken by other firms, and the Boeing-Douglas-Vega B-17 Production Pool became a highly successful operation. Extensive subcontracting was needed to carry out the mass production procedure. Wright Field monitored the entire program and maintained project officers in each of the aircraft factories.

To meet the demand, the American aircraft industry retooled, re-equipped, and rescaled itself for quantity production. New machinery was purchased or invented to accomplish the staggering task of building the industry to a size that would normally take years of development and growth. Sprawling factories mushroomed overnight. Highly skilled engineering, production, and managerial talent was assembled from all parts of the nation. Intricate job tasks had to be split into shred-outs, simplified and broken down so that they could be performed by persons who had never even seen an airplane. Men, women, and young adults from all walks of life were recruited to build planes. Yankee ingenuity, put to a critical test, was healthily resourceful.

At Boeing's Seattle plant, B-17's were being produced at the rate of 60 per month by January 1942 and at 90 per month the following spring. Peak production came during March 1944, when a Flying Fortress rolled out of the Seattle factory at the rate of one nearly every hour during the two main shifts of the day. Meanwhile the Germans had cut back bomber production in order to produce more fighters than the Americans and British combined. As a result they were to lose the air war.

On 17 August 1942, 12 Eighth Air Force B-17's roared over the Channel from England to make the first American air attack from European skies—skies that were dominated by thousands of Focke-Wulf 190's and Messerschmitt 109's. But this was merely the initial American assault on Hitler's Europe.

## The B-24 Liberator

The merger of the Consolidated Aircraft Corporation with Vultee Aircraft Corporation in 1941 accelerated the development of another famous heavy bomber, the B-24 Liberator. Consolidated, founded in 1923, had produced

*Two mechanized aircraft assembly lines turn out B-24 Liberators at Convair-Fort Worth. In foreground combat-slated B-24 heavy bombers are being assembled. On production line to the left B-24's are being modified for specific action on one of the world's battle fronts. The tremendous war effort during World War II rolled out a total of 18,015 B-24's and 12,711 B-17's from Detroit-like assembly lines.*

hundreds of training aircraft for the Army and Navy. In 1928 the corporation began to specialize in the building of flying boats and in the 1930's developed the twin-engine PBY, later famous as the Catalina patrol bomber. Research was begun in 1938 on the design of a large land-based bomber, which evolved into the B-24. With the addition of the Vultee line of planes, the Consolidated Vultee family became a large one covering nearly every type of aircraft.

In March 1939 Air Materiel Division was presented with the preliminary designs and engineering data for the XB-24. A month later the Air Corps signed a contract with Consolidated for the prototype of a new model to be produced within nine months. In December 1939, three months after the European war had begun, the XB-24 was flown at Lindbergh Field, San Diego, California.

B-24's were built at Consolidated Vultee plants in California, Texas, and Oklahoma. The company made aviation production history in December

1941 by placing in operation at San Diego the first mechanized, moving assembly line for the production of heavy airplanes. Subassembly plants and parts factories were operated by the Ford Motor Company at Willow Run, Michigan, and by the North American Airplane Company at Dallas, Texas.

Early in 1942 a B-24 liaison committee was formed to coordinate the vast bomber program. To Consolidated Vultee as master designer fell the task of furnishing the other companies with plans, blueprints, templates, engineering data, production techniques, and "educational" aircraft. These "educational" airplanes were mock-ups carefully marked piece by piece so that they could be disassembled for the benefit of the automotive workers employed by the Ford plant. The pool began to deliver once its assembly lines got rolling. On 20 April 1942 Consolidated Vultee's Fort Worth plant handed over its first Liberator to the Army. Three months later Douglas delivered its first B-24 from its new Tulsa plant. On 6 February 1943 Douglas made initial delivery of bombers assembled from components produced by Ford at Willow Run. The North American Company saw its first Liberator take to the air in March 1943, only 319 days after joining the pool.

## Bombers at War

More than 3000 heavy bombers were operational in the Eighth and Fifteenth Air Forces in June 1944. Approximately two thirds of the 2000 heavy bombers in England were B-17's, while over two thirds of the 1000 heavies in Italy were B-24's.

The reality of the European war gave crucial testing to the air doctrine of the early Air Corps planners. In the fateful skies above the Continent the deep-rooted Air Force concept of paralyzing an enemy's economy and depriving his armies of logistical support was spelled out by bomb-laden formations of heavy bombers. The concept had evoked a sustained air offensive against Germany and all territories under her control. Despite the bitter defenses over strategic German industrial targets, it was deemed that their destruction would turn the tide of the war. It was further held that the best weapon to destroy them was an aircraft capable of substantial range under large bombloads, of flight at altitudes above the heaviest anti-

*From preliminary designs available in 1939, Consolidated developed in 1942 the B-24 Liberator, which was committed to wide operational use in World War II. The B-24 was the first American heavy bomber to operate with retractable tricycle landing gear. Its four 1200-hp engines powered it for a top speed of 300 mph. Carrying a bomb load of 2500 pounds the Liberator had an operational range of 2850 miles. They came into their own in the Mediterranean (above, left) and Pacific theaters where range was the first consideration. Their effectiveness is shown at left, as waves of Consolidated B-24 Liberators of the Fifteenth Air Force fly over the Concordia Vega oil refinery, Ploesti, Romania, on 31 May 1944. Unmindful of flak, the B-24's return to base after dropping their bombs on target. Pillars of smoke rise from hits in the storage tank area, oil cracking plant, and pumping station.*

*A B-17 raid on the German industrial city of Darmstadt in late 1944—part of the successful Allied mission of strategic air forces to force the complete surrender of the Axis powers in Europe by sheer weight of relentless aerial bombardment.*

aircraft fire, and of fighting off enemy fighters, so that it could reach the target by daylight and, having reached it, bomb it with pinpoint precision.

The precision bombing of heavily-defended Nazi Europe was the most critical job of the war. It was expensive of men and materiel. The RAF had abandoned daylight bombing early in the war as too costly and settled for the less accurate nighttime "saturation" raids. British experts were frankly skeptical that the USAAF could continue to mount an extended, intensive assault on Germany in the face of rising attrition in men and aircraft as German radar and defenses became steadily more proficient. Day after day American bombers droned over Germany in increasing swarms. As losses mounted and the Germans threw more and more of their air forces into defense, it became obvious that the vital targets deep within Germany could not be reached and destroyed without excessive losses, unless the bombers were given long-range fighter escort. In a furious burst of technological effort the P-51 was revamped to attain the necessary range, and its production was accelerated. By the summer of 1944 control of the air had clearly passed to the Allies over every reach of German territory.

Strategic bombing in Germany inflicted enormous damage. At the end of the war a wealth of testimony from German officials conceded that bombing had broken the back of the German war economy and had stalled the once-magnificent German war machine. After the Combined Bomber Offensive was formulated at the Casablanca Conference in 1943, the list of principal target systems and the purpose of the bomber campaign had been focused and clearly defined. First, the defeat of the *Luftwaffe* and the destruction of German fighter strength. Then the primary targets: submarine yards and bases, the aircraft industry, the ball-bearing industry, and oil, with secondary objectives in the synthetic rubber and motor vehicle industries. But the pure air strategy that had been envisioned never prevailed in World War II. To the end of the war large elements of the bomber force were frequently diverted to attack other targets, such as submarine pens and V-weapon sites, against which the bombers were not the most effective weapons. More serious, these diversions pulled the bombers off the main job of destroying the German war economy, thus allowing the resourceful Germans periods of grace in which to repair damage and reestablish the flow of material.

In addition to its principal function of carrying war to the enemy, the heavy bomber performed other missions. Many flew high-altitude photo-reconnaissance. Others dropped guided bombs, life boats, supplies, and propaganda leaflets. After V-E Day they flew the victims of Nazi atrocity camps to England and elsewhere for medical attention.

During World War II B-17's and B-24's were used in every theater of operations. In all theaters during World War II, Liberators and Fortresses flew a total of 610,637 sorties and dropped 1,283,633 tons of bombs.

Since the development of the B-24 came four to five years after that of the B-17, it profited by experience. Both required a crew of ten men, but the B-24 could carry a larger bomb load and had a greater range. Because of its greater reach, the B-24 was used especially in China-Burma-India Theater and South West Pacific Area, where it increased the range of overwater search. In 1944 the Fifth Air Force made strikes with the B-24 against Balikpapan, a 2400-mile round trip. In Europe the B-17 became the choice of Air Force commanders against the *Luftwaffe* because of its superiority over the B-24 in armament and armor. Attempts to remedy these and other shortcomings of the B-24 resulted in an increase of weight and in altered flight characteristics that made the plane less stable. By 1945 the increased range of the B-17 had deprived the B-24 of its chief advantage and the sturdy "Flying Fortress" continued to be the favorite of heavy bomber groups flying over Germany.*

## The B-29 Superfortress

The vast distances in the Pacific and the enormous perimeter and depth of the Japanese conquests posed staggering problems to the air strategist. Years of painful land and sea conquest of advance footholds would be neces-

*See *The Army Air Forces in World War II*, Vol. VI, *Men and Planes*, (Chicago, 1955), 207-8.

sary before the B-17 and the B-24 could be based within effective range of the Japanese home islands to destroy the enemy's will and capacity to resist. In 1942 and 1943, B-24's and the few B-17's of the Seventh and Thirteenth Air Forces hammered at shipping, oil refineries, and industrial targets on the whole southern flank of the Japanese empire. They were invaluable in softening enemy resistance and paving the way for the amphibious landings as the island-hopping campaign clawed its way west and north across the Pacific. But for a long two and a half years the only bombs that fell on Japanese home soil were the ones from the B-25's of the intrepid Doolittle raid on Tokyo.

How could the Japanese islands be reached? The answer lay in the B-29, which made possible the realization of a new concept of air power. With the B-29 was born the Strategic Air Command, capable of ranging the globe. The Superfortress began combat against Japanese installations on 6 June 1944 with a "shakedown" raid on Bangkok from bases in West China. Nine days later the real offensive against the Japanese Empire opened with a strike by 60 Superforts against Yawata, the center of Japan's steel industry.

The popular conception that the B-29 was spawned by the war, with production models ordered "off the drawing board," is misleading. The combat potential of the B-29 was a basic consideration in the Air War Plan of 1941. The Superfortress developed through years of precise aeronautical research and design evolution. In building the B-29 Boeing engineers translated the technical know-how accumulated in building the XB-15, the B-17 family, and other mammoth airplanes like the Clipper and the Stratoliner. The B-29 itself went through eight major design changes on paper before construction was begun.

The story of the development of the B-29 begins in the winter of 1938. At that time Air Corps staff officers requested Boeing to suggest ideas for a major modification of the B-17 to feature greater altitude, range, speed, and carrying capacity. The company engineers and aerodynamicists rejected the plan as impractical and instead suggested Boeing Model 316, an extended development of the XB-17 Although no definite commitment was made by the War Department, Boeing pushed new designs ahead on paper and in December 1939 started construction of a full-scale wooden mockup of Model 341 at company expense.

In January 1940, after England and France had been at war with Germany for three months, the War Department issued "Request for Data R-40B," which set forth general specifications for an experimental, four-engined bomber. The aircraft industry was requested to submit bids. Sikorsky, Martin, Douglas, Consolidated, Lockheed, and Boeing submitted designs, Boeing submitting Model 341 as its entry. By the time the War Department had received all entries, European war experience had pointed out the need for greater bomb load, longer range, and heavier armament than had been contemplated previously.

The War Department sent out revised specifications, asking the aircraft companies to submit new designs. An Air Materiel Center evaluation board appraised these designs and rated the competitors. Shortly after the fall of

France in June 1940, the War Department awarded contracts for preliminary engineering data to the four firms and designated the planes, respectively, as XB-29, XB-30, XB-31, and XB-32. Lockheed and Douglas soon withdrew from the competition, and orders were placed with Boeing and Consolidated for experimental models.

Although the XB-32 was the first to fly—on 7 September 1942—numerous design changes retarded its progress toward mass production. Consequently only a few B-32's ever got into combat and then only during the closing days of the war in the Pacific.

The XB-29 was Boeing Model 345 with increased gross weight. The aircraft was so huge and so complex that its design required an entire corps of engineers and draftsmen. In September 1940 the War Department signed a contract with Boeing for two "X" planes and one test model. In December an additional XB-29 was ordered. Fabrication was begun at the Seattle plant in May 1941.

This was the stage at which General Arnold took an unprecedented gamble. With the tide running against the democracies in the war with Germany and tension mounting in the Pacific, General Arnold calculated that if the normal procedure of aircraft procurement was followed—the building of prototypes, followed by exhaustive test flights, leading finally to production orders and tooling of factories—the Air Corps could not expect B-29's in quantity until sometime in 1945. This was too long to wait. On his urging, the War Department on 17 May 1941—6 months before the first prototype B-29 took to the air—authorized Boeing to build 250 B-29's, contingent on the increasing of plant facilities to a point where 25 B-29's could be produced by 1 February 1943. When the XB-29 made its first flight in November 1941, orders already had been placed for 1664 Superfortresses. The three-billion-dollar "gamble" involved more than financial risk. It jeopardized the schedules of badly needed aircraft models already in production, the B-17 in particular. This was command decision, compounded of administrative courage, foresight, and initiative. But the term "gamble" is misleading. Rather it was expression of high Government confidence in the integrity and ability of the American aircraft industry.

The B-29 was the heaviest high-speed airplane in the world. To build the plane in quantity production during a national emergency, it was necessary to mobilize a large slice of the industrial resources of the country. Under the direction of the War Production Board, a Superfortress liaison committee was established at Seattle. In its final form the program called for B-29 production by Boeing at the new Wichita, Kansas, and the Renton, Washington government-owned plants, by the Bell Aircraft Company at Marietta, Georgia; and by the Glenn L. Martin Company at Omaha, Nebraska. The Boeing factory at Seattle was brought in later when its program of B-17's was phased out. From the factories of Fisher Body, Chrysler, Hudson, Goodyear, Briggs, Murray, and Cessna came major components of the airplane. Thousands of subcontractors scattered throughout the nation produced parts, big and small. The whole precise assembly operation was carefully worked out after extensive time-and-motion studies had been made by efficiency experts and manpower specialists. Wright Field monitored the production and furnished project officers and factory representatives.

The niche that the B-29 carved for itself in the Pacific war was done with more resistance from time and distance than from the Japanese. From beginning to end it was a story of struggle against odds to train units, to equip them with the new, relatively untested bombers, to base them in the Pacific, to supply them with bombs and gasoline, to protect their command structure in the midst of a maze of conflicting Army and Navy commands. If this were not enough, the commanders had to put green crews into unproved aircraft, fly them to the limit of their endurance to bomb cloud-shrouded, uncertain targets with radar intended for navigation instead of bombing, analyze the heartbreakingly poor results, and then stake their reputations and their commands on new tactics that would better fit the conditions and the need.

This was particularly true of the bleak eight months from June 1944 to February 1945, in which the XX Bomber Command operated from bases in West China against southern Japan. Gasoline and bombs had to be flown over the "Hump" of the Himalaya Mountains from India, frequently in the same B-29's that were going on the mission. Under primitive conditions half-trained ground crews labored to perform routine maintenance and at the same time to remedy the bugs that are inevitable in any new aircraft that has had inadequate testing. The R-3350 engines particularly turned temperamental in the hot summer and under the strain of maximum-endurance missions and high-altitude bomb runs.

It was in China that the B-29 and General Curtis LeMay got acquainted. Having already acquired a reputation as an operational troubleshooter in the European theater, General LeMay took over the XX Bomber Command, then moved to Saipan to take command of XXI Bomber Command. There, operating under much better physical conditions and over the relatively moderate distance of 1200 miles from Tokyo, LeMay carved out the heart of Japan.

After a shaky start, which saw the XXI Bomber Command employ the classic Tactical School doctrine of high-level precision bombing that XX Bomber Command had tried from China, with both forces producing mediocre results, LeMay boldly switched from 30,000-foot daylight precision bombing with high-explosive bombs to 10,000-to-18,000-foot area attacks on cities by night, with incendiary bombs as the principal weapon. The result was the most decisive vindication of strategic air power the world had yet known. In ten days in March 1945 B-29's burned out 32 square miles of densely populated and heavily industrialized areas in four of Japan's largest cities. The B-29 had come into its own.

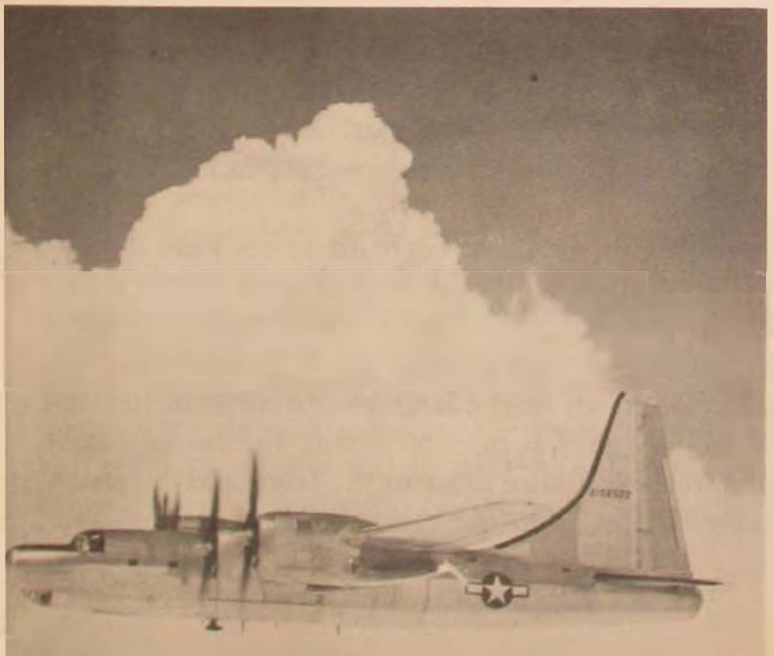
Alternating these tactics with medium-level precision attacks, the B-29's went on virtually to annihilate urban Japan, to crush the Japanese people's faith in the ability of their government to defend them, and to bring about the end of the war without the tremendous cost in American lives and money that the planned invasion of the Japanese islands would have entailed. It was fitting that the B-29 should also have been chosen to usher in the atomic age

## World War II

## Very Heavy

## Bombers


*Once the heaviest high-speed aircraft in the world, the mighty Boeing B-29 Superfortress was the only long-range bomber to play a vital role in two wars. This great dreadnaught was the decisive air instrument against the Japanese home islands. It dropped the atomic bombs that brought final victory in World War II. More recently B-29's were work horses in FEAF's bomber operations in Korea. Powered by four 2200-hp engines for a top speed of 397 mph, the B-29 could fly at 35,000 feet with a 20,000-pound bomb load. Its great size, which astounded observers in 1943 and earned the B-29 the official designation "very heavy bomber," so shrank in later perspective that by the time of the Korean War it was designated "medium bomber." Convair's World War II very heavy bomber and counterpart to the B-29 was the B-32 Dominator (left). Production of the new weapon was coming into high gear when the favorable trend of the war halted assembly lines. A few B-32's reached the Pacific in the closing days of the war.*



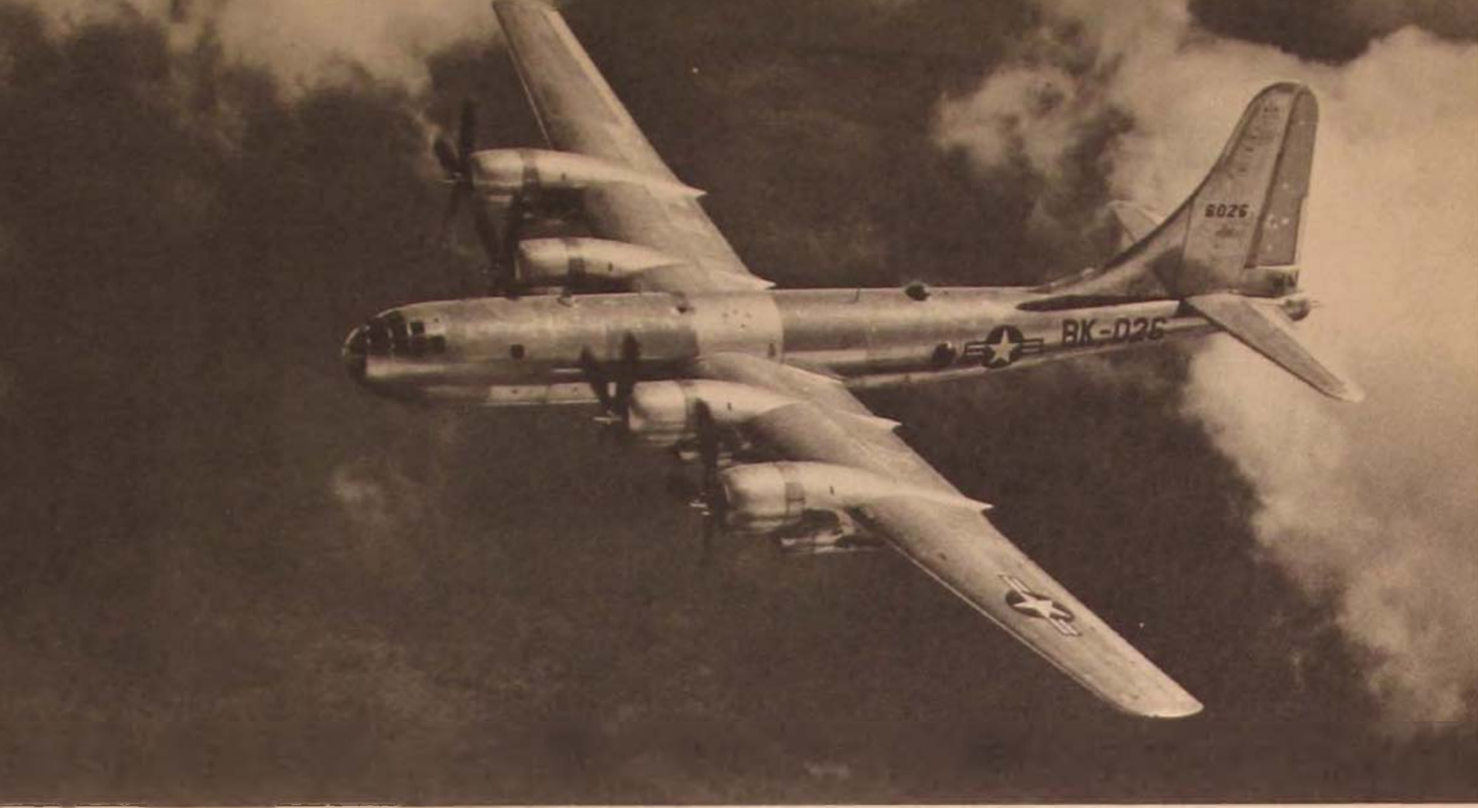
by dropping the secret weapon on Hiroshima and Nagasaki as the final warning of what lay ahead for Japan if she did not surrender.

Aside from the physical results of bombing, another factor in the employment of B-29's in the Pacific was to have great import to the future of strategic air power. This was the unique command arrangement that was devised for the control and employment of the Superfortresses. In Europe the strategic air forces had been grouped in a command of their own, United States Strategic Army Air Forces, placed under General Carl Spaatz as air commander. Beyond this command level had been an air deputy to the Supreme Commander, RAF Air Chief Marshal Tedder, who controlled all air forces in Europe and the Mediterranean. The Supreme Commander, General Eisenhower, had the final control over all air forces as a part of the theater forces under his command.

When the first B-29 wings were being readied for movement to the Pacific, the planners took a long, hard look at the confused command structure in that sprawling ocean area. Essentially there were four supreme commanders, General MacArthur in the Southwest Pacific, Admiral Mountbatten in the Southeast Pacific, General Stilwell in the China-Burma-India theater, and Admiral Nimitz in the Central Pacific. While the B-29's were to commence their operations in India and China, their great range and their unparalleled strategic value meant that their operations would touch all these theaters and that all theater commanders would have valid claims on their services. Such a situation would fritter away the striking power of the force and would hamstring it in its efforts to carry out its primary mission—the destruction of the Japanese capacity and will to wage war.

After much debate and many changes in plans, it was decided that the B-29's would operate as a "headquarters air force." Its missions would be assigned directly by the Joint Chiefs of Staff, with General Arnold acting as the executive agent for the Joint Chiefs and also participating in their deliberations. The theater in which the bombers were based would provide them with logistic support. The theater commander had authority to divert the bombers to his own use in emergency but he must notify the Joint Chiefs of this action immediately. None of the theater commanders was happy with the arrangement. There were many difficulties in achieving a meeting of minds between the planners in far-off Washington and the operators struggling with the realities of fighting a technological war in a primitive theater. But the system worked, and its assertion of the global responsibility of strategic air power remains one of the keystones in the organizational structure of today's Strategic Air Command.

Final assessment of the degree to which strategic air forces were decisive in the European and Pacific campaigns of World War II is of course a very complex and arguable task. Air power is indivisible, even where the missions of strategic and tactical air forces are separate and clear-cut—and their distinction is seldom uniform, as was shown by the large contribution of strategic air forces to the essentially tactical air job of interdicting the lines of communication leading into northwestern France prior to the Normandy invasion. The total impact of air power derives from the close coordination and inte-



*A post-World War II development of the Boeing B-29 was the Boeing B-50 Superfortress. Although evolved from the original Superfort, the B-50 was 75 per cent new design, with such features as steerable nose wheels, thermal anti-icing equipment, and reversible-pitch propellers. Its four 3500-hp engines gave it 59 per cent more horsepower, powering it at 400 mph and enabling it to carry five tons of bombs 4000 miles without refueling. Bigger, faster, and more lethal than its wartime predecessor, the giant B-50 outweighed the B-29 by 30,000 pounds. It could ascend to heights above 40,000 feet, and its top range was greater than 6000 miles.*

grated operations of all air forces in implementing a master air strategy. Again, neither the European nor the Pacific war was fought on the basis of an air strategy. In Europe the basic strategy was a land strategy; in the Pacific there was no one strategy but rather a naval strategy and a land strategy, in each of which air forces were viewed as a supporting instrument rather than as the primary force. The internal disintegration of Germany and Japan which made surrender inevitable is peculiarly the contribution of strategic air forces. The external pressures that added to the desperateness of the enemy's plight—the defeat of Germany's armies and the invasion of the homeland, the crumbling of Japan's outer defenses and the isolation of the Japanese war machine by the capture of its overseas sources of raw materials and the destruction of its merchant marine—are primarily the contribution of armies and navies, with a major assist from air forces.

The respective weight of these various factors will long be measured and variously interpreted by each of the services and by numerous historians. To the air strategist World War II vindicated the doctrine of air bombardment as the decisive force in war, though there was considerable revision in the estimates of the weight and duration of attack that was necessary to bring a modern industrial nation to its knees. The closing days of the war brought the solution to this problem of force with the introduction of the atomic bomb into the air bombardment systems.

The B-29 emerged from the war a battle-tested veteran. More than twenty different B-29 series have been built, which have served in many other capacities than that for which they originally were intended. When production finally ceased at the end of World War II, 3970 Superfortresses had come off the assembly lines—2766 built by Boeing, 668 by Bell, and 536 by Martin. Between 1945 and the end of the Korean conflict, more than 1300 production changes were made to the B-29 to incorporate newly developed equipment and accessories, to accommodate special weapons, and to adapt the airplane to changing combat requirements.

The Korean War added further laurels to the record of the B-29. Superfortresses flew 1076 days of the 1106-day air war. One B-29 set a new record by flying 73,200 miles in a single month. Statistical summaries credit the B-29's with flying 20,000 sorties and dropping 160,000 tons of bombs. In the first weeks of the war the B-29's quickly and efficiently destroyed the 18 strategic targets in Korea. For the remainder of the war they added a mighty right arm to the essentially tactical air war. The variety of jobs they performed was impressive: bombing enemy airfields whenever they were repaired, interdicting transportation lines, bombing enemy supply dumps, and even precision bombing of bridges. Until the development of the B-36 and the all-jet-driven B-47 and B-52, the B-29 was the major weapon of United States strategic air power.

A post-World War II development of the B-29 was the B-50 Superfortress. Although very similar to the B-29 in appearance, the B-50 contained only about 25 per cent of the original design and equipment of the B-29. The 400-mph-plus B-50 had a 6000-mile range. It could carry a maximum bomb load of 28,000 pounds. The plane itself had a gross weight of 170,000 pounds. With in-flight refueling, the B-50 had almost unlimited range, as was demonstrated in the spring of 1949 when the B-50 Superfortress "Lucky Lady II" made the first round-the-world nonstop flight. During the 23,452-mile flight the plane was refueled four times in the air by KB-29's.

A comparison between the B-29 and the B-50 shows the rapid increase in bomber size within the span of a decade. In 1944 the B-29 was designated by the Army Air Corps as a very heavy bomber. Nine years later the B-50, weighing 30,000 pounds more than the B-29, was designated a medium bomber by AF Regulation 55-23. The heavy bomber of today, the B-52, weighs over 350,000 pounds.

## The B-36 — Interim Bomber

Consolidated Vultee's B-36 has served as the interim bomber between the B-29 and the high-altitude, long-range jets. The development of the B-36 began in April 1941. At that time Nazi aggression in Europe was phenomenally successful, and the United States was faced with the overwhelming prospect of having to contest, single-handedly, the Hitler war machine. If

Britain were to fall before the German onslaught, the U.S. would be left without European allies and with no bases outside the Western Hemisphere. These strategic possibilities demanded the immediate development of a high-altitude aircraft with heavy bomb-load and unprecedented range. Four companies, Consolidated, Boeing, Douglas, and Northrop, submitted design proposals. On 15 November 1941 the Consolidated Vultee Aircraft Corporation was awarded a contract for two experimental B-36's. During the summer of 1943 the Army Air Forces placed an order for one hundred of the huge bombers. But the change in the war situation and a lowered priority slowed down work on the B-36, and the first flight of the XB-36 was not made until 8 August 1946.

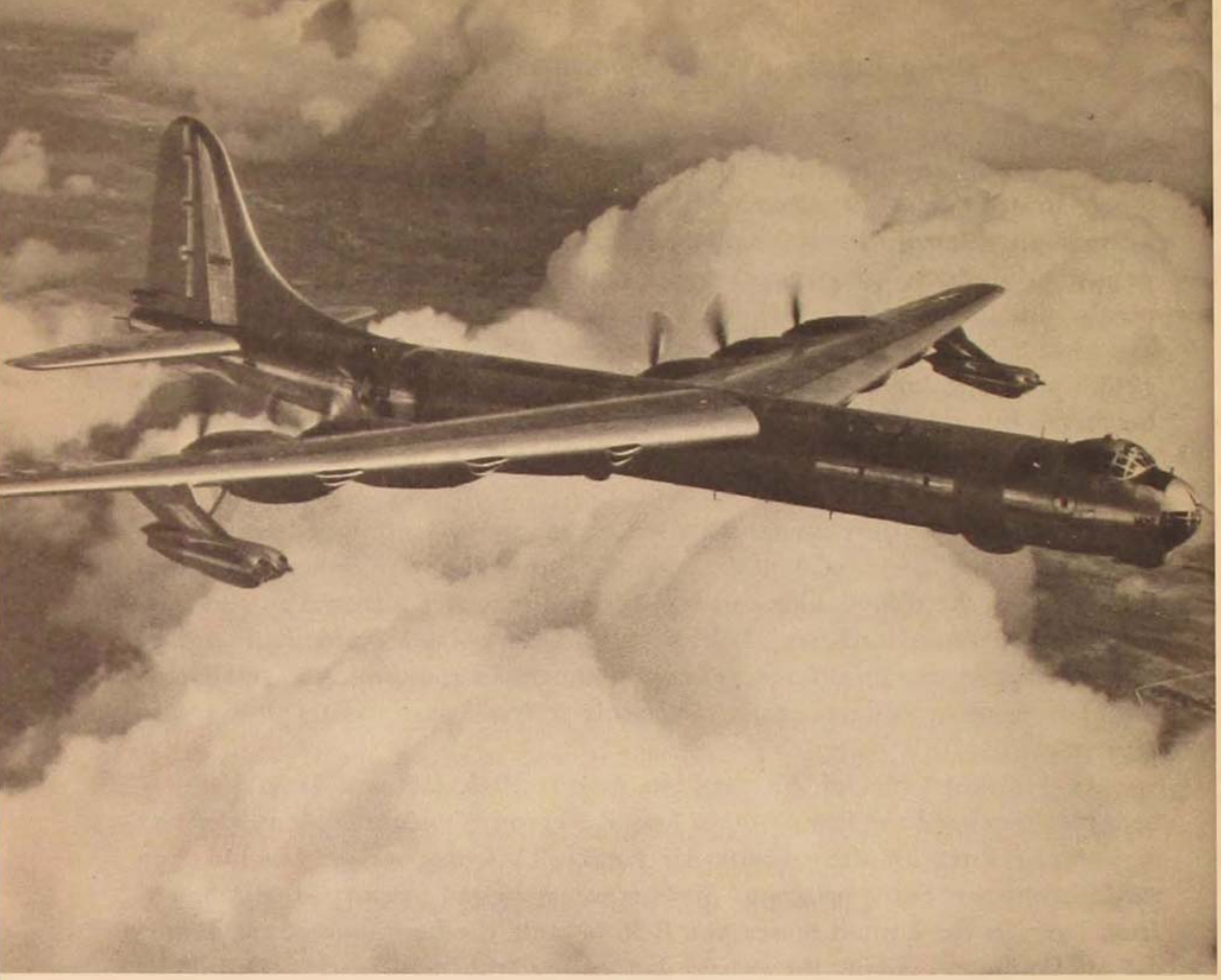
World War II developments had not changed the military requirement for a long-range intercontinental bomber. Instead the requirement had been reaffirmed by the tremendous cost in lives and materiel incurred in the campaigns for advanced air bases. The advent of atomic warfare provided another reason for procuring an intercontinental bomber. In an atomic war retaliation would have to be instantaneous. Certainly it could not await the conquest of overseas bases.

As Assistant Chief of Air Staff, in August 1945, General Hoyt Vandenberg recommended the formation of four B-36 groups to constitute an effective mobile task force for the postwar Air Force. This proposal was included in the 70-group Air Force program. Since it was designed to carry atomic bombs from bases in the United States, the B-36 became the backbone of the Strategic Air Command during the crucial days of the "cold war" and is credited by many observers with playing the major role in deterring Soviet aggression.

B-36's were built at Convair's plant at Fort Worth, Texas—the world's largest integrated aircraft factory—which had originally been designed for the production of B-24 Liberators. The monster plane has a wing span of 230 feet, broader by 110 feet than the length of the entire first flight by Orville Wright at Kitty Hawk, North Carolina, on 17 December 1903. The B-36 has a wing area of 4772 square feet, is 162 feet long from nose to tail, and stands 47 feet high. Sixty-eight thousand shop-made parts and 8500 different assemblies go into each airframe.

By the time the B-36 emerged from the drawing boards into production, engine progress had been sufficient to rescue it from the fate of the XB-15 and the Douglas XB-19, which had been doomed to extinction because of inadequate power plants. The original design objective of the B-36 was a range of 10,000 miles, with a bomb load of 10,000 pounds to be dropped at the midway point. Since the extreme range requirements made weight control of prime importance, magnesium and magnesium alloy were used throughout the fabrication. Extensive use was also made of "Metlbond," a metal adhesive type of construction developed by Convair. Metlbond proved especially valuable in areas of light structure and concentrated stress, where rivets were susceptible to vibration. The plane's maximum altitude is over 45,000 feet and the top speed is in excess of 435 mph.

The B-36, planned at the outset of World War II but coming into service too late for the war, was placed in the unenviable position of bridging



*The Consolidated Vultee B-36 served as USAF's interim strategic weapon between the B-29 and the high-altitude, long-range jet bombers. The advent of atomic warfare firmly asserted the necessity for this intercontinental bomber, first conceived as early as 1941. Powered by six 3800-hp pusher-type piston engines and four jet pods of 5200-pounds thrust each, the 200-ton B-36 can fly a nonstop round trip of 10,000 miles carrying a 10,000-pound bomb load outward bound. With a ceiling exceeding 45,000 feet the giant, intercontinental B-36 betters a speed of 435 mph.*

the gap between World War II aircraft and the new generation of postwar jet bombers. Many of the ups and downs in the B-36's history are attributable to its transitional position. The modifications on the aircraft itself are adequate testimony. Originally built with six piston, pusher-type engines, the plane was later modified to add four jet engines. Originally designed to carry huge conventional bomb loads, the plane was modified to carry nuclear weapons. Originally designed in the maturity of one air age, the plane was flying in the infancy of another. The B-36 inevitably became the stormy petrel of combat aviation.

From 1941 to July 1948 aircraft procurement had been financed out of wartime appropriations. As a result B-36 procurement remained relatively immune from the effects of changes in the Air Force budget and in the over-all aircraft procurement program. The situation changed completely, as far as the B-36 was concerned, at the end of the fiscal year 1948. New appropriations were needed to finance completion of the existing contract. These funds had to be allocated from the over-all program, which was itself subject to frequent changes because of budget limitations. Contracts let under the new appropriation were geared to a 70-group Air Force. Later President Truman placed specific limitations on the services, with the Air Force limited to 48 groups. Since the USAF already consisted of 59 groups, the problem was no longer how to procure additional airplanes for 70 groups but how to cancel, with a minimum loss to the Government, the airplanes already on order. The Air Staff decision was to continue the B-36 program at the expense of medium-bombardment aircraft. This it was felt would greatly enhance Strategic Air Command's ability to launch a strategic offensive.

The B-36 became one of the most publicized of military aircraft during the heated Congressional hearings in 1949. These hearings were far more important than mere interservice controversy. Broad concepts of unification and strategy were at stake. Under the Key West Agreement of March 1948 the Air Force had been specially assigned the primary responsibility for conducting strategic bombing. In 1949 certain naval officers challenged the capability of the USAF to fulfill its assignment, contending that the B-36 was obsolete, vulnerable to fighter interception, and therefore not the aircraft for the job. Air Force leaders maintained that the B-36 was the best available weapon to carry out the strategic mission. The majority report of the investigating committee reinforced the Air Force position.

In mid-1952 the Air Force announced that its schedule called for the phasing-out of B-36 production in 1954. The successful design of the all-jet bombers, first the B-47 and then the B-52, brought the B-36 to obsolescence. In addition stringent budget restrictions imposed on the Air Force necessitated concentration on one long-range bomber—the B-52. But before the B-52, the B-47 must be reviewed, because its evolution made possible the creation of the huge Stratofortress.

## Building for the Jet Age

Two of the major lessons that had been learned from World War II were to be answered by technological developments coming into view at the end of the war. One lesson was that the bombers available in World War II had not proved to be nearly as invulnerable to fighter attack as their designers had envisioned. Perhaps at the time the first B-17's were built, their speed equaled that of contemporary fighters. By 1943 they had been badly outstripped. Nor did the firepower of their guns, whether from single aircraft or from massed fire of large formations, provide enough protection against determined fighter attack. The bombers got through; they were never turned back. But they suffered losses higher than the five per cent rate at which operations can continue on the necessary large scale for the length of time required in a war of attrition. Fighter escort had to be provided, and it was a desperate struggle to develop a fighter quickly enough, with the range to do the job.

The second lesson was that the war economy of a large industrial nation is much more flexible and resilient than most air planners had thought. Airmen remained certain that industrial nations could be forced to surrender solely through the punishment inflicted by strategic bombing. But it had to be admitted that in a TNT war of attrition only tremendously large air forces could dump enough explosives on the enemy's industrial structure in a short enough period of time to paralyze both the enemy's war production and his ability to recuperate.

In the jet engine and the atomic bomb the scientist placed in the hands of the air strategist new tools that were to produce drastic changes in the equipment, composition, and strategy of strategic bombardment. The jet engine put the bombers back in the speed class of contemporary fighter aircraft. Coupled with the tremendous advances in aerodynamics and in electronic and auxiliary equipment, the jet engine provided bombardment aircraft with sonic speeds at such high altitudes that pursuing fighters must consume much of their precious warning time in climbing. When they got to the high altitude of the bombers, the thin air deprived them of most of their advantages of maneuverability. These factors, together with the aerodynamic necessity of keeping the bomber super-sleek in its lines if it was to achieve the high speeds promised by the jet engine, led the strategists to make a radical compromise on bomber armament. They reversed the trend toward heavier armament that had marked the bomber progression from the B-17 through the B-36, settling on one twin gun turret in the bomber's tail. The validity of the compromise could only be tested fully in war, and even then the results would depend on how early in the bomber's life span the test came. Later in the life of a jet bomber the newer fighters would once more gain a substantial speed edge. At this later time additional armament, perhaps omnidirectional rockets, might have to be added to the bomber. But there was also a strong possibility that at the speeds at which the bomber and the defending fighters would be flying, much of the armament on both sides would be electronic—radar devices to locate, track, and compute distances and closing courses. Much of the air battle would resolve itself into thrusts and parries between the electronic devices and the electronic countermeasures thrown at them.

The uranium bomb, and later the hydrogen bomb, offered the strategist new and vastly more effective means of achieving the ends of strategic bombardment. The enormous destructive power of the bombs makes it possible to destroy a nation's capability for war in a matter of days, where the TNT air forces had labored for years. Furthermore the job could be done with fewer aircraft. The days of 1000-plane raids were over. A few aircraft or even one lone bomber now could fly 600 miles an hour at 40,000 feet to a target deep in enemy territory, drop an atomic bomb with an accuracy that virtually guaranteed destruction of the target, and slip away to its base.

As atomic bombs grew from one weapon to a family of weapons, each gain in versatility and size of bombs provided more flexibility and opportunity for the strategist. As bombs became larger and more powerful, he could include larger and more complex targets in his plans. As the bombs were

*A Boeing B-47 Stratojet, now the standard medium bomber on Strategic Air Command bases around the world, takes off with the aid of its 33 external rocket units. The B-47's six turbojet engines power it at better than 600 mph—matching the speed of most operational fighter aircraft. The sweptwing aircraft has a bomb capacity exceeding 20,000 pounds and is armed with a remote-controlled tail turret capable of knocking out enemy interceptors at night and under all weather conditions.*

broken down into smaller packages, he could plan for their use against pinpoint targets or against enemy surface units. All these factors assumed more and more stature as postwar developments made it increasingly obvious that the potential major enemy of the United States and of the free world was Soviet Russia. It did not take expert knowledge to realize that only the airways offered access to the vast reaches of continental Eurasia. And the additional cold fact that the Soviets also possessed atomic bombs and strategic air forces made it vital to our survival that we be able to strike anywhere in Russia, immediately and with overwhelming force. Only with such a capability could we hope to deter Soviet aggression or to survive if aggression came. These were the facts of life in the postwar years. They provided the urgency to spur the development of strategic jet bombers.

Out of World War II experience, particularly the experience with the B-29's of XX and XXI Bomber Commands in the Pacific, came a third lesson: that air forces employed in a global strategic role must be centrally controlled.

Only under single command can their enormous capability be quickly, flexibly, and decisively applied to meet the changing dictates of a global strategy. The larger the area of the earth's surface these forces encompass in their operations and the more theaters of war they pass over or operate from, the greater the need for a centralized authority to direct their operations. Only direct, immediate, and undivided control can commit and operate such forces to the greatest benefit of the broadest aspect of the world situation, rather than of segments of the whole. When Strategic Air Command was activated on 21 March 1946 with the mission of providing a global delivery system for nuclear weapons as a deterrent to aggression, the principle of centralized control was strongly evident in its command structure. The commander of SAC was to be responsible to the Chief of Staff of the Air Force, who in turn

*Longer legs for the 600-mile-an-hour Boeing B-47 Stratojet have been provided by the recently developed "flying boom" technique of air-to-air refueling. The sleek six-jet B-47 flies slightly behind and beneath a double-decked Boeing KC-97 Stratofreighter tanker. The telescopic, swiveling, flying boom is controlled by tiny V-shaped "ruddevator" control surfaces actuated by a specially-trained airman from a station under the tail of the big tanker airplane. The pipe is actually flown into a slipway coupling in the nose of the jet bomber and fuel is pumped at high speed from the KC-97 freighter to the B-47. By extending the operating range of jet aircraft despite their ravenous appetite for fuel, the development of in-flight refueling has greatly enhanced the capabilities of USAF's strategic bombers.*

would act as the executive agent for the Joint Chiefs of Staff. Clearly SAC was to be not merely an Air Force weapon but the national weapon.

In the years that followed, this emphasis on the primacy of strategic air forces continued to be a foundation stone of United States national defense policy. When budgets and manpower were cut, other forces were pared first, so that the SAC build-up as the potent spearhead that any aggressor must respect would not be retarded. As the aggressive intentions of the Soviet Union became more apparent in the postwar years, the urgency of creating in SAC an American survival force grew apace. Air defense and tactical air were relegated to second and third priorities while SAC added wing after wing, converted as quickly as possible from obsolescent piston-engined bombers to jets, and girdled the globe with air bases that offered concrete evidence of SAC's ability to devastate every corner of the Communist empire, if war was forced upon the nation.

Today the greatest portion of the build-up is completed. The air order of battle of Strategic Air Command now includes three air forces in the United States and three air divisions overseas. These air forces and divisions embrace 44 wings of heavy and medium bombardment and reconnaissance aircraft. All wings have now been equipped with B-36's, B-52's, or B-47's in place of the phased-out B-29's and B-50's. Most of the wings are fully operational, and additional wings are programmed for activation by July 1957, the target date for the fulfillment of the Air Force 137-wing program. To protect the bomber and reconnaissance wings, SAC has wings of jet fighters, and to support them as tankers and cargo carriers there are air-refueling squadrons and air-refueling wings equipped with KC-97's. Each air force, each air division, and each wing is self-contained and highly mobile.

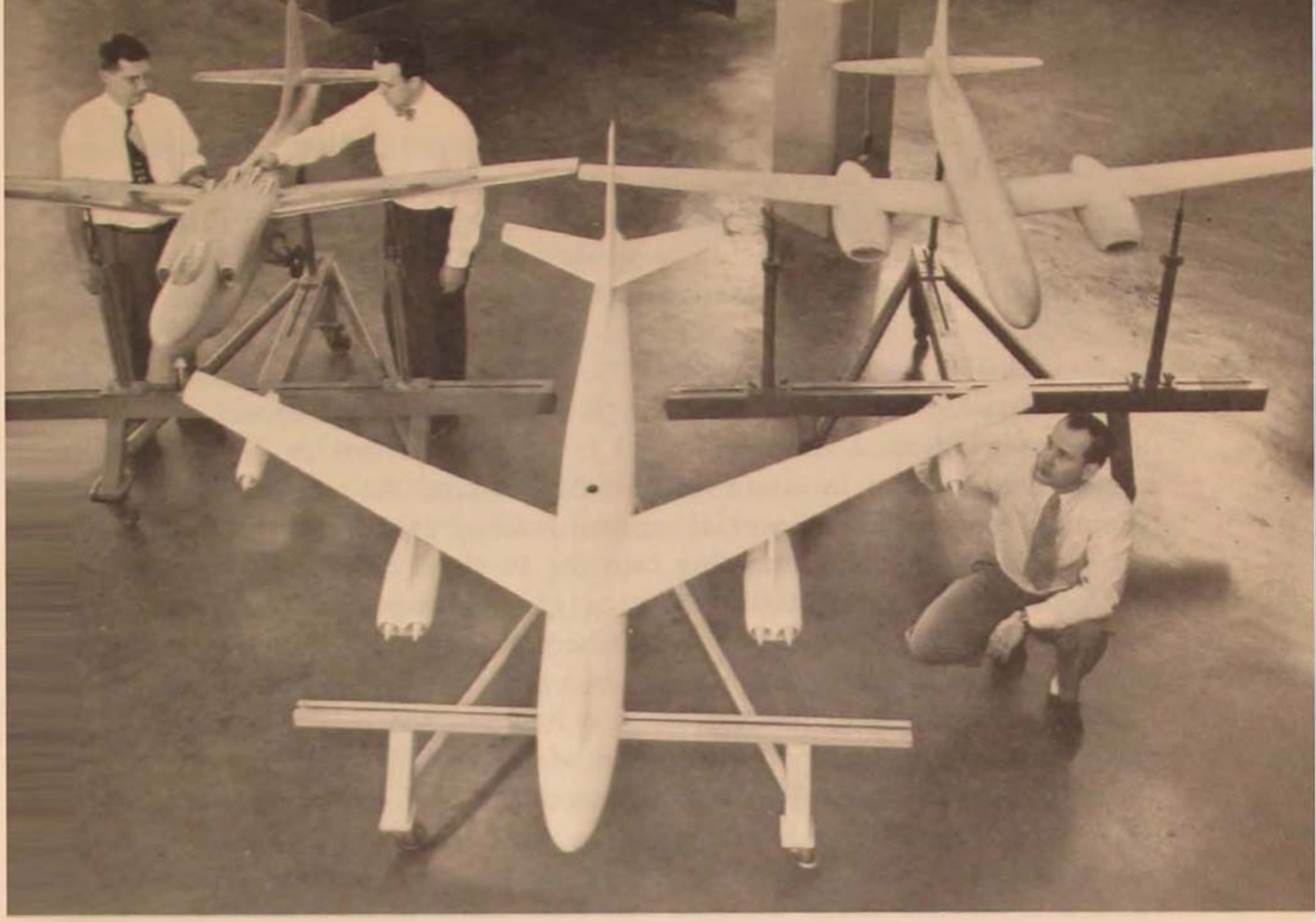
This structure might be called the skeleton of SAC. The meat on these bones developed out of another lesson born in the last days of World War II when the immense destructive force of the atomic bomb burst upon the world. As air planners contemplated the effect of this new weapon on military strategy, they quickly realized one stark fact: a strategic atomic war would concentrate enormous destruction—and hence the military decision—in the first few days or weeks of the war, so that this critical phase must be fought with the forces-in-being on the first day of the war. No time could be envisioned to call up and train reserve forces; no time to fill out professional cadres with green men; no time to mobilize the industrial resources of the nation.

This fact put an unprecedented premium on the combat-readiness of the strategic air forces. From the beginning SAC has been shaped by atomic realism. There is no reserve fat in SAC. It is a first-line striking force. Its rigorous training program has been rooted in the knowledge that the men of SAC may literally hold in their hands the future of the free world in the opening days of an all-out atomic war. Training has been incessant, competitive, and exacting. Crews fly long, realistic missions to bomb simulated targets that have every possible resemblance to the actual targets they would be assigned if SAC's war plan had to be put into effect. They are graded on the results of each mission. When a crew is rated combat-ready, spot promotions are in order, but the new rank is retained only so long as the crew maintains its keen edge of proficiency. On very short notice and in secrecy bomber wings fly halfway around the world to overseas bases for 90 days of operational training that familiarize the crews with the weather, the operational difficulties, and other conditions that are involved in air operations in that particular part of the world. Perhaps never before in the history of peacetime military forces, and certainly never in the history of peacetime air forces, have the men in a military organization been held to such a peak of tension for such a length of time.

The results in efficiency are unquestionable. So expert have these crews become that "bombs on the target" is almost a foregone conclusion. There would be little need for second and third trips to one target. In a very real sense their proficiency has doubled the strength of SAC. It is a proficiency that is all the more remarkable because it has been achieved and maintained in the midst of a continuous upgrading of the equipment employed. Successive improvements in the bombers have demanded missions flown at greater and greater speeds, at higher and higher altitudes, with more and more complicated electronic equipment supplementing manual techniques. The technological revolution has moved fantastically. In ten short years the jet engine has developed from a radical innovation to maturity.

Development of the jet aircraft engine began in the 1930's. The American National Academy of Sciences had a limited jet-research program in 1939. Scientists in other countries also were engaged actively in the field. German and British researchers delved into jet propulsion with considerable success. In 1939 Italy had achieved working models of a jet-propelled aircraft. By 1943 the USAF had begun a study of jet bomber designs. Very little information on basic jet engines or transonic speeds was available in the United States at the time. Practically nothing was known about the specific fuel consumption, maintenance, or general performance characteristics of the turbojet. Thus any attempt to build a successful jet bomber was a major challenge to the American aircraft industry. It meant joining a virtually unknown type of power plant to a wholly new airframe, a task that demanded a radical departure from the industry's thinking at the time. The Air Force nevertheless informally invited all airplane manufacturers to submit designs, and four aircraft companies entered the competition. But even the preparation of a mere design study was an undertaking of enormous proportions.

Boeing engineers had been working on four different bomber designs—two jet and two turboprop—all with straight wings. The Boeing Company had the advantage of being the only manufacturer in the country to have exclusive use of a high-speed wind tunnel—its own in Seattle—to aid in the development of a new jet bomber. Extensive wind-tunnel tests were carried out, and design configurations were altered. Even the early wind tests had indicated that the conventional straight-winged design did not use the full potentialities of the new jet engine. Evidence accumulated over the past decade has shown that the jet airplane, regardless of the power of its engines, is only as fast as its aerodynamic characteristics permit. With sweptback



*Extensive research of scale models preceded final development of the B-47. Behind a model displaying the B-47 configuration of today are two early models that played a part in the evolution of the sweptwing bomber. The model to the right called for a body and a tail patterned on the B-29, and the model to the left attached jet engines to the fuselage with exhaust pipes atop the wing center section.*

wings an airplane can reach higher Mach values and endure the accompanying rougher effects of compressibility without danger to its structure. This knowledge was not at hand before 1945, and progress came slowly as the wind-tunnel testing continued.

Late in 1944 Boeing submitted its design model, and in March 1945 the Air Force concluded a letter contract for a phase-one study, including engineering, wind-tunnel tests, and mock-ups of Boeing Model 432, which then became known as the XB-47. Model 432 retained conventional wings and the B-29 type of tail, except that the horizontal stabilizer was placed well up on the vertical fin. Four jet power plants were to be used.

Following the victory over Germany in May 1945, three Boeing engineers visited Europe and obtained German technical data on jet-plane performance. Earlier theoretical research by the National Advisory Committee for Aeronautics and Boeing was confirmed by German statistical information. The German conclusions were given to project engineers, who initiated a thorough wind-tunnel test program. In September 1945 a new XB-47 agreement was concluded between the Air Force and Boeing, based on swept-wing model 448 instead of the conventional wing 432. The new model featured a sweptback horizontal tail, changes to provide better visibility for pilot and bombardier, and six engines. Four engines were in the body and the other two were beside the rear fuselage under the tail. Because Air Force officials were concerned over the vulnerability to gunfire of enclosed jet engines and over their inconvenience for maintenance, Model 450 was substituted for Model 448 in October 1945.

Model 450 was very much like the B-47 of today. Its extremely thin wings were swept back at an angle of 35° and the six engines were mounted under the wings in a combination of two twin and two single pods. This arrangement did not interfere with air flow around the wing and permitted extremely high speeds. A special tandem landing gear was devised, with the two double-wheel units retracting into the fuselage. Small outrigger wheels which provided lateral stability during ground operation folded into the inboard engine nacelles on take-off. The prototype Stratojets were powered by six General Electric J-35 engines, each delivering 4000 pounds of thrust.

In April 1946 the Boeing Company was granted a supplemental letter contract providing for the construction of two XB-47's, together with spare parts and special tools. The finished product rolled from the Seattle plant on 12 September 1947, only seventeen months from the date of final approval of the design by the Air Force. On 17 December—the 44th anniversary of the first flight of a heavier-than-air machine by the Wright brothers—the first XB-47 roared off Boeing Field on its initial flight to Larson AFB at Moses Lake in central Washington. Several months later, on 8 February 1949, the XB-47 set a new transcontinental speed record for all types of planes by flying from Larson to Andrews AFB in Maryland in three hours and 46 minutes, covering the 2288 miles at an average speed of 607.8 miles per hour.

The first of the production Stratojets, the B-47A, was rolled from the Boeing Wichita factory in March 1950. Series B-47B made its first flight on 26 April 1951. The B-47E was initially flown on 30 January 1953. A photo-reconnaissance version, the RB-47E, was flown for the first time on 3 July 1953. Reminiscent of the production pools during World War II, a massive tri-company program was inaugurated to build the new space-devouring Stratojet. By a license agreement Douglas and Lockheed joined Boeing in the huge undertaking, utilizing reactivated World War II bomber plants. Production men had to key their factory procedures to design characteristics that called for very close tolerance standards, high structural strength without bulk, aerodynamic sleekness for high speeds, and wide-scale use of new electronics equipment. Never before had a single production enterprise so blanketed the nation. The B-47's 52,000 parts were manufactured from coast to coast to the extent that it would be difficult to tabulate the total number of cities and firms participating in the program. The vast network of contractors settled into a smoothly integrated schedule, and in October 1954 the one thousandth B-47 rolled off the production lines of the Boeing Wichita plant.

The three-man crew of the B-47 consists of a pilot, co-pilot, and a "triple-threat" man who serves as navigator, bombardier, and radar operator. The B-29 required a crew of eleven, while the B-36 has fifteen aboard. Stratojet crewmen therefore must possess versatility for a multiplicity of duties.

The continued emphasis on the B-47 during the postwar years was not achieved without pain to the rest of the Air Force. It was the result of the decision that first things had to come first, and a strategic air force was the nation's first need.

The creation of the Air Force as an autonomous service in 1947 was followed by an economy and retrenchment program that cut into the military structure of the nation. The Air Force, like the Army and Navy, was required to examine its mission and to keep manpower and equipment to a minimum. The evaluation of air weapons in 1949 resulted in the conclusion that standardization of the B-36, B-47, and B-50 would eliminate costly and time-consuming development of a fourth operational bomber. President Truman and Secretary of Defense Louis A. Johnson approved the cancellation of the B-54 (improved version of the B-50) and the RB-54 contracts and applied the released funds to the procurement of B-36 and B-47 aircraft.

The Korean War again accelerated aircraft production and placed new emphasis upon jet-powered bombers as the mainstay of Strategic Air Command. The B-47 was designated a medium bomber, and plans for its progressive integration into the Air Force were made to increase strategic operational capabilities. The re-equipment program of converting SAC wings from B-29's and B-50's to B-47's was scheduled for completion by 1955. As a speedy bomber with intermediate range, the B-47, refueled by KC-97 tankers, gives SAC the ability to strike swiftly and repeatedly from many overseas bases at target systems of great size and variety.

## The B-52

The decade after World War II saw gradual phasing-out of piston-engined bombers and their replacement by high-performance jets. As the decade ends in 1955 replacement of the B-29 and the B-50 will be completed. All medium bombers will be B-47's. The year 1955 will also see the B-36 wings begin to convert to B-52's as they become available for operational use. More than a modernization of the strategic bomber forces, this change represents another large step in the direction of a truly intercontinental strategic air force.

For when the Air Force made the decision to go ahead with the production of the B-52, it in doing so decided in favor of the intercontinental force. In the years since World War II the Air Force had laboriously built a large system of overseas air bases. By siting B-47's on these bases and by also using the bases for tanker aircraft to extend the range of the medium bombers, the B-47's could reach any target in the Soviet Union. In itself this was a massive achievement. It was also a necessary one as long as the B-47 was the only jet weapon in the strategic air arsenal. A part of the decision whether to order the B-52 into production hinged on the system then in effect. Was the system the best that could be had? Certainly there were disadvantages to it. One major problem was that many of the bases were close enough to the Soviet Union to be very vulnerable to atomic attack.

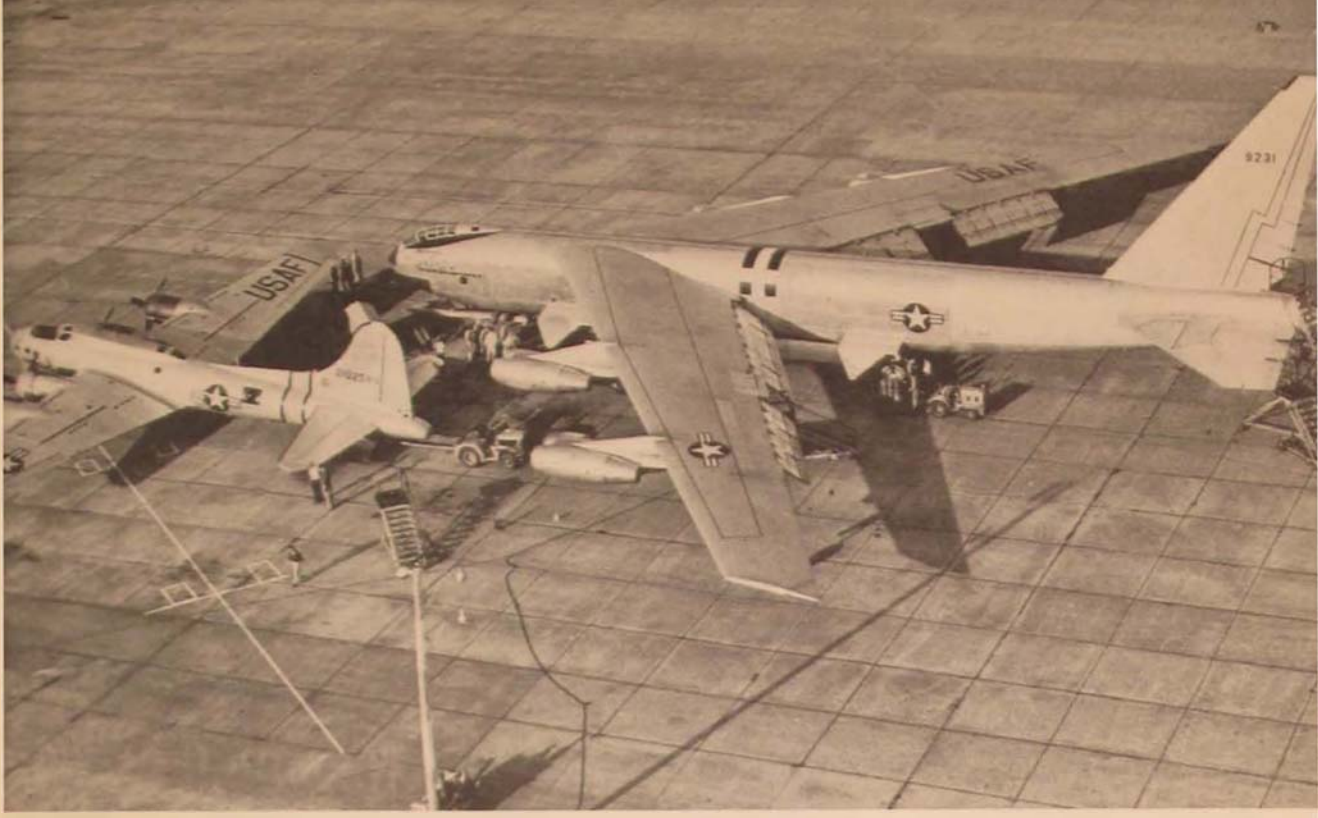
Another was that in time of crisis there was danger that the bases in areas inhabited by strongly organized minority groups might be difficult to protect from sabotage on the ground. There was even danger that if a general atomic war began, some nations might attempt to ensure their neutrality by refusing to allow the bombers to operate from bases on their soil. To these considerations was added the formidable cost and logistic problems involved in maintaining strategic air forces on overseas bases scattered throughout the world.

The decision in favor of the B-52 was thus a decision to modify the structure of Strategic Air Command in the direction of an intercontinental force. When B-52's have replaced B-36's as the heavy bomber, the USAF will be able to launch a major atomic assault in any direction, to any spot on the globe, from bases within the United States. This will not eliminate the need for overseas bases; they will still be needed for some of the operations of the B-47's and as bases for the tanker aircraft. But it will mean that the most-modern, most-powerful element of the strategic air forces will be able to operate immediately and continuously, regardless of how events might affect the overseas bases.

The chronology of the Stratofortress goes back to 1946 when preliminary engineering studies and designs were started. The American public first heard of the new jet bomber in September 1947. Production tooling began in March 1951. The YB-52 rolled out of Boeing's Seattle plant on 15 March 1952, and its first flight took place on 15 April 1952.

The creation of a heavy bomber with the extremely high performance specifications of the B-52 presented major problems. The Air Staff had to consider the financial implication, the time phasing, and the impact on the aircraft industry. This bomber was to be more than a mere aircraft—it was to be a complete weapons system. If one company were awarded the contract without competition, the effect on the industry would be obvious. Air Force planners were very conscious of this dilemma and sought to encourage all the top manufacturers to submit design proposals. The new bomber would play such an important role in the security of the nation that any failure would not only jeopardize the stature of the Air Force but would impair the effectiveness of the United States in world affairs. Under the circumstances many top-level Air Force officers believed that a better design would evolve under the pressure of competition than if one company were awarded a direct contract. Because of this reasoning the decision was delayed, and a production contract was not concluded with Boeing until August 1952.

The B-52 illustrates the extent to which science and research have become the handmaidens of aviation. In the development of the B-47 and the B-52 more than 19,000 man-hours were devoted to wind-tunnel research. This is the equivalent of nine years at a 40-hours-a-week rate. By way of contrast Boeing devoted only 248 hours to wind-tunnel research while working out the design of the B-17 and 3718 hours to the B-29. To accelerate the test program of the B-52, a $5,000,000 flight test center with a dozen laboratories for applied research was built at Seattle. In addition a new transonic wind tunnel was constructed. It is estimated that to date the aerodynamic research on the B-52 has totaled more than 318,000 engineering man-hours.



*One of the biggest deterrents to aggression in the world today is USAF's mightiest strategic weapon—the B-52 Stratofortress. Possessing global capabilities of a devastating impact, this Boeing giant, now in quantity production, will soon phase into all SAC's heavy-bomber units. Equipped with eight of the world's most powerful jet engines, the B-52 ascends to altitudes above 50,000 feet and cruises with fighter speed. The newest, largest, and fastest jet bomber, the B-52 offers a comparison of eleven years of air power as it completely dwarfs the B-17 of World War II. Below, the graceful B-52 is in test flight over the Pacific Northwest.*

## Characteristics of the Strategic

| Aircraft | Power Plant | | Performance Data | | |
|---|---|---|---|---|---|
| | *Type* | *hp/lbs of thr* | *Max. Speed (mph)* | *Service Ceiling (feet)* | *Max. Range (miles)* |
| de Havilland DH-4 | 1 Liberty 12 | 400 | 124.7 | 19,500 | 325* |
| Breguet 14 | 1 Renault 12 | 300 | 118 | 20,000 | |
| Martin MB-2 | 2 Liberty 12 | 418 | 98 | 9900 | |
| Witteman-Lewis XNBL-1 "Barling" | 6 Liberty 12 | 520 | 96 | 7275 | 335 |
| Curtiss B-2 Condor | 2 Curtiss V-1570 | 632 | 132 | 17,100 | |
| Boeing Y1B-9 | 2 Curtiss V-1570 | 600 | 173 | 19,200 | 1250 |
| Martin B-10 | 2 Wright R-1820 | 700 | 213 | 24,400 | 600 |
| Boeing XB-15 | 4 P&W R-1830 | 1000 | 197 | 18,850 | 3400 |
| Boeing XB-17 (Model 299) | 4 P&W R-1690 | 750 | 236 | 24,620 | 3010 |
| Boeing B-17G Flying Fortress | 4 Wright R-1820 | 1200 | 310 | 30,000 | 2000* |
| Douglas XB-19 | 4 Wright R-3350 | 2000 | 224 | 23,000 | 5200 |
| Consolidated B-24J Liberator | 4 P&W R-1830 | 1200 | 300 | 30,000 | 2850* |
| Boeing B-29 Superfortress | 4 Wright R-3350 | 2200 | 397 | 35,000+ | 4000+* |
| Convair B-32 Dominator | 4 Wright R-3350 | 2200 | 358 | | 3700* |
| Convair B-36J | 6 P&W R-4360<br>4 GE J-47 | 3800<br>5200 | 435+ | 45,000+ | 10,000* |
| Boeing B-47E Stratojet | 6 GE J-47 | 6000 | 600+ | 40,000+ | 3000+ |
| Boeing B-50B Superfortress | 4 P&W R-4360 | 3500 | 400+ | 40,000+ | 6000+ |
| Boeing B-52A Stratofortress | 8 P&W J-57 | 10,000 | 600+ | 50,000+ | 6000+ |

*Sources for statistics on ranges of aircraft vary in the basis of their computations. The ranges

## Bombardment Aircraft of the U.S.

| Gross Weight (pounds) | Dimensions: Span | Dimensions: Length | Dimensions: Height | Armament | Crew | Remarks |
|---|---|---|---|---|---|---|
| 3582 | 42′4″ | 29′8″ | 10′10″ | 4 .30 mgs | 2 | *at full speed; British-designed |
| 3771 | 47′1″ | 29′6″ | 10′10″ | 3 .30 mgs | 2 | French-built |
| 12,027 | 74′2″ | 42′8″ | 14′8″ | 5 .30 mgs | 4 | |
| 32,203 | 120′ | 65′ | 27′ | 7 .30 mgs | 6 | only one built |
| 16,516 | 90′ | 47′6″ | 16′3″ | 6 .30 mgs | 5 | |
| 13,351 | 76′9″ | 51′6″ | 12′8″ | | 4 | only one built |
| 14,400 | 70′6″ | 45′3″ | 15′5″ | 3 .30 mgs | 4 | |
| 65,068 | 149′ | 87′11″ | 18′5″ | 3 .30 mgs & 3 .50 mgs | 10 | only one built |
| 32,432 | 103′9″ | 68′9″ | 15′ | 5 .50 mgs | 8 | test aircraft |
| 55,400 | 103′9″ | 74′4″ | 19′1″ | 13 .50 mgs | 10 | *with 4000-lb bomb load |
| 160,000 | 212′ | 132′2″ | 42′ | 6 .30 mgs, 5 .50 mgs, & 2 37mm cn | 11 | only one built |
| 56,000 | 110′ | 67′2″ | 18′ | 10 .50 mgs | 10 | *with 2500-lb bomb load |
| 140,000 | 141′3″ | 99′ | 27′9″ | 12 .50 mgs | 11 | *with 10,000-lb bomb load |
| 100,000 | 135′ | 83′1″ | 32′2″ | 10 .50 mgs | 8 | *with 20,000-lb bomb load |
| 400,000+ | 230′ | 162′1″ | 46′9″ | 16 20mm cn | 15 | *with 10,000-lb bomb load carried halfway |
| 200,000+ | 116′ | 107′1″ | 28′ | 2 20mm cn | 3 | |
| 170,000 | 141′2″ | 99′ | 32′8″ | 13 .50 mgs | 10 | |
| 350,000+ | 185′ | 156′6″ | 48′4″ | 4 .50 mgs | 6 | |

followed by asterisks are qualified by a specific operating condition explained in the remarks column.

*Developed from the 707 prototype, the Boeing KC-135 Stratotanker has reached altitudes above 42,000 feet and speeds over 550 mph. Now in production for SAC's air-refueling units, the four-jet tanker is equipped with a new streamlined, high-speed flying boom. With previous tankers fuel-hungry jet aircraft had to drop from their cruising altitude of above 40,000 feet to below 20,000 feet and cut back power to near-stalling speeds while they refueled. The KC-135 can refuel strategic bombers at optimum jet speeds and altitudes. Not only does this mean that the jet bomber will not have to expend part of its new fuel load in regaining its cruising altitude, but it makes aerial refueling much safer from enemy interference.*

## One Story Among Many

The ability to penetrate a nation's heartland is one of air power's greatest contributions to warfare. Within the past few months the Air Force announced that a contract had been concluded with Boeing to build the 707 jet tanker-transport, which has been designated as the KC-135. Refueled by the KC-135 at optimum jet speeds and altitudes, the B-52 will gain a decided advantage in the delivery of bombs. Unfortunately these striking developments in long-range jet bombers are not confined to the United States. The Soviet Union has demonstrated rapid progress in this field, as was shown in recent May Day celebration flyovers.

Yet American strategic air power today stands on a bedrock of dynamic USAF air doctrine. Much of this basic doctrine is the same as that once evolved by the old Air Corps Tactical School. The doctrine was proved and clarified by World War II and was further refined by the events and actions of the Korean War. As world conditions change and newer weapons are added to the air arsenal, the tactics and techniques consequent upon the doctrine will again find the additional modifications to assure the nation of the most effective development and employment of its air power in peace or war.

The story of the strategic bomber that has been the subject of this monograph is only a part of the story of the growth of the United States Air Force, and a number of other monographs remain to be written. The role of U.S. air power is a dual one. Kept strong, it appears the best means of persuading aggressors to remain at peace with the world. But if the Communist leaders recklessly attack, air power is our first line of defense. Strategic Air Command's ability to defend through offensive retaliation is strengthened by Air Defense Command's constant alert to intercept and repel enemy strikes at industrial centers and military installations. Although there is still a distinction between the missions of tactical air forces and of strategic air forces, the family of atomic weapons has reduced these differences largely


to a matter of range, and atomic-age planners are coming more and more to integrate the two concepts. The global air capability of Strategic Air Command, the defensive potential of Air Defense Command, the theater air forces of Tactical Air Command and its capability to fight "limited" war, plus the ability of Troop Carrier Command and the Military Air Transport Service to deploy and supply fighting forces in troubled areas at a moment's notice—all air forces acting as an indivisible entity—are potent dissuaders to any aggressor.

In meeting its challenge the Air Force relies upon the aircraft industry as an equal partner. General Twining's words to Boeing's president last March when the first B-52A was rolled off the assembly line epitomize the spirit of American defense. General Twining said: "The minute that airplane rolls out—forget it. . . . Start thinking about the next one, a bigger one, a faster one."

# Books and Ideas...

## *Air Doctrine*

Colonel Paul C. Droz

*U.S. Military Doctrine* by Brigadier General Dale O. Smith,* formerly Director of Education of Air University and now with the Operations Coordinating Board of the National Security Council, is a welcome and valuable contribution to a most important field of learning about which very little has been written. The existing literature in this field, even including technical publications with almost no circulation outside the military profession, is insufficient and incomplete. General Smith's book will be valuable and interesting both to the professional military corps and to the civilian public. It will help to provide a basis for understanding what is being done and what must be done to assure our survival in the air-atomic age.

General Smith's own point of view in developing *U.S. Military Doctrine* may be described in these words of Dennis Hart Mahan, father of the naval philosopher: "It is in military history that we are to look for the source of all military science." General Smith begins his look into military history with the Revolutionary War. By an analysis of the major contributions of most of the famous military theorists since that time, he traces the development of military doctrine and policy to the present day. In doing this, his treatment is remarkably complete in spite of his statement that "only those doctrines and policies are considered which bear on today's problem of national security."

Those who have been urging recognition of the full potential of air power will find concentrated between the covers of this volume many of the ideas and concepts which they have supported but which heretofore have been presented piecemeal. General Smith argues logically and forcefully that air power has assumed the dominant role in national defense. Or in the words of Winston Churchill which he quotes, "For good or ill air mastery is today's supreme expression of military power, and fleets and armies, however necessary, must accept a subordinate rank."

General Smith emphasizes repeatedly that the national defense policy announced by Secretary Dulles on 12 January 1954, of depending "primarily upon a great capacity to retaliate, instantly, by means and places of our own choosing," is absolutely sound and essential. For him this announcement "gave the broad outline of a realistic and dynamic policy, the like of which

***U.S. Military Doctrine, by Dale O. Smith, Brig. Gen., USAF (New York: Duell, Sloan and Pearce; Boston: Little, Brown and Company, 1955, $3.50).**

this nation has not seen since George Washington submitted to the Continental Congress in 1783 his 'Sentiments on a Peace Establishment.' " General Smith would go further with his approval, declaring that "never before has military policy been more harmonious with military doctrine."

The majority of well-informed Air Force officers appear to be almost as strongly in favor of the military policy of massive retaliation as General Smith, although they appear to be more critical of existing U.S. military doctrine as such. When the massive-retaliation policy was announced, most airmen, in the opinion of this reviewer, were quick to interpret it to mean that we were to become an air power nation in the true sense of the term. To them the new policy implied that the United States was to rely for security on the capacity of air power to apply instantly at any place in the world whatever degree of force the situation required. The majority of airmen reasoned, as General Smith reasons, that "no instant retaliation, of course, is possible through our movement of massed surface forces." This reviewer believes that they saw in this policy an apparent repudiation of another national policy, contained in the Roles and Missions Papers, agreed to at Key West, Newport, and Quantico by the three Service Chiefs of Staff and approved by the President. In effect the Roles and Missions Papers had established mutually exclusive missions for four separate military services, each having its own air force. In other words the older policy had declared this nation to be a land-power, sea-power, air-power, marine-power nation.

But now we were to become an air-power nation. The massive-retaliation policy represented, as General Smith describes it, "a major, strategic reorientation toward war." If this was the purpose of the new policy, certainly a parallel major reorientation of existing plans and doctrine was necessary. To this reviewer this reorientation still has not been accomplished. Considerable progress has been made, but there appears to be ample room for argument whether existing plans take maximum advantage of the decisive capabilities of air power. It is apparent, too, that individual service doctrines continue in existence which are difficult to reconcile with one another, as well as with the executive policy. General Smith does not ignore this. He acknowledges that individual services may have differing doctrines. As an example he states that the strategic air doctrine that was adopted long ago by the Air Force "is not yet uniformly held in the armed services of the United States even though it is substantially subscribed to by the Joint Chiefs of Staff." There is considerably less agreement among the Services concerning application of the strategic air doctrine to limited war.

Although well aware of the disparity in doctrine throughout the armed forces, General Smith identifies and describes four "basic military doctrines," which he says "are, for the first time in American history, in accord with the executive policy of the government." They are *professionalism, unity of command, celerity with the counteroffense,* and *technical application.* In his development of these, he convincingly establishes their present-day validity. But it is important to point out that interpretation of these four "basic military doctrines" varies widely throughout the military establishment. U.S. military doctrine does not appear to be based upon a common understanding of these "basic doctrines" described by General Smith but to be a composite or synthesis of the existing doctrines of the individual services.

If U.S. military doctrine and executive policy are not as fully in accord as General Smith indicates, perhaps the reason is that the formulation of the massive-retaliation policy did not follow the "steps in the evolution of ideas for waging war" that the author describes. He says that these steps "go from concepts to doctrines and plans, then from executive policy to Governmental policy, to national policy. Finally, the last step is the existing military establishment that ensues, and the military posture, which will usually, in turn, force revision of some doctrine and plans to fit the facts of life." It appears likely that at least one of these steps was reversed and that executive policy, in the case of the "New Look," preceded rather than stemmed from plans and doctrine. If this was so and if the new policy represented a major reorientation toward war, it would follow that existing plans and doctrine of the U.S. armed forces require considerable revision. This reviewer believes that much remains to be done within our military household to place the steps below the executive policy level more in line with this policy. The existing military establishment and the plans and doctrine for its employment still do not appear to reflect the relative emphasis on air power consistent with the declared executive policy. This inconsistency may appear to be a relatively minor matter, since the chief executive is also the Commander-in-Chief of the Armed Forces. But its resolution is actually an extremely difficult task and one not likely to be accomplished quickly.

EVEN a superficial look at military history, much more the careful, comprehensive study and evaluation that General Smith has made, is sufficient to establish that the reluctance of military leaders to keep abreast of change invariably has preserved obsolete weapons and gray-bearded doctrine long after their usefulness had passed. General Smith states most forcefully his views on the consequences of failing to keep both weapons and doctrine in pace with technological developments. He cites Alfred Thayer Mahan's recognition "that the conduct of war changes rapidly with technology" as the most signal contribution of the noted naval philosopher in the field of military doctrine. In *The Influence of Sea Power Upon History* Mahan reasoned that "changes in tactics have not only taken place after changes in weapons, which necessarily is the case, but that the interval between such changes has been unduly long." Mahan recognized the great advantage that would accrue to the one who adapts methods of use to the qualities of new weapons. General Smith's opinion on this subject is so strong that he says we are today forced to recognize a tenth principle of war: "*Technological change has a significant influence on the art of war, and the military power which first learns how to exploit new devices will have the greater chance for success in war.*"

Acceptance of the idea underlying General Smith's tenth principle was what Mahan strongly advocated. Mahan explained not only what must be done to exploit the improved qualities of new weapons without undue delay but also that "history shows that it is vain to hope that military men generally will be at the pains to do this." It is this reluctance to change from battle-tested weapons and doctrines of the past that will have to be overcome in shaping our military establishment for the future security of the United States.

*Air War College*

## BRIEFER COMMENT

**The Power of Personality in War, by Major General Baron von Freytag-Loringhoven. Translated from the German by the Historical Section, Army War College, September 1938, pp. 167.**

In this little but compactly filled book written in 1911 by a typical German Junker General Staff officer there is a great deal for the young and not-so-young Air Force officer to think about in the completely dead-serious professional analysis of the theories of Clausewitz on the psychological aspects of leadership and the effect of the personalities of commanders on the battles that they fought. The author's textual method is the adduction of numerous examples drawn from the battlefields of Napoleon, Frederick the Great, Washington, Grant, von Moltke, Sherman, Lee, and others, whose battle success or failure he annotates in the light of their traits of military character. In our day of military "management," the mass impact of the technician, and the enormous impedimenta of specialist staff-work, it is not without value to think seriously of the role of the battle commander and the inevitable effect of his nature upon his planning and decisions. In the quickly decisive air operations to which the art of war has come, the qualities of audacious acceptance of uncertainty and risk, of bold imagination and stubborn strength of will are not likely to yield lesser reward to the fortunate nation whose commanders possess them than was yielded in the days of infantry maneuvering.

*Military Service Publishing Co., $3*

**Psychological Warfare, by Paul M. A. Linebarger, pp. 318.**

A new edition (the second) of Dr. Linebarger's expert, interesting, and highly readable examination of what psychological warfare is, what it does, how it is fought, and who fights it. Three fresh chapters have been added on problems confronting practitioners of such operations. A solid introduction to professional understanding of cold war tactics, as well as to the techniques of wartime propaganda and counterpropaganda.

*Combat Forces Press, $6*

**American Military Policy, Its Development Since 1775, by Major C. Joseph Bernardo, Ordnance Corps, and Eugene H. Bacon, pp. 512.**

A copiously documented volume of factual research, principally useful for its summarization of United States military history at the "political level," where it proposes to examine "military policy." Although the authors' style and interpretive conclusions are pedestrian, their book is a fair enough candidate for the professional library as a reasonably well-done résumé of its subject.

*Military Service Publishing Co., $5*

**Beyond Courage, by Clay Blair, Jr., pp. 247.**

Narratives of dramatic escapes by captured USAF personnel during the Korean War. Derived from official records and interviews.

*David McKay, $3.50*

**Development of the Guided Missile, by Kenneth W. Gatland, pp. 292.**

The available facts on the evolution

of guided missiles up to the present. In this second edition new chapters have been added dealing with problems of propulsion, research into rocket techniques, and recent work on the guided bomb. There are over a hundred photographs and drawings and a table of characteristics of over 130 significant powered missiles from several nations. Written and first published in England. There is a chapter on space-satellite vehicles and one on interplanetary flight.

*Philosophical Library, $4.75*

**"Sound Barrier," The Story of High-Speed Flight, by Neville Duke and Edward Lanchbery, pp. 129.**
A new edition of an excellent introduction to the technical and historical aspects of supersonic flight, with enough of aerodynamics and propulsion engineering to provide a solid understanding of current developments in high-speed flight.

*Philosophical Library, $4.75*

**Technical publications**

*Guidance, by Arthur S. Locke et al, pp. 729, D. van Nostrand, $12.50.*—A technical survey of guidance devices and techniques that proceeds from a discussion of fundamental problems to methods of obtaining intelligence of a target by employment of infrared, radio, or acoustic waves and fixing its location by celestial and terrestrial references.

*An Outline of Atomic Physics, by Oswald H. Blackwood, Thomas H. Osgood, and Arthur E. Ruark, third edition, pp. 501, John Wiley & Sons, $7.50.*—Readers with an elementary knowledge of physics who would like to know more of what science has to say about the structure of atoms and molecules and the nature of radiation. A textbook, but readable by the studious.

## The Quarterly Review Contributors

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COLONEL ROYAL H. ROUSSEL joined the Evaluation Staff, Air War College, from the Office of the Secretary of the Air Force, where he was Deputy Executive Assistant. His prior service included assignments as intelligence staff officer in the ETO and as Project Officer in the War Plans Division of Hq USAF. Colonel Roussel is a native of Houston, Texas. He interrupted his schooling to enlist in the Air Service in 1918. After the war he entered the newspaper business as a reporter and continued his education under tutors. He was Managing Editor of *The Houston Press* at the time of his direct commission in the Air Force in 1942.

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COLONEL PAUL C. DROZ (B.S., University of Utah) has been on the faculty of the Air War College since his graduation in 1954. After his completion of flying training in 1938 he served as a fighter pilot and as squadron commander. In the China-Burma-India Theater from January 1942 to November 1943 he commanded the 25th Fighter Squadron, 51st Fighter Group. In 1946 Colonel Droz was selected to attend the Russian Language and Area Course at Columbia University, and from there he continued this line of study through 1949 in Europe and in Moscow. He served in the Directorate of Intelligence, Hq USAFE, 1949-50; then in Washington as military member of the Interdepartmental Foreign Information Staff, State Department, 1950; and in the Psychological Warfare Division, DCS/O, Hq USAF, from 1951 until his assignment to the Air War College.

## ATTENTION

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

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