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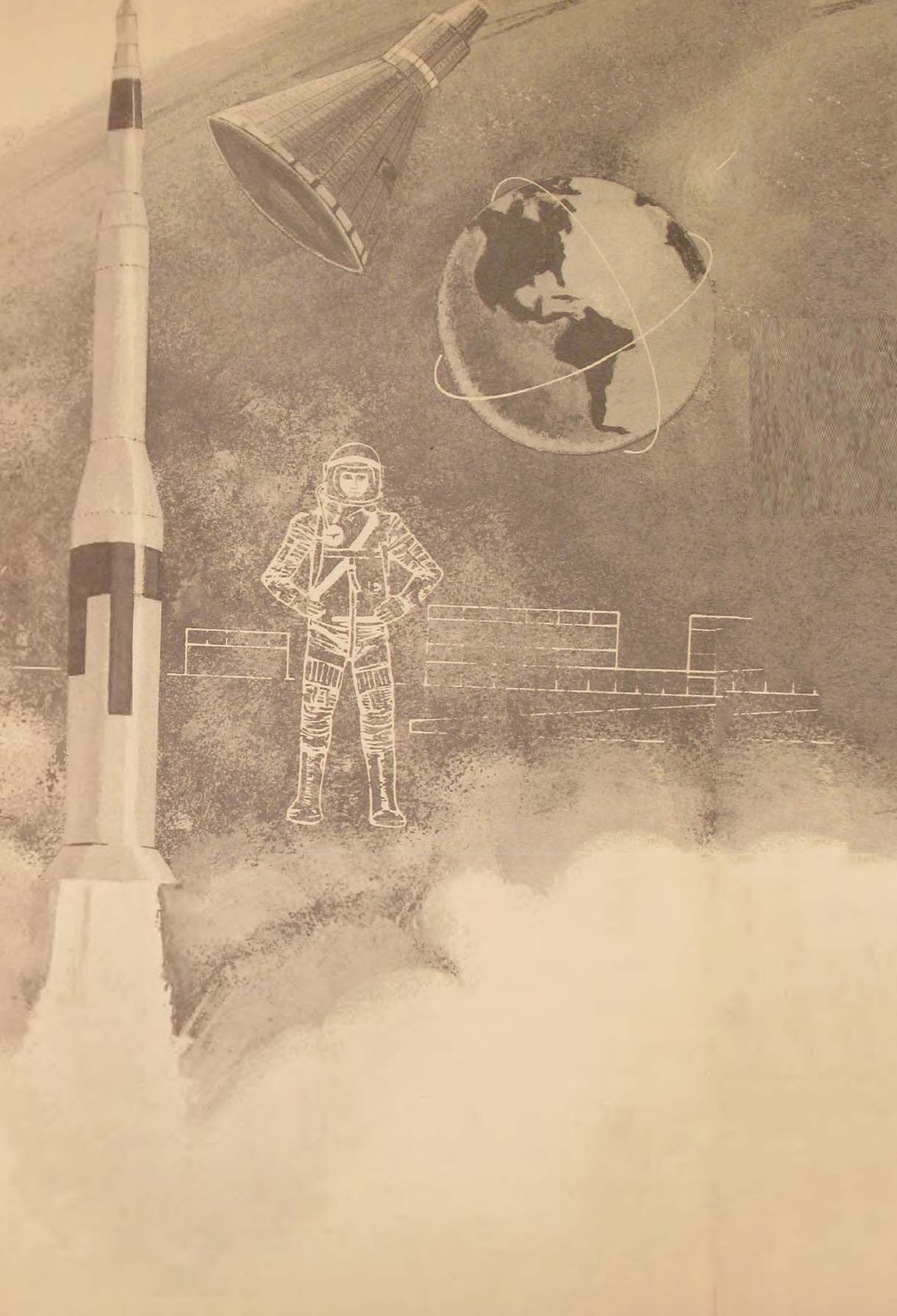


Educating Cadets for the Aerospace Age

The Academic Program of the U.S. Air Force Academy

BRIGADIER GENERAL ROBERT F. MCDERMOTT

SOME people wonder why the Air Force Academy is concerned with the subject of educating cadets for the aerospace age. "Why," say these critics, "should these cadets be worrying about he problems of space? This is looking too far into a doubtful future. Why not just give them a good basic grounding in the duties of a econd lieutenant, and let it go at that?"

One answer is that we are not educating our cadets to be just econd lieutenants. The mission assigned to the Academy by the Air Force and by Congress is to help them develop the qualities that will ead to long-term career development during a whole lifetime of ervice to the Nation.

But I would go further than that. I would say we are educating our cadets for the aerospace age because space is the next great fron-ier of the human race. It is a frontier so challenging that it will lwarf previous challenges to the mind of man, the discovery of the

New World, and all the geographic and scientific frontiers of our past. Military men have ever been in the van of frontier movements. Their discipline, hardiness, and devotion to duty have made them particularly suited for the task of exploration. We recall that the legions of Caesar carried civilization into the wilds of western Europe, that the United States cavalry surveyed the wagon trails into our West and guarded its first settlers, and that the Navy and Air Force have carried out our penetration of the Antarctic—an area where the extremes of operational problems are not unlike the ones found in space.

Future military leaders—which we hope our cadets will become—will have an even more direct interest in space than past military commanders have had in the frontier operations of their day. They know how important control of the air is, and has been, in recent decades. They know further that, as General Thomas D. White, former Chief of Staff of the Air Force, told them in the Wright Memorial Lecture at the Air Force Academy, ". . . there is no fine dividing line between the air and space. Air and space are an indivisible field of operations. . . . It is quite obvious that we cannot control the air up to twenty miles above the earth's surface and relinquish control of space above that altitude . . . and still survive."

There is a related point here, one that is vital to the future of all mankind. We know that our control of the air, particularly by our Strategic Air Command, the mightiest weapon of all time, has not led to war, as some of our well-meaning pacifist friends have thought it would. Instead, backed by the rest of our military strength, it has preserved the peace and deterred the Communist threat that would overrun the free world if it could. Similarly, as General White said a year ago, ". . . further contemplation of man's extension into space suggests . . . that here in this vast arena we may find the most imaginative and challenging key to the control of peace. We must take every advantage of this possibility."

Of course many of the reasons for the establishment of the Air Force Academy run further back in our history than the beginning of the space age. Some are related to the role played in the older armed services by their academies—the Military Academy at West Point and the Naval Academy at Annapolis. All three of these institutions provide academic education as well as the professional military training and leadership experience which we hope will make good officers out of our cadets and midshipmen. All try to give them motivation for a lifetime of service to their country, and all hope they will graduate with a deep sense of honor and dedication to duty.

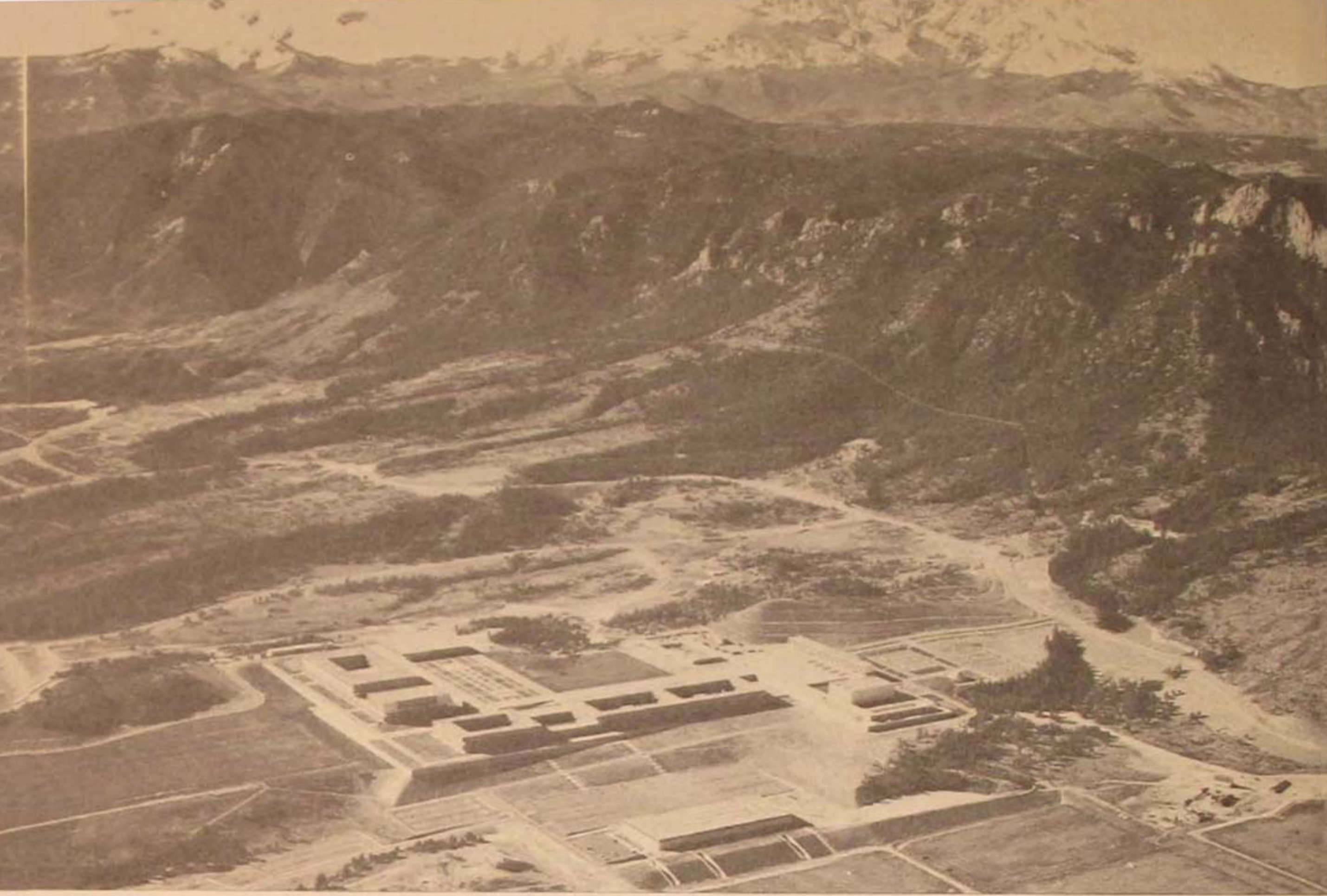
The mission of the Air Force Academy reflects the traditional service academy emphasis on the development of career officers. It is stated in Air Force Regulation 23–23: "To provide instruction, experience, and motivation to each cadet so that he will graduate with the knowledge, character, and qualities of leadership essential to his ogressive development as a career officer in the United States Air orce."

The emphasis on career motivation and development can be aced far back in American military history. Almost from their be-nnings, the service academies have been relied on to provide the ard core of professional officers, dedicated to their country and moti-ated to serve it during a lifetime career. In the case of the Air Force cademy this emphasis stems also from the Stearns–Eisenhower Board, ppointed by the first Secretary of Defense, James Forrestal. This oard had as its chairman Robert L. Stearns, President of the Uni-ersity of Colorado, and as its vice chairman General Eisenhower, nen President of Columbia University. The board examined the xisting academies and studied the whole problem of regular officer rocurement. It concluded that West Point and Annapolis should e retained and that a similar institution should be established to urnish the Air Force with a continuous flow of qualified young career fficers. The board also stated the general mission of the service acade-nies in terms very similar to the mission statement just quoted, and it mphasized that the basic function of the academies was to give gen-ral education, in an atmosphere of devotion to country and service.

It is this emphasis on career motivation that is responsible for everal special features of the Air Force Academy. It explains some spects of the cadet way of life, some of the approaches we use in he classroom, and even the composition of our faculty, as we shall ee later. On the other hand, we are not training the cadet for a job, nor are we interested solely in giving him professional military in-doctrination. Our mission is to provide a combination of academic education, professional orientation, and skill training in an environ-nent that will motivate our graduates to devote their lifetime careers o the Air Force and the country.

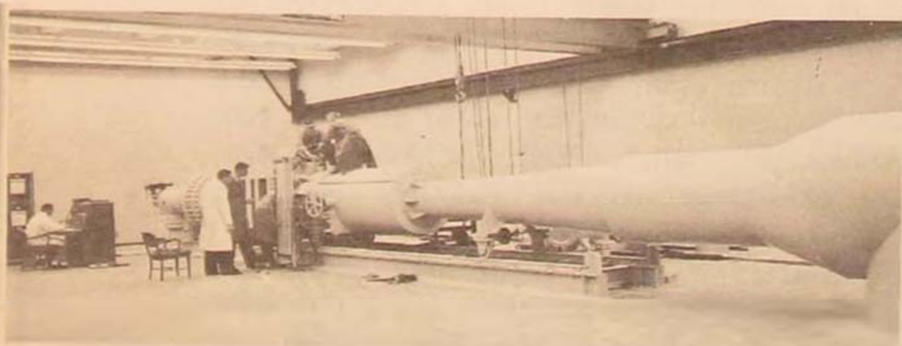
The basic structure of the Academy illustrates another dual as-pect of its operation: while the Academy is a major Air Force com-nand, its organization for education is similar to that of many col-eges. Militarily the Academy is also an Air Force base, with many of he facilities and operating elements found on other air bases. The Superintendent, Major General William S. Stone, is the Commander of the Academy but also occupies a position similar to that of a col-lege president. He has a staff and support units which help the opera-tional elements. Under him are the Dean of the Faculty and the Commandant of Cadets.

This discussion will deal primarily with the academic program, although the program of professional military training and the ath-letic program are also integral elements of our broad program for educating and training future leaders of the Air Force. Taken to-gether, these programs have complete responsibility for the student's development; such full-time responsibility is not normal in a civilian school.

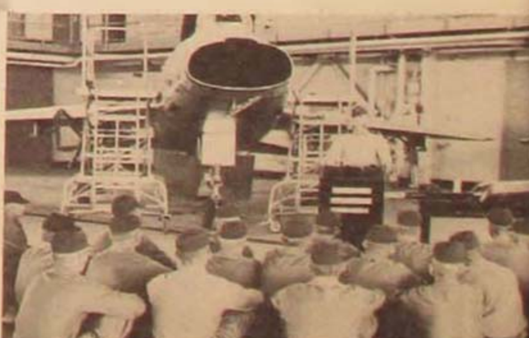


The Air Force Academy equips cadets for officership in the Aerospace Age . . .

. . . in the classroom, as in this lecture on transplanetary trajectories,



. . . in the laboratory, as with this trisonic wind tunnel,



. . . in practice, as in this demonstration of armament loading.

he prescribed program

By law, cadets in American service academies must complete the equirements of a prescribed curriculum before they can graduate nd receive their degrees and commissions. This program is carried n by academic divisions and departments which are under the over-ll supervision of the Dean of the Faculty. Related departments are rouped into the four divisions that are found in many American nstitutions of higher education—the Basic Sciences, Applied Scien-es, Humanities, and Social Sciences divisions. To these the Air Force cademy has recently added a fifth, the Division of Military Affairs, hich will integrate academic instruction in military subjects. There re also various policy-making bodies within the faculty, and the urriculum and the whole Academy come under the scrutiny of sev-ral outside agencies. We have a Board of Visitors reporting to the resident, which meets annually; the General Officer Advisory Com-nittee, which also meets annually, looks at us from the standpoint of he ultimate consumer; and the North Central Association of Col-eges and Secondary Schools monitors our academic standards. And, f course, as a public institution we are ultimately responsible to ongress and the people.

The accompanying chart shows the over-all curriculum of the ir Force Academy. The prescribed academic courses add up to a otal of 146½ semester hours. In addition there are the military train-ng program, equated at 27 semester hours; the intensive athletic rogram, 13 semester hours; and the First-Class Option, 2½ hours. The irst-Class Option replaces the full-scale navigation program given to ur classes through 1961. Under that program graduates were awarded avigator wings along with a commission as regular second lieutenants nd the degree of Bachelor of Science.

Under the new option program all cadets will get 10 hours of ight-plane orientation flying, so that they will know something about ircraft and the problems of flight. Cadets who are physically quali-ied may choose to take the pilot indoctrination course, about 30 ours in the air and 60 hours of ground school—roughly the first phase f Air Force pilot training. Likewise cadets physically qualified for avigator training may take navigator indoctrination. Those who are not physically qualified or who do not elect either of these programs or who want to postpone their flying until after graduation may take the First-Class Option, an additional 2½-semester-hour course in our enrichment program of elective courses.

Two points about the prescribed Academy curriculum are strik-ing. One is its weight, 189 semester hours, in comparison with the 120–130 semester hours required to graduate from a typical liberal arts college and the 140–145 hours usually required by engineering schools. Our academic curriculum alone adds up to 146½ semester

Curriculum of the Air Force Academy

Total Curriculum	**semester hou[rs]**
Academic Program	146½
Military Training Program	27
Athletic Training Program	13
First-Class Option	2½
	189

Prescribed Academic Program	**semester hour[s]**
Basic Sciences Division	
mathematics	17
chemistry	5½
human physiology	2½
physics	8½
	33½
Applied Sciences Division	
mechanics	6
engineering drawing	2
electrical engineering	8
aeronautics	11
astronautics	8½
	35½
Humanities Division	
English	15½
philosophy	2½
history	11
foreign language	9
	38
Social Sciences Division	
geography	4
economics	5½
psychology	5½
law	5½
political science	10½
	31
Military Affairs Division*	
military studies	4½
military history (5½ sem hrs)	
psychology (5½ sem hrs)	
economics of national security (2½ sem hrs)	
American diplomatic history (3 sem hrs)	
international relations & defense policy (5½ sem hrs)	
Cadet Composition Program	
(monitored by all divisions)	4
Total Academic	**146½**

*Except for military studies, courses listed under the Military Affairs Division are the primary responsibility of departments in other divisions. Their semester hours are listed under these divisions, but since they have a military orientation they are integrated with the Military Affairs Division and listed under it also.

hours. This figure does not include the equivalent of physical education and ROTC courses frequently included in the semester-hour requirements of other schools.

How can our cadets complete such unusually high requirements and in addition participate in all the command training and other practical cadet experiences that help give them the background of a professional officer? One answer is that we really have the equivalent of a five-year program, for our cadets go to school eleven months a year instead of the usual eight and one half or nine. Another is the intensive nature of our program. Robert Maynard Hutchins, former President and later Chancellor of the University of Chicago, once said that if college students could be induced to put in a real eight-hour day the effect would revolutionize higher education. Our students do. They normally carry about two hours more per semester than civilian students and in addition participate in intensive military training. Obviously we keep them at work.

The other striking point about our prescribed curriculum is its almost even balance between the sciences and engineering subjects on the one hand and the social sciences and the humanities on the other. More will be said later about this balance, but first let us take a quick glance at the subject areas in the prescribed academic curriculum.

the academic program

The prescribed academic program is administered by the Dean of the Faculty. Related departments are grouped in five academic divisions as shown in the accompanying summary. The subjects listed correspond to the academic departments, with four exceptions. Chemistry and physiology constitute one department, economics and geography another. The thermodynamics and aerodynamics courses are taught by the Department of Aeronautics, and the philosophy course is administered by the English Department.

Except for the short course in human physiology, the basic science courses are similar in content and scope to those found in any engineering college. Likewise the applied science courses are similar to those found in the prescribed curriculum of any engineering college, except that our curriculum excludes all courses not related to aeronautics and astronautics. For example there are no applied science courses related to the civil engineering field.

The Air Force Academy has the Nation's first undergraduate Department of Astronautics. This subject is defined by the Academy as the science and technology of the design, construction, and operation of space vehicles and the study of the environment in which they operate. The prescribed astronautics courses build very closely on the cadets' previous courses in physics, chemistry, mathematics, and engineering and deal with the following subject areas: powered, free-flight, and re-entry trajectories of ballistic missiles, space trajectories for satellites and interplanetary vehicles, nuclear and other propulsion systems, and automatic control and guidance systems. The Academy feels that this is a substantial introduction to the space problems that will be faced by its graduates.

Courses in the humanities and social sciences total 69 semester hours—far more than engineering students normally receive in these areas. Here is exhibited the general balance of our academic curriculum which as a result cannot properly be described either as an engineering curriculum or as a liberal arts curriculum since it combines the two. Some may question the amount of time we devote to the humanities and the social sciences, on the grounds that this is the era of technology, an age of nuclear energy, weapon systems of tremendous power, and the thrust into space. Science and technology, they say, have revolutionized warfare as well as all of human society. Why spend so much time on nonscientific subjects?

That line of reasoning would ignore what Clarence Randall, a well-known industrialist and government executive, has called "technical hypnosis," the belief that all human problems can be resolved by the processes of physical research and the application of engineering methods. Randall said that the lesson of his experience was to the contrary: that the art of management, even in fields relying heavily on science and engineering, requires a broadly cultivated mind. He went on to say the greatest asset he had in his management career was the general education he had received at Harvard. Early selection of a specialty would have left a long-time limitation.

There is another basis for our feeling that a broad, general education is the best background for professional military officers. We believe they must understand the society and economy of which the military organization is a part. They must know their economic, social, and political heritage. Military policy, particularly in these days, cannot be isolated from economic, political, and diplomatic factors. For all these reasons we firmly believe that the proper breadth of understanding in our graduates requires heavy emphasis on the social sciences and humanities. This general point of view has been summarized by Gordon Sproul, President of the University of California: "A world without both the sciences and the arts . . . would be an unbalanced and a dangerous world. Essential to the personal safety and mental health of mankind, even in an age of moons and missiles, is the spiritual and cultural heritage of ages past."

the enrichment program

So far this discussion has concerned the prescribed curriculum of the Air Force Academy. In compliance with Federal law all cadets must complete the requirements of this four-year prescribed program, which leads to the award of an accredited B.S. degree. The Academy also has a curriculum enrichment program, for gifted students and those who have completed college-level courses with acceptable grades in other institutions. Its basic objective can be stated very simply: to challenge the cadet to advance academically as far and as fast as he can.

Completion of the prescribed curriculum means that a cadet has satisfied the legal requirement for academic achievement at the Academy. It means he has also been exposed to what we think is the best basic combination of courses that will prepare him for a career as a professional officer and future military leader. The enrichment program furnishes an additional challenge to gifted students to make the best possible use of their time and their minds; it takes advantage of any previous college education; and it broadens the fields of study open to cadets, giving them the opportunity to concentrate in areas of special interest and usefulness to the Air Force.

The enrichment program is entirely voluntary. Cadets may participate in it through transfer credit, by validation, by acceleration, and by carrying extra elective courses. The Academy has a liberal policy of acceptance of all possible transfer credit. Validation means the award of course credit on the basis of examinations—college board, advance placement, or our own—which cover the work of our prescribed courses. Acceleration affords gifted students, identified by high examination scores or prior achievement, an opportunity to take some of the basic prescribed courses at a faster rate. The two-year prescribed mathematics sequence, for example, may be completed in one and one half years, or even in one year. Finally, cadets may carry extra elective courses, over and above the normal load. Eligibility for this privilege is based on College Entrance Examination Board scores or prior achievement. It may be maintained by continued high marks, and the extra load may be as much as two or three courses each semester. The greater the extra load, the higher average mark required. In all these ways cadets build up free time that can be used for substitute courses—and whenever a cadet has time available in his program, he must take substitute courses. A cadet may concentrate these courses to form a major, or he may broaden his background by taking courses in several areas.

The Air Force Academy developed its enrichment program in 1956–57, its second year of operation. At the time there were some misgivings, for the service academies, unlike most civilian schools, do not send their graduates into a variety of professions. They are preparing cadets for one career, that of the professional officer. The value of a common educational background is apparent, particularly when it is the product of years of curriculum study and planning by the most eminent military and civilian educators. Nevertheless it was felt that we needed to challenge our students to the utmost, and we believe the results have justified this major departure in the service academy approach.

To the cadets participating in the enrichment program the benefits include not only the additional learning acquired but the self-discipline involved in the drive to reach higher goals. The faculty derives an extra stimulus from teaching groups of highly motivated and gifted students and from the research and planning involved in developing advanced and special courses for the enrichment program. This stimulus is probably something like a coach feels when he is coaching intercollegiate athletics rather than intramurals. The Air Force derives a benefit in graduates who are better educated and better motivated for an Air Force career, many of whom will have specialized preparation for the later graduate education needed in the increasingly complex tasks of our armed services. The stimulus to cadets to work right up to the limit of their capacities should be of incalculable long-term value as they pursue their careers in the Air Force.

The enthusiastic response to the opportunities of the enrichment program has been reflected in the extent of completely voluntary student participation. During the last fall semester 63 per cent of our cadets were participating in the enrichment program. Even more impressive is the fact that 40 per cent of the cadets were carrying one or more electives above the normal semester-hour load.

Of course the Academy's program is more than an academic program, and some skeptics have feared that the curriculum enrichment program might operate at the expense of, or interfere with, other objectives in the Academy's mission. Good evidence that the academic enrichment program is compatible with the Academy's military training and athletic programs lies in the fact that of the cadet lieutenant colonels and majors—who constitute the outstanding group in military aptitude—85 and 77 per cent respectively had participated in the enrichment program. Of the letter winners in the classes of 1961 and 1962, 80 per cent had participated in the enrichment program during the past fall semester. This compares with the 63 per cent participation by the entire student body. Another result of the enrichment program—superior cadet performance on national standardized examinations—will be discussed later. Now let us see how the program allows cadets to concentrate to form a major in various areas.

majors and proposed master's programs

As an incentive to participation in the curriculum enrichment program and to tailor participation to the educational requirements of the Air Force, cadets are given an opportunity to major in one of four areas: basic sciences, engineering sciences, international affairs, and military affairs. These majors are so designed that in most cases gifted students with no prior college-level work can complete them by the extra-elective method alone.

Completion of the prescribed curriculum of 146½ semester hours is required for a cadet to graduate with the regular (unspecified) bachelor of science degree. A major in international affairs, military affairs, or basic sciences requires another 19 semester hours. Twenty-two are required for the B.S. with a major in engineering sciences. It is interesting to note that when we add the last figure to the 69 semester hours of prescribed science and engineering courses, we find that our engineering science majors graduate with a total of 91 hours of science and engineering. This is only a few semester hours less than those required of an engineering major at Massachusetts Institute of Technology. So I think that we certainly offer the opportunity to the young man who is interested in specializing in the sciences and engineering.

The first few classes at the Air Force Academy were small because we were operating at a temporary site. Our first full-sized entering class —about 750 cadets—came in 1959. In these larger classes so many members are found to have extensive college transfer or validation credit that a graduate program for selected cadets is entirely feasible. This is particularly true in regard to the 50 or so mentally gifted cadets out of the 200 plus in each entering class who come to us with one or more years of college. It would be perfectly possible for this select group to complete the requirements for a master's degree in the four years that they must, by law, remain at the Academy.

We have therefore developed master's programs in two areas, astronautics and international affairs. Both are broad programs, integrating instruction in several departments; each requires 55 semester hours beyond the prescribed curriculum. Some cadets in our last two classes have already started on the course programs which could enable them to complete these requirements. The actual award of a master's degree will, of course, depend upon approval by Congress and accreditation of the programs by the North Central Association.

faculty and teaching methods

Among several interesting facts about our faculty probably the most significant is that all its members, except a few officers from the other services, are Air Force officers on active duty. They are in touch with the requirements of the profession for which they are preparing students.

We have an even stronger reason for maintaining an all-military faculty in the Air Force Academy. Our mission is much broader than that of a civilian undergraduate college. The Academy must motivate as well as educate. Its whole program is designed to instill in its students the desire to devote a lifetime of service to their country. We want them to have knowledge, but we also want them to develop the character and leadership qualities that are essential to career growth. Since 78 per cent of the cadet's supervised time is under the jurisdiction of the academic faculty, it is obvious that the only way the Academy can fulfill its mission completely is to have an academically qualified military faculty—instructors who teach by what they are as well as by what they say. How can cadets be better motivated for a lifetime of service to their country than by instructors who are career officers?

Some observers have commented that in emphasizing the military character of the faculty we may be sacrificing academic quality. This is simply not so. Nearly every one of our instructors has at least a master's degree in his field, and many of them have a doctorate. We all know that in civilian colleges much of the teaching in the first two years is done by graduate students who have not yet earned advanced degrees. Our instructors may have less college teaching experience than most civilian college teachers. They have come from other types of assignment in the Air Force, and most of them serve only a four-year tour at the Academy. We offset this by the most careful faculty-selection procedures. Our instructors have above-average military backgrounds, are chosen for higher academic potential, and are prepared by graduate training. After they arrive at the Academy, they go through an intensive in-service training program. Further, the Academy continuously supervises the actual classroom instruction, a practice which civilian colleges rarely follow.

Another special feature about our faculty is that many of our instructors not only are qualified in their subject area but bring into the classroom related professional experience that one rarely finds in civilian instructors. For example, most of our instructors in the social sciences and foreign languages have had oversea experience, and some of those teaching foreign languages, history, and international relations have had attaché or mission duty or have served in Intelligence. Similarly, many of our instructors in physics have had assignments involving the development of nuclear weapons. We have officers from the Ballistic Systems Division, Air Force Systems Command, in our astronautics department, we have former test pilots serving in the aeronautics department, and so on.

We have several well-qualified officers from the other services on our faculty, as well as several foreign officers. One of them, an instructor of German, is a captain in the West German Air Force who flew for the Luftwaffe in World War II. We are proud of our faculty members from the other services and other countries. They have the same high career dedication that characterizes our own career Air Force officers.

I mentioned that most of our faculty members serve a four-year tour at the Academy. The law establishing the Academy provided for 21 permanent professors, including the Dean of the Faculty. The Dean and six heads of departments now hold permanent appointments. Others will be appointed in the future. We obtain further continuity by provision for selected members of the faculty to return for second tours of duty at the Academy, after intervening tours elsewhere in the Air Force.

Some may wonder about the quality of an academic program that is taught by an all-military faculty. Without exception, experts in higher education who have actually visited the Air Force Academy have praised the academic caliber of the faculty and the high level of classroom instruction. Examiners of the North Central Association, for example, noted that the academic performance of the cadets is much further above the median than even their relatively high level of ability would indicate. They attributed this high level of performance to the Academy's curriculum, faculty, and instructional system. In the words of these examiners, ". . . the faculty is a superior one for the institution's purposes, which are not only to train and educate the cadets but to orient them positively toward a permanent career as Air Force officers."

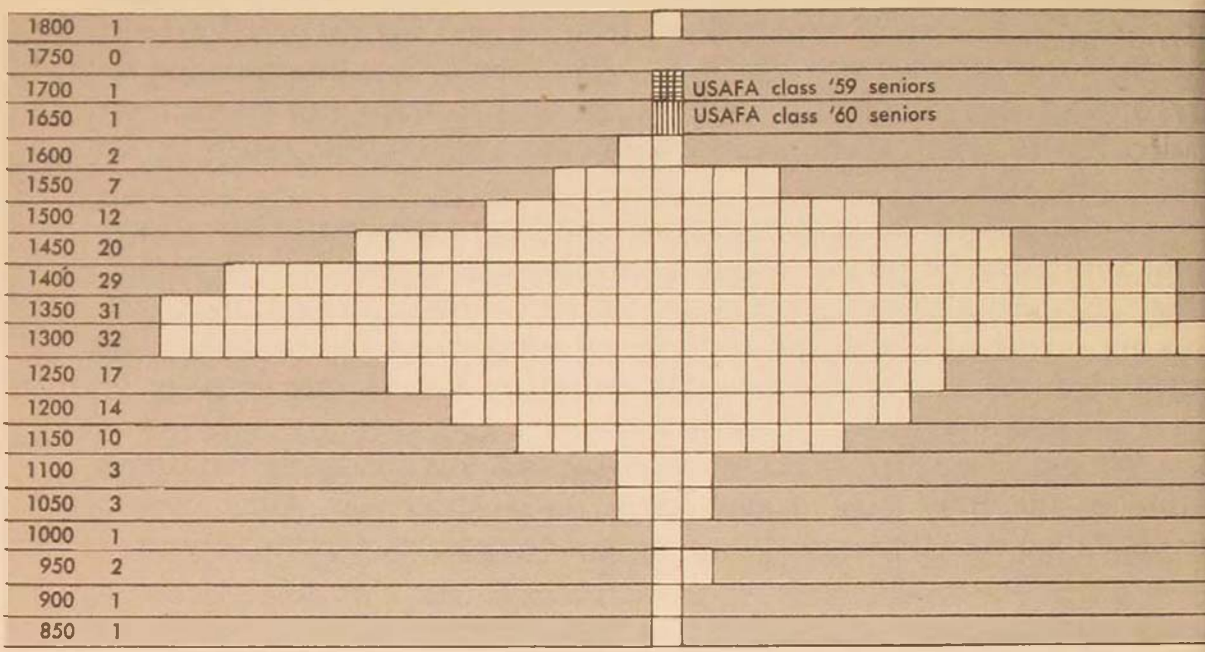
As for our teaching methods, we emphasize the small-class, discussion approach. Normally about 14 cadets are assigned to a section. The classroom atmosphere is not rigid and formal; in fact, most visitors are surprised at the give-and-take which goes on among cadets and between cadets and instructors. Of course we have larger lecture sections when called for by the subject.

We test more often than most civilian schools but lately have been reducing the frequency of our testing, particularly in some departments. We have also been laying more stress on essay examinations.

cadet achievement

The Air Force Academy is a young institution and one that is peculiarly responsible to the American people. We have therefore felt obligated to check our progress frequently and make sure that our program is bringing about the achievement we think our cadets should demonstrate. We have given many national standardized examinations in various subject areas, and our cadets have uniformly ranked high. I will not discuss these tests but will say something about the Graduate Record Examinations which cover broader areas and check cadet achievement after a longer period at the Academy.

The Graduate Record Examinations are given to nearly all college seniors who contemplate going into graduate work, and many schools have all their graduating seniors take some of the tests as a check on their student achievement. The Academy has given the Educational Testing Service Graduate Examination area tests to the three classes graduated so far. These area tests were the ones most commonly administered—in the natural sciences, the social sciences, and the humanities. The accompanying chart shows the composite scores (the sum of the means of the three area tests) made by the Academy classes of 1959 and 1960 and by the seniors of 186 other schools in the testing program. The two darker squares show where the Academy classes scored, and the 186 gray squares show the score distributions of the other colleges and universities. Our graduating classes were excelled by the seniors in only one civilian school out of the 187 schools in the testing program. We expect the class of 1961 (which made even higher raw scores) to rank just as high, but we are waiting for new normative data as basis for comparison. The schools whose scores are shown on the chart with the Academy's scores comprise an extremely heterogeneous group in terms of size, location, support, and general academic reputation. Many are widely recognized for academic excellence.



The performance of Air Force Academy graduates on such national standardized examinations is, I think, particularly noteworthy in view of the short time the Academy has been in operation. I also think it validates the quality of our educational program and the quality of the teaching performed by our all-military faculty. Similar conclusions were also reached by the examiners of the North Central Association of Colleges and Secondary Schools when we applied for accreditation. The examiners reported, "There is ample evidence to show that the cadets' performance is much farther above the medians than even their relatively high level of ability would warrant . . . various standardized measures show clearly that standard achievement, compared to other selected colleges, is high, higher indeed than even the relatively excellent abilities of the student body would indicate."

Our unprecedented early accreditation by the North Central Association is itself another evidence of the Academy's achievements to date. Normally institutions are not even allowed to apply until they have operated at least four years, but after preliminary examination the NCA allowed the Academy to apply early. After the most thorough examination, the Academy received accreditation in time for our first graduating class to be awarded accredited degrees.

A few Academy graduates have gone directly to graduate school—at Cal Tech, MIT, Princeton, and Oxford. They have all done well.

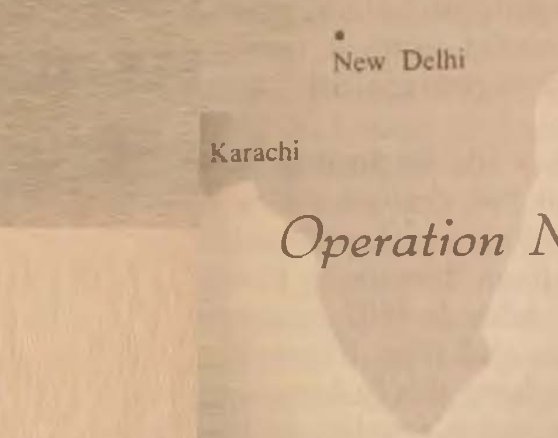
Our man at Cal Tech achieved his degree as master of science in aeronautical engineering in just one year, taking the highest honors in the MSAE program. He had come to us right out of high school and had participated in our enrichment program to the maximum extent.

WHILE we are proud of our accomplishments so far, we realize that the Air Force Academy, as the youngest of the service academies, owes much to its sister institutions. They pioneered the concept of professional officer education in America and established the main elements of the pattern we follow today. On the other hand, we proudly take credit for having established five years ago something that our older service academies have adopted within the past two years: the curriculum enrichment program, which cuts across class and departmental lines and enables students to advance from the level of their past achievements, in accordance with their interests and abilities, as far and as fast as they can in the pursuit of academic excellence.

There will be no resting on our laurels. Tomorrow's Air Force and the Nation as a whole are going to need leaders who are better and better prepared. The Academy plans to evaluate its program continually to meet the changing needs of our cadets and the Nation they are going to serve. We are convinced that our policy of an all-military faculty is sound, that our methods of instruction are working well, that our enrichment program will produce more and more benefits, and that we ought to preserve the general balance of the curriculum. But we certainly intend to strive for improvement. We welcome constructive criticism, unafraid that criticism will impair our endeavors to carry out our mission. We think that with the understanding and support of the officers and men of the Air Force and the American people as a whole the Air Force Academy will add to the splendid traditions of the older service academies and produce future aerospace leaders of whom their country will be proud.

United States Air Force Academy


Gardermoen
Malmo
Dublin
Brussels
Rhein-Main
Ramstein
Evreux
Chateauroux
Bordeaux
Torrejon
Athens
Adana
Teheran
Tunis
Rabat-Salé
Wheelus
Nouasseur
Sidi Slimane
Cairo
Dhahran
Aden
Khartoum
Asmara
Dakar
Niamey
Kano
Conakry
Addis Ababa
Roberts Field
Accra
Lome
Juba
Bunia
Douala
Stanleyville
Entebbe
Libreville
Coquilhatville
Goma
Nairobi
Brazzaville
Kindu
Leopoldville
Pointe Noire
Luluabourg
Kamina
Luanda
Elisabethville



Operation New Tape

The Congo Airlift

BRIGADIER GENERAL TARLETON H. WATKINS

OPERATION New Tape was the 322d Air Division's Airlift in support of the United Nation's action in the Republic of the Congo. The operation was activated on 8 July 1960 by the United States Air Forces in Europe (USAFE) to implement the United Nations' intercession in that troubled area. In its first three months this airlift accomplished the transport of 20 thousand people and 7 million pounds of cargo from 21 countries, was supported by 110 aircraft, and spanned 4 continents. This achievement, initiated with no prior planning, provides opportunity for timely and penetrating study of the capabilities and employment of a modern air transport force.

the Congo

Africa is a continent of contrasts. This is especially true in its geography and weather. The highlands of Ethiopia, where major airfields are situated at 7000-foot altitudes, give way to the hot, dry Sahara Desert with its sand storms and runway temperatures of 150°F. The Republic of the Congo is situated along the equator in the tropical rain belt, an area of dense jungle produced by year-round high temperatures and torrential seasonal rains of about 45 inches per year.

The Belgian Congo, with a population of 14 million people, including approximately 200,000 Europeans, had been governed by Belgium since 1878. When Belgium granted the Congolese full independence on 30 June 1960, the Congo crisis erupted. When Belgian troops were flown in to restore order, fighting broke out between the Congolese and the Belgian Army. Chaos ruled instead of the native government; finally the Congolese premier made a formal request to the United Nations to send U.N. troops to replace those of Belgium and to restore peace and order. The U.N. called upon member nations for aid, which was soon volunteered by numerous countries in the form of troops, food, and equipment. The United States offered to provide the necessary airlift.

Many technical problems were evident from the beginning. Because of location of the adequate airfields and the desired delivery points, many of the flight legs were 1500 miles long, with only minimum navigational aids. For example, the leg from Evreux to Cairo is 1765 nautical miles, the leg from Karachi to Aden is 1507 nautical miles, from Tunis to Kano is 1498 nautical miles, and from Khartoum to Leopoldville 1325 nautical miles. It was throughout this hodgepodge of topography, climate, and distances that the major portion of the airlift operated. The difficulties inherent to aircraft operations in such a situation are obvious.

the airlift

The 322d Air Division first entered into the Congo situation on 8 July 1960, upon Headquarters USAFE's directive to prepare for the possible evacuation of as many as 330 American refugees. Seven C-130 aircraft and crews were placed on a one-hour alert status at Evreux-Fauville Air Base, France, the division headquarters. Another ten were sent to Furstenfeldbruck AB, Germany, and were similarly placed on a one-hour alert. This alert status continued until 14 July, when the first actual airlift missions were directed by USAFE—Tunisian troops were to be picked up at Tunis and transported to Leopoldville, food was to be flown to the same city from Chateauroux Air Base, France. Two C-130's were immediately dispatched to Leopoldville, transporting a combat airlift support unit (CALSU). This advance party, consisting of 56 personnel plus necessary equipment, was to control operations at the receiving end of the airlift. Within 24 hours after the initial notification, 22 C-130's and 4 C-124's had departed and were participating in airlift operations. The airlift had begun in earnest and was gaining momentum as the mission commitments rolled in.

The 322d Air Division was now aware of the extent of its job. United Nations troops were to be transported from a score of countries to the Congo and resupplied. Food and emergency equipment were to be picked up from locations scattered throughout Europe and Africa and flown into the troubled area. Refugees from the Congo were to be evacuated on the return flights to European cities, mainly Brussels.

The division immediately began expanding its operation to handle these new commitments. At the outset, on 14 July, the division's available aircraft strength was three squadrons of C-130's operating out of Evreux and three squadrons of C-119's based at Dreux AB, France, plus operational control of a C-124 squadron of the Military Air Transport Service based at Rhein-Main AB, Germany, for temporary duty on rotation from the United States. The division commander relieved most of the C-130's and C-124's of their normal logistical missions in support of USAFE and NATO installations in Europe, North Africa, and Asia, assigning this task to the C-119's. This arrangement virtually doubled the workload at Dreux AB but left the C-130's and C-124's free to handle Congo flights almost exclusively. On 16 July two MATS squadrons of C-124's, a total of 24 aircraft, left Dover Air Force Base in the United States for Chateauroux AB, where a provisional wing was established. On 19 July two additional MATS squadrons left Donaldson and Larson AFB for Chateauroux. All the C-124's were maintained and resupplied by MATS personnel in accordance with their contingency plans, but they were scheduled and flown as an integral part of the 322d Air Division. The capability for the Congo job now stood at 46 C-130's and 60 C-124's, a total of 106 aircraft.

The fantastic increase in flying hours over far-flung operational areas placed strenuous demands on maintenance and supply. C-130 and C-119 parts were given new priority and expedited through the supply system. Maintenance teams were deployed throughout the new theater of operations. Their working hours were increased radically. A civilian maintenance team of 80 men from Warner-Robins Air Materiel Area, Georgia, was flown to Evreux to augment the 317th Consolidated Aircraft Maintenance Squadron.

Field command units had to be organized and flown to the staging bases, where they would set up operations. The main unit, the CALSU at Leopoldville, arrived 15 July and established its headquarters at the Ndjili Airport there. In addition CALSU's were sent to all airfields where troops or cargo were to be onloaded or offloaded. The CALSU's had the responsibility of directing and controlling aircraft operations at their specific staging bases, in compliance with instructions by 322d Air Division headquarters in Evreux. Here the inevitable communications problem raised its ugly head. Communications were virtually nonexistent between Evreux and the airfields in Africa until mobile single side-band radio sets were installed at key points several days after the beginning of the airlift.

Aircrews had to be briefed to fly into totally unfamiliar territory where navigational aids were far from adequate and weather reports sparse and unreliable. Flight planning was further hampered by the lack of charts, information on navigational aids, and particularly information on instrument approach procedures for airfields. Evreux base operations obtained the necessary publications from British, Belgian, and French sources and became the briefing center for all flights into the Congo.

While this operational structure was being created, the airlift continued to assume ever larger proportions as new mission commitments were laid on. Forty aircraft arrived at Leopoldville on the second day of operations with loads of U.N. troops and food, which were eagerly received. By 25 July, 4120 troops had been flown into the Congo along with 1,715,400 pounds of food and equipment. By 10 August these figures rose to 9190 troops and 2,268,000 pounds of food and equipment. During the early period of the operation aircrews were flying crew days of 30 to 40 hours, were given 12 hours' crew rest, then sent out on another mission. Aircraft were so thoroughly utilized that at one time only 5 of the 46 C-130's were available at Evreux, the home station.

New Tape was an airlift of widespread operations. Troops were airlifted from 15 nations—Canada, Congo, Ethiopia, Ghana, Guinea, India, Ireland, Liberia, Mali, Morocco, Pakistan, Sudan, Sweden, Tunisia, and United Arab Republic. One immediate difficulty in transporting troops of so many different nationalities is, of course, the language barrier. To communicate a flight briefing to troops with whom no common language exists can be most difficult. No official interpreters were available, so reliance was placed upon finding someone among the troops who spoke English or an American crewman who spoke French. Some troops, such as Sudanese and Ethiopian, spoke neither language.

The large number of staging airfields to be used contributed to the immensity and intricacy of the airlift—52 airfields in 33 countries.* Some of these fields were onload and offload points; others were merely used for refueling and maintenance, diplomatic entry or exit of a country, or stops for operational reasons. Several presented problems. For instance, the C-124 could not stage out of Addis Ababa because of the field elevation of 7749 feet, and Coquilhatville was also beyond the operational limitations of the C-124 because of insufficient runway length. These are just two examples; there were many more. These

*Accra, Ghana
Adana, Turkey
Addis Ababa, Ethiopia
Aden, Aden
Asmara, Ethiopia
Athens, Greece
Bangui, Central African Republic
Bordeaux, France
Brazzaville, Congo
Brussels, Belgium
Bunia, Congo Republic
Cairo, Egypt
Chateauroux, France
Conakry, Guinea
Coquilhatville, Congo Republic
Dakar, Senegal
Dhahran, Saudi Arabia
Douala, Cameroon
Dublin, Ireland
Elisabethville, Congo Republic
Entebbe, Uganda
Evreux, France
Gardermoen, Norway
Goma, Congo Republic
Juba, Sudan
Kamina, Congo Republic
Kano, Nigeria
Karachi, Pakistan
Khartoum, Sudan
Kindu, Congo Republic
Kitona, Congo Republic
Libreville, Gabon
Leopoldville, Congo Republic
Lome, Togo
Luanda, Angola
Luluabourg, Congo Republic
Malmo, Sweden
Nairobi, Kenya
New Delhi, India
Niamey, Niger
Nouasseur, Morocco
Pointe Noire, Congo
Rabat-Salé, Morocco
Ramstein, Germany
Rhein-Main, Germany
Roberts Field, Liberia
Sidi Slimane, Morocco
Stanleyville, Congo Republic
Teheran, Iran
Torrejon, Spain
Tunis, Tunisia
Wheelus, Libya

problems did not exist for the C-130, thanks to its exceptional performance characteristics. Some runway surfaces were of insufficient strength to withstand the over-all landing weight or single-wheel weight of the C-124. Again, this problem was nonexistent for the C-130. Lack of parking, refueling, maintenance, and tower facilities did, however, often hamper the operation of both of these aircraft at many airfields.

An indication of the initial accomplishment of Operation New Tape can be obtained from the accompanying statistical tabulations,

Airlift Breakdown of Operation New Tape

from	to	type airlift	cargo (lb)	passengers	sorties C-124	sorties C-130	start	completed
Tunis	Leopoldville & Luluabourg	Tunisian troops & equip	463,796	2,612	33	17	15 Jul	3 Oct
Rabat & Sidi Slimane	Leopoldville	Moroccan troops & equip	776,160	3,179	52	9	16 Jul	22 Aug
Cairo	Leopoldville	Swedish troops & equip	379,315	637	12	9	19 Jul	26 Aug
Accra	Leopoldville	Ghana troops & equip	203,889	539	10	3	19 Jul	22 Jul
Conakry	Leopoldville	Guinea troops & equip	131,750	751	1	13	22 Jul	31 Jul
Roberts Field	Leopoldville	Liberian troops & equip	20,000	250	0	4	25 Jul	26 Jul
Addis Ababa	Kamina & Stanleyville	Ethiopian troops & equip	365,536	1,872	1	35	23 Jul	17 Aug
Dublin	Goma, Kindu, & Kamina	Irish troops & equip	549,603	1,406	21	20	27 Jul	25 Aug
Karachi	Leopoldville	Pakistanian troops & equip	106,409	540	7	5	31 Aug	28 Sep
New Delhi	Leopoldville	Indian troops & equip	208,234	662	11	7	20 Aug	28 Sep
Juba & Khartoum	Leopoldville	Sudanese troops & equip	109,547	370	3	6	16 Aug	17 Aug
Dakar	Leopoldville	Mali troops & equip	187,169	574	15	0	2 Aug	6 Aug
Cairo	Coquilhatville	United Arab Republic troops & equip	39,193	515	0	17	20 Aug	24 Aug
Chateauroux, Bordeaux, & Rhein-Main	Leopoldville	food	1,948,115	0	43	30	15 Jul	10 Aug
Lome	Leopoldville	food	200,000	0	0	7	17 Jul	18 Jul
Malmo & Gardermoen	Leopoldville	6 Super Cubs & 2 Otter acft	200,000	0	3	0	28 Jul	1 Aug
European Continent	Congo	miscellaneous	624,521	351	20	8	16 Jul	15 Sep
Flight Support		troops & equip	476,390	1,802	0	41	16 Jul	31 Jul
Elisabethville, Kamina, & Kitona	Brussels	Belgian troops & equip	93,381	1,757	20	11	27 Aug	29 Sep
Congo	European Continent	miscellaneous	125,098	34	5	0	16 Aug	2 Oct
Congo	European Continent	refugees		2,540			15 Jul	3 Oct

compiled as of 3 October 1960. The first is a breakdown of the airlift into its subordinate lifts. For instance, the first line indicates figures for all missions originating in Tunis and terminating in the Congo. This chart clearly portrays the diversity of the operation, involving 20 minor lifts each of which possessed its unique features.

The second chart sets forth the over-all accomplishments of the airlift in terms of C-130 and C-124 figures as of two dates, 10 August and 3 October 1960. It must be remembered, however, that the airlift

Statistical Summary of Operation New Tape

	10 August 1960			3 October 1960		
	C-130	C-124	total	C-130	C-124	total
flying hours	4,059	8,294	12,353	5,981	13,137	19,118
nautical miles	965,448	1,720,239	2,685,687	1,495,844	2,632,372	4,128,216
passengers	8,161	5,006	13,167	11,150	8,923	20,073
tons of cargo	1,113	1,367	2,480	1,386	1,951	3,337
passenger miles	23,122,594	22,472,292	45,594,886	31,176,547	52,134,888	83,311,435
ton-miles of cargo	3,379,262	7,746,130	11,125,392	3,975,825	10,999,546	14,975,372
sorties flown	176	163	339	245	261	506

did not end on 3 October. Operation New Tape continues in effect, now a smooth, normal operation.

flight problems

When flights were initiated on 14 July the immediate concern was to get aircraft and crews into the air. Visa requirements and diplomatic clearance were of secondary importance, although absolutely necessary. Coordination with the U.N. through USAFE made possible the immediate waiver of visa requirements for all 322d Air Division personnel, thus preventing a possible snarl in the early stages of the airlift. The U.N. and the Joint Chiefs of Staff also obtained a blanket diplomatic clearance for all countries at which landings were intended and overflight clearance of all countries en route, including all of Europe with the exception of Switzerland, Austria, and the Iron Curtain countries and all countries in Africa from the Mediterranean Sea to the Congo area. Later India, Pakistan, and all of the Middle East, except Yemen, were included.

As previously mentioned, charts and publications for flight planning were not immediately available, because 322d Air Division's area of responsibility extended only to 20 degrees North latitude in Africa. When the flying areas involved in the possible airlift were indicated to Evreux base operations on 11 July, the base operations officer initiated a crash program to obtain the vital materials. The next day telephone calls went out to many offices in USAFE, other NATO air forces, and civilian airlines. By the following day maps, radio facility charts, letdown plates, and other flight publications had been contributed by the Royal Air Force, Belgium's Sabena Airlines, and Air France in sufficient quantity to prepare five navigation kits. Later almost 200 kits were prepared and distributed to aircrews at Evreux, Chateauroux, and Wheelus AB, Libya. In addition 25 kits were given to the Italian Air Force, as it too participated in the Congo airlift. The 322d Air Division now maintains flight publications for all of Europe, Africa, and as far east in Asia as Indo-China.

In-flight navigation itself was a demanding task. The only navigational aids available over the routes in Africa were a few low-frequency radio beacons, which were frequently off the air or erratic in their operation. Navigators found themselves using celestial navigation as their sole means of positioning, because the lack of large cities and significant terrain features made visual and radar navigation techniques almost useless. Most of the flight legs were quite long (for example, Tripoli to Kano is about 1500 miles), so that the use of dead-reckoning techniques alone would have been foolhardy for flying over the Sahara Desert.

Air-to-ground communications were generally poor. En route traffic-controlling agencies were so few and so widely scattered that large portions of flights were flown without contact with a controller. Tower and approach-control facilities were good at the larger terminals but often nonexistent at the smaller airfields. Most airport towers were operational only during weekends and daylight hours. The language problem was again present, many operators speaking only French. At Leopoldville the tower situation became so harassing that four bilingual air traffic controllers from European AACS resources were assigned to assume control of tower operations for two weeks.

Weather forecasts, especially for crews departing African airfields, were often inadequate. The prime source of information for forecasts of weather in Africa was the Strategic Air Command's weather center at Torrejon AB, Spain, which has the capability of forecasting weather conditions throughout the world on the basis of climatological weather data. This system bases its forecasts upon conditions which should theoretically exist at a given location at a given time of the year, rather than on actual observed conditions. The information was found to be quite reliable and easily obtained through ordinary teletype circuits. But communications was the rub. When a weather team of one forecaster and one observer arrived at Leopoldville with the CALSU team, they had to rely on Belgian and French weather-reporting services and pilot reports for their forecasts until teletype communications were

The USAF Congo airlift transported refugees

. . . Morocco

. . . moved troops within the Congo

installed ten days after flight operations began. The Belgian and French weather-reporting information was accurate, but it had to be obtained piecemeal for each airfield by telephone and radio, since the weather facilities at the Leopoldville airport had been abandoned at the onset of the crisis. At other fields in Africa where no USAFE communications existed, reliance was placed totally on the civilian services when they were available.

communications

If the communications problem was not the greatest encountered in the airlift, it was certainly the most widespread. The lack of adequate, reliable communications between headquarters and field units was felt by almost all agencies. Prior to the Congo airlift, the only military radio facilities in Africa were some high-frequency liaison radio capability and single side-band radio stations at Sidi Slimane AB, Morocco, and Wheelus AB, Libya, which tied into the SAC and

. . . troops from Ireland

. . . Indonesia

. . . brought in food

USAFE "Twilight" system. The first few days of the airlift were aggravated by deficiencies in communications support. The communications complex featured a conglomeration of HF radio, teletype circuits, telephone, and ICAO circuits (a network of the International Civil Aviation Organization which is not configured to provide communications in support of tactical airlift operations). Communications problems would have continued in this haphazard fashion had not USAF authorized the incorporation of the Congo airlift into its Twilight system a few days after operations had commenced.

The Twilight system is composed of single side-band radio stations located at most of the major military centers in Europe and the Middle East, plus Wheelus and Sidi Slimane in Africa. The single side-band radio set is quite similar to the HF liaison radio in that it is amplitude-modulated and uses the same frequency band. Its great advantage lies in its far more efficient transmission characteristics, which increase range considerably and reduce static interference. Permanent Twilight stations were soon installed at Chateauroux in France and at Kano and Leopoldville in Africa. In addition three mobile Twilight stations were available to be shifted around the theater as airlift requirements dictated. These mobile stations operated for varying periods out of such fields as Addis Ababa, Accra, Elisabethville, Dakar, Kamina, Kitona, Karachi, and New Delhi. No station was installed at 322d Division headquarters in Evreux until 25 August, so that it was necessary for headquarters to tie into the Twilight system by telephone through the stations at Torrejon AB, Spain, or Wiesbaden AB, Germany. With the installation of the station at Evreux, the system became completely operational. In addition to the Twilight stations, AACS provided an extension of AIRCOM (World-wide Air Force Communications System) from Sidi Slimane, Morocco, to Leopoldville which provided four teletype channels with over 90 per cent reliability.

Division headquarters had in the past maintained contact with its in-flight aircraft by hourly HF radio calls through the Military Airways Network, which has stations throughout Europe, the Middle East, and North Africa. Now with flights operating as far south as Elisabethville it was necessary to establish two new radio stations: Kano Airways, which transmitted out of Kano, Nigeria, and Congo Airways at Leopoldville.

operations

The command structure to control the airlift was organizationally sound and functioned without any difficulty. The 322d Air Division received full support from all organizations in the chain of command and from all outside support agencies. For example, during the heat of the operation when decisions requested from the Commander in Chief of USAFE also required action by the Joint Chiefs of Staff, decisions were received at 322d Air Division headquarters within two hours of the request. The main reason that the command structure functioned so efficiently was that everyone knew what the command channels were and followed them. There were no occasions when people jumped command channels for expediency—a fact which prevented malfunction of command control.

At division headquarters airlift operations were controlled by the deal of authority was delegated to CALSU's, especially at Leopoldville, because communications were too poor to maintain close control and Transport Operations Division. At the beginning of the airlift a great because the situation was so unstable. For this reason status reports of all aircraft and crews participating in Operation New Tape were required every six hours.

The CALSU at Leopoldville, totaling 6 officers and 50 enlisted men, was composed of operations, aerial port, maintenance, and medical personnel. It was later augmented by an Army communications unit of 3 officers and 37 enlisted men. The Army unit was replaced by the USAF 2d AACS Mobile Squadron in September. This gave us an outlet for effective record communications between any European point and Leopoldville. Some of the responsibilities of the Leopoldville CALSU were maintenance and refueling of aircraft; loading and unloading of aircraft; providing housing, messing, and medical facilities for crew members; and conducting final coordination of airlift operations in the Congo between the United Nations, the American Embassy, the Belgian Army, the Congolese authorities, and 322d Air Division headquarters.

Other permanent CALSU's were established at such fields as Wheelus AB, Libya, and Kano, Nigeria, which were stopover points for maintenance and refueling of aircraft and for crew rest. Temporary CALSU's were established at onload points in the theater and at offload points in the Congo to support the individual missions. During the first few days the rapid pace of the airlift forced CALSU personnel to work round the clock. The long work day was occasioned by the shortage of materials-handling equipment such as fork lifts, trucks, flat beds, and portable lights for night loading and unloading, as well as an extreme shortage of personnel—only 25 aerial port men were available at Leopoldville whereas a team of approximately 100 men was needed. CALSU personnel were rotated to Evreux about every three weeks.

logistics

When Operation New Tape started, maintenance requirements virtually doubled in spite of the fact that 322d Air Division was only responsible for support of its C-130's, the C-124's receiving their maintenance support from Military Air Transport Service. During a specific period in which maintenance was geared to support 2000 flying hours, 4104 hours were actually flown. To meet these new demands, a civilian team of 80 mechanics was flown to Evreux from Warner-Robins AMA, Georgia, to help perform periodic inspections. Additional maintenance personnel were donated by Chateauroux AB, France, Alconbury AB, England, and Rhein-Main AB, Germany. Dreux AB, France, provided shop support to back up the capability existing at Evreux. In spite of this increase in personnel, it was necessary to increase the work week to a 12-hour day and 7-day week.

Several field maintenance teams were established, the main one, at Wheelus AB, being composed of 1 officer and 34 airmen. This team, in addition to performing most types of maintenance, handled postflight inspections, thus eliminating the return of an aircraft to Evreux every 50 flight hours for inspection. As a result C-130's could remain in Africa, participating in the airlift, until the periodic 300-hour inspection was due. A team of 1 officer and 13 enlisted men was established at Leopoldville with the capability of turnaround inspection, engine change, propeller change, and routine maintenance. During the height of activity a 5-man team was positioned at Kano for turnaround maintenance. Mobile maintenance teams, consisting of an engine-change crew plus other specialists as necessary, were kept on a standby alert to recover aircraft experiencing severe maintenance difficulties at airfields with no support. These teams were deployed as necessary, being flown by a maintenance aircraft which was controlled by Transport Operations at Evreux.

Close coordination was established with the supply depots to expedite delivery of critical aircraft parts such as engines, reduction-gear boxes, generators, and propellers. Ordinary repair parts were supplied from en route kits carried aboard the aircraft and from way-station kits prepositioned at key points in the system. More unusual items had to be airlifted from Evreux.

The lack of adequate refueling facilities at many airfields was an ever present problem. Sometimes the limited choice of fuel available presented a more critical problem for the C-124's than for the C-130's. A C-124 uses aviation fuel 115–145, with 100–130 as the only alternate

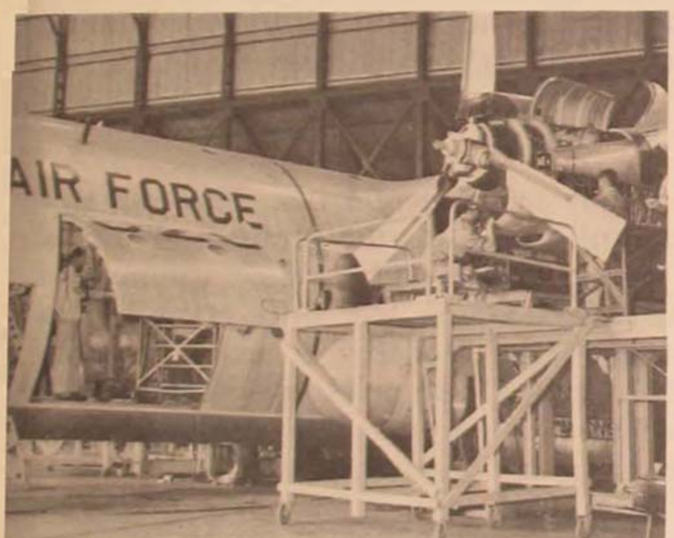
Airlift problems included maintenance

. . . hand-pump refueling in Nigeria

. . . crew rest at Wheelus

grade, whereas the C-130 engines, although designed to operate on JP-4 for optimum performance, can utilize almost any grade of fuel with only minor reduction in operating efficiency. Refueling equipment was rather obsolete at many fields, and this hindered operations when several aircraft were waiting for fuel. It was not unusual to encounter a hand-pump delivery system working from 55-gallon drums. Often the available equipment could only deliver fuel at low volume, low pressure, and with a slow pumping rate.

At intermediate refueling stops such as Kano, Nigeria, the resupply of fuel in storage presented a serious problem, since it had to be brought in by a single-track railroad across the 550 miles from the seaport of Lagos. The amounts of fuel required by the C-130 and C-124 aircraft, as well as the commercials going through Kano, rapidly exhausted the supply and made the routing of aircraft very critical. To alleviate the congestion somewhat, many of the C-124's were routed



. . . scattered from Evreux, France

. . . to Wheelus, Tripoli

. . open mess at Leopoldville

via the west coast of Africa through Dakar and Accra, points where fuel was more plentiful and resupply easily effected. Although this route added almost a thousand miles each way, it enabled the airlift to stage in orderly fashion when otherwise it would have been stalled by fuel exhaustion.

Occasionally fuel was not available at all or was denied U.N. aircraft. Such was the case at Leopoldville, where a great deal of difficulty was encountered because the airport authorities controlling the issuance of fuel were at first quite reluctant to cooperate with the USAF. Fuel reports by airport authorities were often erroneous, if submitted at all, making the planning of refueling operations difficult.

Facilities for the care of the CALSU's and aircrews improved as the lift progressed. Billeting and messing ranged from quite adequate hotels, available at some cities, to sleeping bags and C-rations. At Leopoldville a field-ration mess was established and maintained by two food service personnel from Evreux. A mobile dispensary, manned by a flight surgeon and two medical corpsmen from the 322d Air Division, was also on hand at Leopoldville. Other facilities provided in the Congo were chaplain services, occasional mail deliveries, and a visit by the Evreux finance officer.

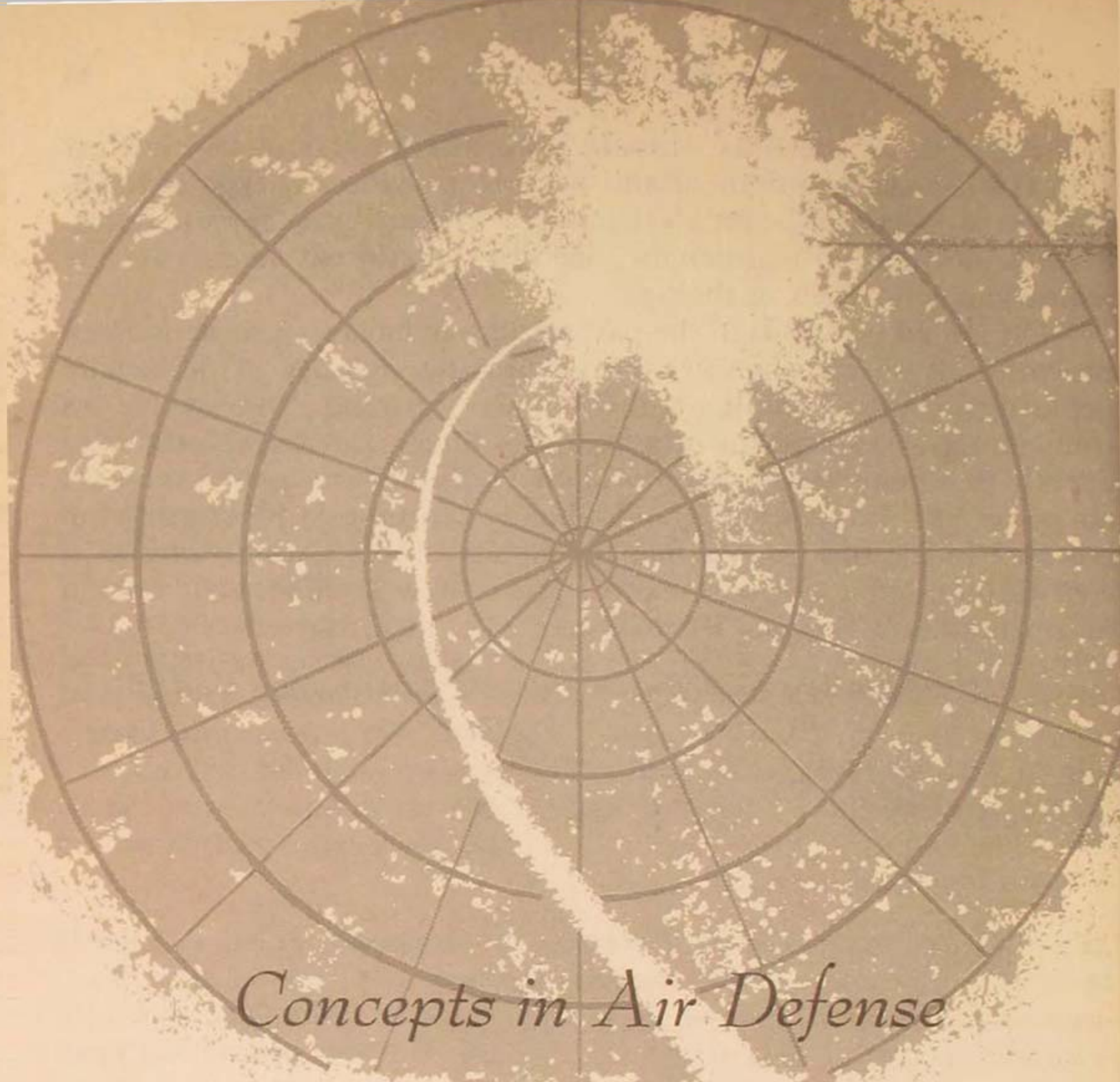
HINDSIGHT being inherently a more facile mental task than foresight, it can now be seen that communications was the problem area most injurious to Operation New Tape. This is nothing new; communications has been a thorn in the side of armies ever since Hannibal descended from the Alps to ravage Italy. Modern air power, utilizing complex aircraft systems and equipment and necessitating an army of specialized technicians, has placed strenuous demands upon communications. Furthermore the fact that air operations must often be conducted throughout an entire hemisphere upon a few hours' notice has not simplified the problem at all. As previously discussed, the 322d Air Division did not have the communications capabilities to support Operation New Tape at its inception. The single side-band radio set demonstrated its worth as a long-range, reliable system of sufficient mobility.

Another deficiency highlighted by Operation New Tape was the need to replace the C-124 as the Air Force's heavy transport aircraft. Although quite serviceable in many missions, its operational limitations make it obsolete for this type of operation. The take-off and landing limitations of the C-124 at fields of high elevation with high runway temperatures severely restricted its acceptable cargo load and therefore its utility. Its need for a much longer and stronger runway than the C-130, its slower cruising speed (180 knots versus 290 knots), and its higher cost of operation per ton-mile are other factors that warrant its replacement.

The Congo airlift demonstrated that one C-130 must be utilized as a full-time maintenance aircraft. This aircraft should be outfitted with the necessary equipment and parts to provide any type of maintenance support and be on alert status. Such capability for the immediate deployment of maintenance facilities should effectively ease the maintenance problem in the field.

On several occasions in the past decade we have seen demonstrated the value of an air transport force with the capacity of immediate deployment, the capability to transport anything from trucks to troopers across a continent in a matter of hours, and the versatility to operate in remote areas of the world on a self-sufficient basis. Transport air power of this caliber will undoubtedly continue to be of great importance in the future. Whether the situation be a natural disaster, a civil dispute, or a hot outbreak in the cold war, airlift will remain indispensable to "getting there fustest with the mostest."

Headquarters 322d Air Division (Combat Cargo) USAFE



Concepts in Air Defense

The art of planning ahead has long been accepted, at least in theory, as a requisite to sound military posture. The aerospace age is superimposing a new dimension—the art of thinking way ahead. Even when it may be too early to plan ahead, at least in terms of specific military situations and detailed requirements for weapon systems to meet those situations, it can still be the time to examine, first in isolation and then in combination, the probable impact on concept, doctrine, and strategy caused by virtually unlimited range, altitude, firepower, and maneuverability of future aerospace systems. When such thinking is sound and offers firm footing for the detailed planning of later years, doctrine and strategy may fully and meaningfully control the soaring technology of our age.

It is in this sense that the Editors of the *Quarterly Review* requested Headquarters Air Defense Command to offer several areas of thinking on what air defense will be like out beyond the current generation of hardware. The four articles presented here do not represent official positions of the Government nor do they attempt to describe the entire complexion of future air defense. Rather they discuss themes that at this point seem certain to bear significantly on the structuring and operations of such a force. In the area of strategy, General Agan asserts a key role for aerospace defense in the Air Force strategy of counterforce. In force capabilities and deployment Colonel Wegenhoft assesses the requirement for defense in depth. Colonel Bennett discusses the tactical significance of maneuverability. In force composition, Colonel Scott outlines the kinds of defense systems that will make up the future aerospace force.

—*The Editors*

Aerospace Defense in a Counterforce Strategy

Major General Arthur C. Agan, Jr.

An examination of the role of aerospace defense in a counterforce strategy must be preceded by an understanding of just what is meant by counterforce. A "counterforce" strategy is a strategy based on the fundamental premise that our military forces must be able to counter effectively and decisively an enemy's military forces. This counteraction is accomplished against the enemy's bases, his launch pads, other military targets, or while he is en route to his targets. To ensure this war-winning capability, our forces must be able to counter those of the enemy and must have sufficient military power remaining to impose our national will on any enemy who may have attempted to impose his on us. When this kind of war-winning capability exists, no rational potential enemy would likely attempt an attack against us. Should an irrational enemy attack us, our nation would retain its freedom and its position as a major power in the world because its war-winning capability would sustain it in that position.

To carry out a counterforce strategy, we must have offensive and defensive military power and the toughness to remain a viable nation with dominant military forces during and after engagement in war.

The USAF concept is that the counterforce strategy is the best way to achieve the national objective of deterring a potential enemy from acts of aggression, including provocative acts against our allies. This deterrence results from an aggressor's appreciation of U.S. resolve and capability to employ any degree of force required to prevent such acts from succeeding. A rational enemy could be expected not to want to suffer defeat as a consequence of aggression or provocation on his part.

But an enemy may not be rational, as we define the word; or hostilities may be started by a "third party" hoping to ascend to the top of the list of world powers by default; or a localized, limited war may expand into a major war. We must be prepared to accommodate these other possibilities in the tense times in which we live. We must have the capability to prevail in any event. The Air Force believes it imperative to maintain a credible war-winning capability because this capability provides the maximum deterrence and at the same time ensures a strong United States if for any reason deterrence fails.

Why is counterforce the best strategy to achieve such a position? Why not one of the several other strategies advocated by some today? Because a counterforce capability is developed and maintained to destroy, selectively, hostile military forces, and deterrence results as a logical consequence of this capability. The U.S. has no designs on cities or the people in them as targets. It is the military forces and weapons of an enemy which are the greatest threat in a hostile situation.

The case was different in World War II. During that particular period, the state of the art of war dictated the strategy of striking at the enemy's sources of production and supply. The limited destructive power available, even in bombs of blockbuster size, was insufficient for immediate destruction of military forces on a broad scale. The alternative was to deny the enemy, locked in combat, the logistical support required for sustaining hostilities. However when the atomic bomb provided an instrument by which military forces could be destroyed on a massive scale, the process of producing and supplying the materials of war to forces in combat became meaningless in the target sense after the first few days of a nuclear war. It is his military forces which an aggressor holds most valuable. Consequently, it is his military forces and weapons which we must seek to destroy or neutralize if he forces war upon us.

The Air Force advocates and supports modernization of mobile, well-equipped, dual-capable aerospace forces. These forces contribute materially to our over-all deterrent posture. They are ideal for quick and positive reaction to the threat of limited military aggression or in the support of our allies. Operating as an integral part of a credible war-winning counterforce capability, this kind of fast-reaction capability acts as a deterrent to the use of force in local conflict.

Our national policy must be clear, and the purpose of each element of the military forces which make it valid must be understood. Distortion may portray counterforce as a first-strike or pre-emptive-strike strategy. It is not. It is the required strategy for deterring attack upon the United States and the war-winning strategy if the United States is attacked first. This consideration leads us to the role of aerospace defense in the counterforce strategy.

the role of aerospace defense

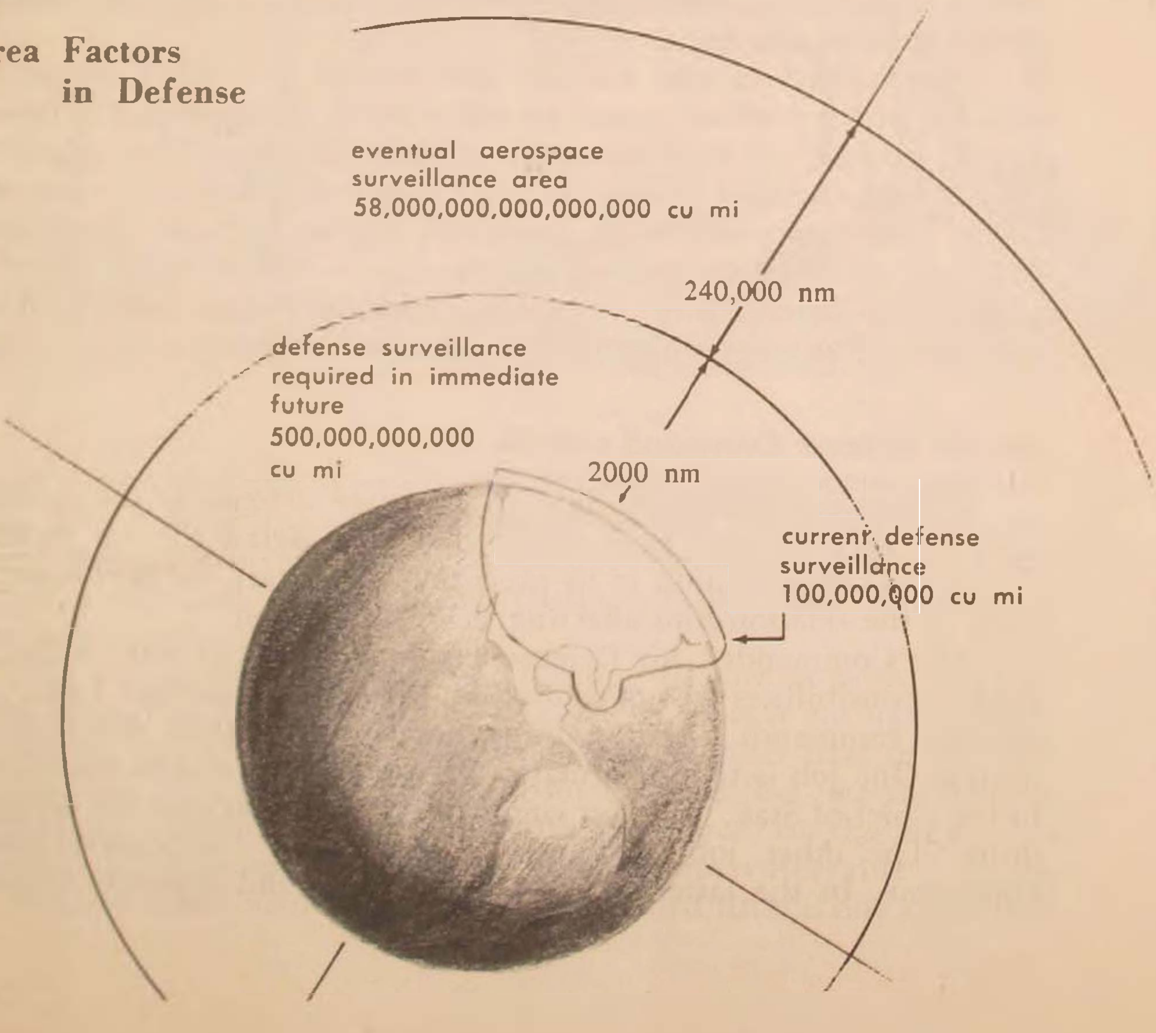
It is quite clear that, in the event of an attempted surprise attack on our country, the aerospace forces which an enemy has committed against us must be engaged first by our aerospace defense forces. No other forces can do this job. Aerospace defense is the inseparable partner of offense in the counterforce strategy. As Lieutenant General Atkinson, former commander of the Air Defense Command, said in a presentation to the Air Staff in Washington in 1957, "Air defense has become as indispensable as our offensive forces. Without both, we may not have either."

The functions of aerospace defense have not changed. They remain as detection, identification, interception, and destruction. The command and control element, composed of the various decision-making centers and their vast communications and electronics links, ties all these functions together and makes the defense effort an integrated one for maximum effectiveness.

If our early-warning systems guarding the North American continent—such as the Ballistic Missile Early Warning System (BMEWS) and the Distant Early Warning (Dew) Line—should indicate that an attack is on its way, the offensive forces would be immediately alerted so that a counterattack could be launched. Simultaneously all other national resources, including our people, would be warned, and the aerospace defense force would be brought to peak alertness. Then, as the enemy approached and our own strategic forces were on their way, the many millions of cubic miles of aerospace would be kept under continuous surveillance, to make sure that friendly offensive forces have a free path as long as they are within our surveillance area. The aerospace defense team must make sure that no aborting friendly bomber or returning tanker is mistaken for an enemy vehicle and shot down.

Of prime importance is the fact that we must engage the enemy forces as soon as possible after they are launched. We must hit them when they are as far from our borders as possible. We are sure that the

Area Factors in Defense



bases of our strategic striking forces will be high on any enemy's target priority list. Consequently we provide active defense of those bases by engaging the enemy strike force inbound, as well as by providing warning for decision to launch our counterattack. Throughout the entire spectrum of the four functions of aerospace defense, we focus our attention on the forces bent on attacking our area of defense responsibility. Our targets are the enemy military forces from start to finish. The strategy of aerospace defense is, inevitably, counterforce.

Aerospace defense of the North American continent is accomplished by the combined efforts of elements of the Army, Navy, and Air Force of the United States, plus the Royal Canadian Air Force. The command structure organized to accomplish this mission is the North American Air Defense Command (NORAD), commanded by General Laurence S. Kuter, USAF. Of the total forces involved in this enterprise, the USAF provides 73 per cent.

Lieutenant General Robert M. Lee, Commander of the Air Defense Command, summarized the aerospace defense job when he spoke before the Institute of Aeronautical Sciences at Los Angeles, California, on 30 June 1960. In the aerospace defense business, General Lee said, we hold that a potential enemy must be made to feel that a breach of the peace will be unacceptably costly to himself. "Our method of doing this is to be ready to extract such a great penalty on an attacking aerial or spaceborne force that the enemy's planner must seriously doubt his ability to accomplish his attacking missions. And we must convince the enemy that we can do it!"

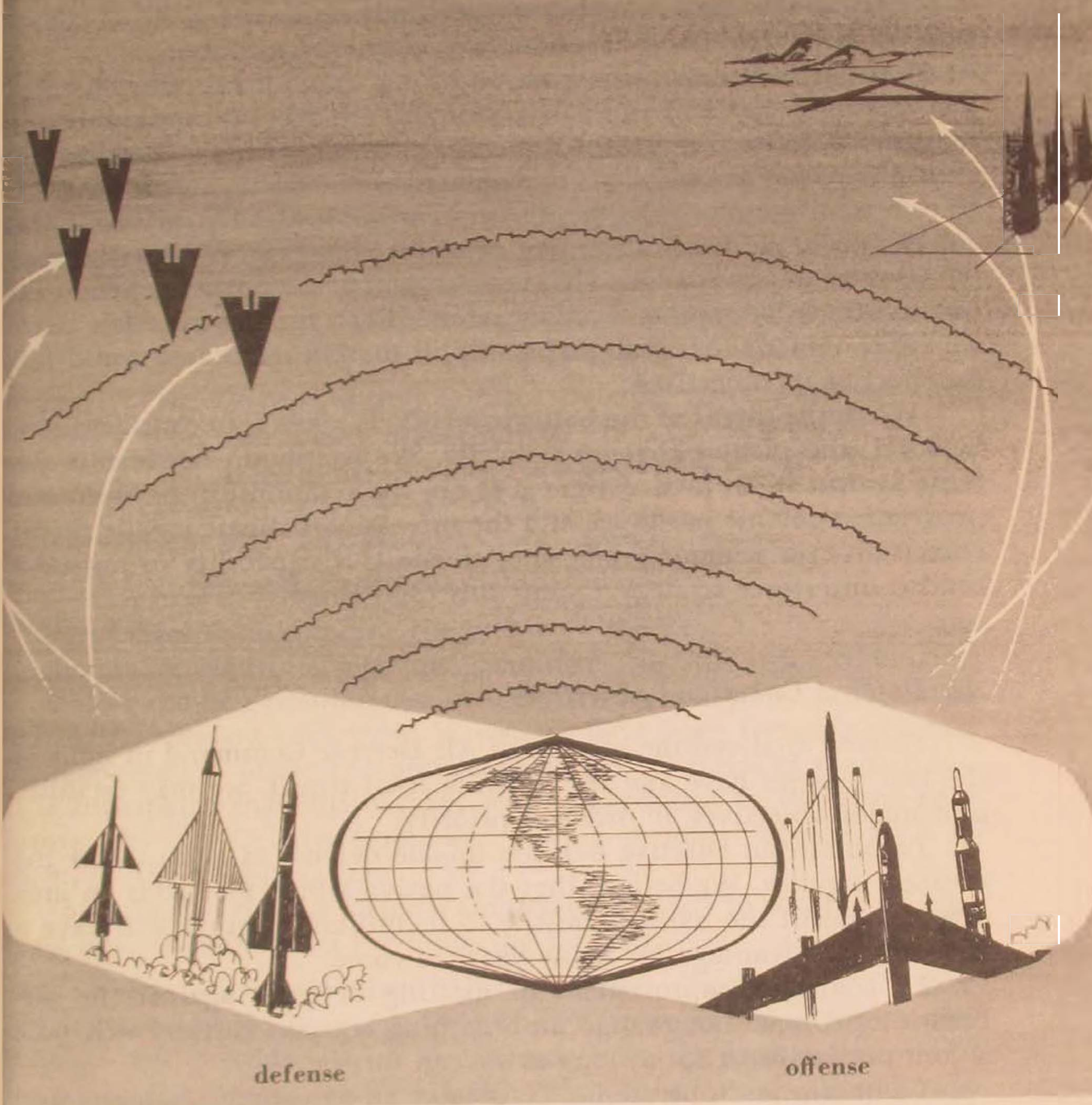
The enemy's doubt that he can achieve his attack objectives, coupled with a realization that he will suffer a counterattack delivered against his forces at their bases, is a powerful deterrent. The capability to win, with the least possible damage to our own country, is essential because deterrence might fail. To ensure that we will win, the primary objective is always the enemy's military forces—counterforce. The role of aerospace defense is to provide that essential defense portion of the counterforce strategy which makes true counterforce possible.

the Air Defense Command mission

Having established the role of aerospace defense in the counterforce strategy, we may now examine in some detail the Air Defense Command's contribution to its execution. As a start, we may examine some of the relationships affecting this contribution.

The Commander, Air Defense Command, has two jobs. Although dual responsibilities are not unusual in these days of unified, joint, and specified commands, a certain uniqueness to the situation does warrant noting. One job is that of a major air commander who is responsible to the Chief of Staff, USAF, for command jurisdiction over his assigned units. The other job is that of a component commander under CINCNORAD. In the latter capacity he provides and supports combat-

Defense in the Counterforce



ready Air Force elements which are under CINCNORAD's operational control. This statement is somewhat oversimplified, but it points out the uniqueness of this command relationship. Operational control of ADC forces is exercised through NORAD channels rather than through the ADC component channels.

At the present time ADC is performing its jobs at peak effectiveness. What this means is that for the past few years it has had a better capability against a growing threat than at any other time in the past decade. In 1950, for example, the United States had lost the atomic monopoly. Subsequently we also lost the monopoly on the long-range weapon-delivery capability. We had then become vulnerable to attack by nuclear-armed manned bombers, and we had little if any capability to contend with such an attack. Ground radar coverage was spotty and of limited range. Early warning was virtually nonexistent. Interceptors lacked speed, range, and adequate fire-control systems. Armament consisted of .50-caliber machine guns and some explosive rockets. Yet the job facing us in 1950 was fairly straightforward. We needed better armament, better fire-control systems, and a semiautomatic electronic ground environment. Every improvement we made to our growing defense system gave us a leg up on the entire threat. Up to about the current time, the lag in defensive capability has been reduced, so that now defense is about as good as it could get, for the purpose of countering an attack by manned bombers alone. Even for the next few years we are convinced that such an assault on the United States would fall far short of its objectives.

When the threat of the ballistic missile is taken into consideration, however, the picture changes radically. We simply do not have a defense against it. In fact, as time goes on, the relationship between our programed defense hardware and the increasing ballistic missile threat reflects an ever widening deficiency in the U.S. capability to pursue a total counterforce strategy against this total threat.

Air Defense Command objectives

Having analyzed the mission of Air Defense Command in light of the two jobs we have and the growing total threat, we may establish four major objectives, in order of priority:

1. To obtain an effective ballistic missile defense as a matter of the greatest urgency. We believe that the nation which first adds an area defense against the ballistic missile to its military posture will have a tremendous advantage for many years to come.
2. To continue improvement of existing defenses against the air-breathing threat. Long-range air-breathing weapon carriers will pose a continuous threat for as long as we can foresee.
3. To obtain and operate for CINCNORAD an aerospace command and control system which will reduce reaction and decision time. The present four functions of air defense—detection, identification, interception, and destruction—are equally valid for aerospace defense of the future. The big problems are the compression of time and the increasing vulnerabilities resulting from advances in military technology. The time available for performing these functions is dwindling at a remarkable rate. Accuracy and destructive power of offensive weapons are increasing rapidly.
4. To develop new weapons to meet possible new threats. We feel that our research should be directed toward countering what an enemy could do in the future. Obviously the big payoff here is the contraction in lead time which would result from research and development in this important area of aerospace defense in advance of actual existence

of the specific requirement. The key to success is in decision—in picking the right system at the right time and getting on with it.

Our approach to the achievement of these objectives is in line with the spirit and intent of the 375-series of Air Force regulations. These regulations cover the progress of Air Force systems from concept to phase-out, providing for the closest participation in systems development between private industry and USAF agencies, including the eventual user. The procedures represent systems management at the highest level of efficiency. As a user, ADC participates daily in the development and attainment of aerospace defense systems. We have established three field offices which provide permanent members from the user command to the System Program Offices:

ADC Command and Control Defense Systems Office,
Hanscom Field, Massachusetts

ADC Aeronautical Defense Systems Office,
Wright-Patterson AFB, Ohio

ADC Aerospace Defense Systems Office,
Inglewood, California

The end result is to combine the talents of the new Air Force Systems Command, appropriate elements of industry, and the using command, to achieve the best possible new systems in an orderly and timely fashion. At the present time some 12 systems have been formally selected for management under the provisions of the 375-series of regulations. It is anticipated that this number will be expanded to 18 in the near future, the Air Defense Command having primary interest in 8 of them, or about 44 per cent.

Specifically, the Air Defense Command intends to achieve its four basic objectives in much the following manner:

- For a defense against ballistic missiles, ADC supports the concept of boost-phase intercept. We hold that an orbiting interceptor system would provide us with true area defense—the most valid concept for countering any aerospace attack. This would take the battle away from our homeland and solve the time-compression problem. We believe that the public should be made aware of the requirement for, and the feasibility of, a true area defense against the ballistic missile. Area defense is sound tactical doctrine. It is supported under the most critical examination both by logic and by accepted principles of military operations. An interceptor system that will destroy ballistic missiles far from our nation is the ultimate towards which we must strive—a true area defense. We must gain public recognition of the validity of this concept. This acceptance would contribute greatly towards getting the area defense system which sound strategy demands.
- Our second objective is the improvement of existing defenses. Here we are progressing in an orderly fashion. We are pushing our present interceptors to altitudes never before achieved. Among the

training targets against which we have been flying is the U-2 airplane. Our success rate on these practice missions has been significant and encouraging. However our existing equipments can be stretched just so far. The ever increasing range of the air-to-surface missiles will eventually put the carrier vehicle beyond the range of our current interceptors. Consequently we have for some time been fighting for an advanced long-range interceptor to meet this portion of the threat. The F-108, canceled in 1960, would have been a step in this direction. Air Defense Command feels that we must get a much better interceptor with capability to intercept high-speed, high-altitude, missile-carrying bombers far from our shores.

There is still room for improvement. A case in point is control of the Bomarc missile in a battle situation. Originally Bomarc was intended for employment within a hardened SAGE system. As a result no means other than SAGE was provided for launch and control of this very fine weapon. We are now diligently applying ourselves to securing an effective backup system for Bomarc control. Electronic countermeasures constitute another problem which has faced us and which will in all probability continue. Our program for countermeasures has given us every confidence that we can continue to solve it as it develops.

• The third major objective is to provide CINCNORAD with a faster, more accurate command and control system. Such a system is certainly one of the keys to the aerospace age. The progress in the attainment of the new NORAD Combat Operations Center (COC) to be located near Colorado Springs has been the subject of frequent news releases for the past year or so. It is now being constructed. The NORAD COC will be the hub of the future aerospace defense systems. BMEWS information is now flowing directly to the existing unhardened COC at Colorado Springs. It is planned that instantaneous readout from Midas will also go directly to the center.

Plans for the expansion of the Space Detection and Tracking System, now operated in Colorado Springs by the 1st Space Surveillance and Control Squadron, call for centralization of this function in the hardened COC. Instructions for the accomplishment of satellite inspection must originate from a single source, the COC. This center will include an accurate, rapid, over-all data-collection and data-processing system. It must be centralized for efficiency. It must be hardened and backed up by alternates for survivability. It must be capable of instantaneous action against ballistic missiles, satellites, and other space vehicles as well as advanced air-breathing threats.

• The fourth major objective seeks the capability of rapidly shifting to meet newer threats as they develop. This approach is compatible with the logical concept that space is merely a continuation of the historical environment of the Air Force. Technological improvements are removing the artificial barriers to altitude. There is no real separation between air and space. Our environment is that of aerospace. Within this rapidly expanding environment, new threats are occurring and will continue to occur, at all altitudes. Newer threats to be met could range from supersonic low-altitude missiles, through intercontinental cruise missiles, through maneuvering, boost-glide, "Dyna-Soar" type vehicles to orbiting vehicles at extreme altitudes. A vigorous research and development program must be maintained to enable us to offer, quickly, counter systems to meet any conceivable threat. If we fail to do this, we shall find ourselves in a similar situation to that of today vis-à-vis the ballistic missile threat. In the surveillance picture alone we have an immediate requirement to scan continuously some half trillion cubic miles of aerospace. Soon the extent of aerospace under surveillance must more than double. The eventual surveillance system should provide virtually global coverage, and deep into space. As tied into the hardened COC, it would be the greater "SAGE" system of the aerospace age. When effective weapons are integrated with it, an aerospace counterforce posture would be secured.

Although not a separate strategic consideration, toughness sufficient to remain a viable nation with a fighting force superior to that of any enemy is fundamental to a war-winning capability. Because atomic weapons and swift, efficient methods of delivering them exist today, the ability to destroy these weapons before they can inflict damage on our fighting forces and our Nation must become a reality. Before we get this ability and while the enemy can deliver his weapons, we must so design, deploy, and employ our forces as to make them tough enough to withstand enemy strikes and still defeat his fighting forces wherever they exist.

Air Defense Command is convinced that the Air Force has a sound strategy in fixing its prime objective as that of destroying enemy fighting forces. A counterforce composed of competent offensive and defensive elements is needed to carry out the strategy. Public support for the world's best strike force and recognition of its objectives are realities. The same must be true for the defensive part of the Air Force team. Our Nation always has recognized sound strategies legitimately born of firm fact and sound logic. It always has had, and still has, the fortitude to deal with difficult challenges born of perilous times. It must face one now, because defeat could be ours if we failed to meet the facts and the challenge.

We have a choice between two courses of action: we can build a counterforce of offensive and defensive elements which can win any war thrust upon us, or we can shrink from this task and take some lesser course.

The first course will probably make war unnecessary and will ensure a free America. The second choice will not.

Headquarters Air Defense Command

Defense in Depth

Colonel Victor C. Wegenhoft

"AREA defense" and "point defense" have been a part of the air defense vocabulary for years. Yet they probably are the two most nebulous terms in the air defense business. It is difficult to find two people who interpret their meaning in the same way. To some, they denote a dividing line in air defense coverage based on weapon capabilities. To others, the terms imply maneuverable defenses as opposed to fixed defenses. To still others, they involve the tactical aspects of engaging the enemy at different portions of the attack profile. All may be correct in varying degrees. The purpose here is to set forth some considerations concerning the true meaning and relationship of area defense and point defense—past, present, and future—in regard to a modern defense in depth.

area vs. point defense

The Army Air Forces came out of World War II convinced that it should have primary responsibility for air defense of the United States. Accordingly in the spring of 1946 the AAF established the Air Defense Command to organize and operate an integrated continental air defense system.

Almost immediately a dispute arose over which agency, the Army Air Forces or the Army Ground Forces, should have the air defense mission. The AGF challenged the concept developed during the war that an Air Force commander should be responsible for air defense of an area and have operational control over antiaircraft artillery deployed in the area. The AGF proposed that the air defense mission be divided, the AGF to take over local defense of potential targets and the AAF to provide air defense beyond the range of antiaircraft weapons. Air defense should be redefined to include "antiaircraft defense" and "defense by air" as separate missions.

The AAF disagreed with this proposal to split air defense responsibility on the basis, fundamentally, of a limitation of weapons. It took the position that the speed of modern bombers, coupled with the possibility of surprise attack, made it essential to have a coordinated defense in depth under one commander. Thus began the great controversy over the relationship of area defense and point defense.

When, under the National Security Act of 1947, the new United States Air Force was formed from the Army Air Forces, it was given the air defense mission. Service roles in air defense were not spelled out, however, until the Key West Conference of 1948. The Key West Agreement assigned primary responsibility for continental air defense to the Air Force and gave the Army and Navy a collateral role of providing air defense forces. Until activation of the Continental Air Defense Command (CONAD) as a joint command in September 1954, a coordinated air defense arrangement was based solely on such interservice agreements.

During this period there was a progressive increase in the capabilities of air defense weapons. The Air Force was procuring both fighter-interceptors and missiles for air defense purposes. Development of the semiautomatic ground environment (SAGE) system was undertaken to permit centralized control of these weapons in a relatively large geographic area.

The short range of World War II antiaircraft guns had dictated that they be deployed in close proximity to the specific point being defended. There was little need for coordination of fire between gun batteries, and each battery commander was an air defense commander of the area within range of his guns. With the Army's introduction of surface-to-air missiles having greater range, the coverage provided by point defenses began to overlap, and battery fire had to be coordinated. The result was Army development of a fire-control coordination system known as Missile Master. Missile Master would permit centralized control of surface-to-air missiles within a limited area in much the same manner as SAGE does for a larger geographic area.

To minimize Air Force and Army duplication in developing missiles for air defense, the Secretary of Defense published a directive on the subject in late 1956. It assigned to the Air Force the responsibility for developing and procuring missile systems for "area defense." The Bomarc was placed in this category. The Army was given responsibility for developing surface-to-air missiles for "point defense," i.e., missiles having a horizontal range on the order of 100 nautical miles. The Nike I, Nike B, and Talos were designated as missiles in this category.

The 1956 directive went on to state that area and point defense systems could not be defined with precision. However an attempt was made. Area defense, the directive pointed out, involves the concept of locating defense units to intercept the enemy attack remote from and without reference to individual vital installations, industrial complexes, and population centers. It further stated that, because of widespread sitings, area defense missiles normally receive their guidance information from the ground environment network rather than from acquisition and tracking radars located in the vicinity of the missile-launching site and that point defense had as its purpose the defense of specified geographic areas, cities, and vital installations, a distinguishing feature being receipt of its guidance information from radars located near the launching site. Although "area" and "point" defense had been discussed for years, such a breakdown of air defense had never before had official top-level sanction.

During this period the USAF Air Defense Command, as the Joint Chiefs of Staff executive agent for CONAD, and the Army Antiaircraft Command held conflicting views on how the air battle should be conducted. Air Defense Command wanted the assignment of targets to antiaircraft batteries to be centralized at the SAGE Direction Centers. The Army Antiaircraft Command preferred a decentralized control system that would permit its batteries to take under assignment any target within range of its acquisition radars. Coordination of fire within and between Nike-defended areas would be accomplished by the Missile Master system.

This matter was resolved in June 1956 when the Secretary of Defense approved a new organizational arrangement for CONAD. The Commander in Chief, Continental Air Defense Command, was given authority to centralize the control of air defense forces, including assignment of individual antiaircraft batteries to designated targets. He was authorized to set up such subordinate joint organizations as he deemed necessary to permit the centralized control and combat employment of all air defense weapons made available by the component services. Plans were developed for integration of the SAGE and Missile Master systems. When the North American Air Defense Command (NORAD) was established in September 1957 to integrate the air defense forces of the United States and Canada, CINCNORAD was given a similar authority.

defense in depth today

Thus today the line of demarcation between area and point defense has all but disappeared. Air defense of North America is carried out under a concept of defense in depth with a family of weapons. Operational control of all these weapons is centralized under CINCNORAD and his subordinate NORAD commanders.

Under this concept an attacking enemy force would be engaged by air defense weapons as far out as possible from its target objectives. The speed and standoff capabilities of enemy bombers and missile-launching submarines make them a dangerous threat while still hundreds of miles from our borders. Therefore engagement must be initiated at maximum range with weapons of maximum destruction. In addition to reducing the enemy's air-launched and submarine-launched missile capability, early engagement will disrupt his plan of attack, break up his bomber formations, and cause him to commit himself prematurely.

Implementation of this concept requires employment of long-range interceptors that have sufficient speed, endurance, and flexibility to concentrate firepower against an attacking force far out from all potential target objectives. In addition it requires a warning system and a weapon-control system that permit exploitation of the long-range interceptors to their maximum capability.

There is a limit to the number of long-range interceptors which the defense can concentrate in a given time and space against numerous rapidly moving targets. Therefore the concept of defense in depth entails the capability to engage the hostile force all along the route of attack until destruction is completed. This is the job of the shorter-range fighter-interceptors and interceptor missiles. Vital areas receive additional protection from surface-to-air missiles deployed in close proximity to specific targets or target complexes.

Such is the present-day manner of conducting air defense—a family of weapons integrated into a single system under centralized control to provide defense in depth. There is no operational distinction between area defenses and point defenses. All available weapons are employed in a manner best suited to exploit their inherent capabilities for engaging a hostile force as far out as possible and then keeping it under continuing attack until destroyed.

aerospace defense in the future

The classic functions of detection, identification, interception, and destruction will not change for the aerospace age we are now entering. Only the weapons and techniques will change. Advancing technology is drastically compressing the time available to perform these basic functions. A short time ago air defense had as much as 15 hours to do the job. Now there may be less than 15 minutes.

The ballistic missile is the most imminent threat which exploits this dimension of time. But it is by no means the ultimate threat confronting aerospace defense. Advanced offensive systems of both aerodynamic and space types undoubtedly will become threats in this decade. Such systems may include supersonic manned bombers armed with air-launched ballistic missiles, intercontinental cruise missiles with high speed and altitude capabilities, nuclear-powered low-altitude missiles, boost-glide delivery systems operating at lower orbital altitudes, and maneuverable space vehicles with weapon-delivery capabilities.

The tremendous speed with which future mass-destruction weapons can be brought to bear will impose severe constraints on aerospace defense. The defense must have as its goal the capability of engaging enemy aerospace offensive forces immediately after a clear-cut hostile commitment. To do less is a forfeiture of time and space. The defense should be capable of striking the hostile force all along its attack profile to ensure maximum attrition. It should have the inherent ability to counter aerospace offensive forces presenting a threat to United States interests anywhere in the world.

In other words, the current system for continental air defense must evolve into a global aerospace defense system. Still the basic concept of defense in depth with a family of weapons will remain valid. Unfortunately each member of the family will place a considerable demand on the military budget because of increasing complexity. We must be able to answer two questions. First, is aerospace defense really necessary? If so, what type system should have priority call on the Nation's resources?

The answer to the first question is an unequivocal yes. The ballistic missile will soon become the main immediate threat to this country. With the United States and its primary potential enemy approaching parity in deliverable offensive capability, the nation which has a truly effective defense against this aerospace threat will acquire a tremendous tactical advantage. The only sound strategy for defeating an enemy should war be forced upon us in the aerospace age is a counterforce strategy, i.e., destruction of his military forces before he destroys ours. In the event of general hostilities, counterforce must be applied against the enemy offensive force wherever and whenever it can be engaged—on its launch pads, on its air bases, or en route to its targets. Since the United States would not strike the first blow, a large portion of the enemy aerospace force could be on its way to targets in this country before we could react. It may be necessary to apply counterforce against a large portion of the enemy offensive force in the aerospace medium. This is the job of aerospace defense. The defense is an essential partner of the offense in providing a true counterforce capability.

There are opposing views on the answer to the second question—what type of aerospace defense should receive priority support. These views do not represent a doctrinal controversy harking back to the old considerations of area defense versus point defense. Defense in depth with a family of weapons is the valid concept for the aerospace era. Rather they represent a difference of opinion as to how the newer concept should be implemented. An analysis of the differing views is essential to decision on this vital point.

Much effort is now being expended to obtain an operational aerospace defense capability. Since the ballistic missile is the most immediate and ominous of the aerospace threats, it has received priority consideration. The Ballistic Missile Early Warning System (BMEWS) is now becoming operational and will provide a minimum of 15 minutes' warning of ICBM attack over the north polar region. An orbiting ballistic missile warning element known as missile defense alarm satellite (Midas) will complement BMEWS in the near future to provide approximately 30 minutes' detection time.

A weapon to intercept and destroy a ballistic missile after it is detected presents a formidable challenge. The flight of an ICBM can be divided into three phases—the boost phase, the mid-course phase, and the re-entry phase. A boost-phase intercept must be accomplished with a satellite in orbit passing over or near the enemy's launch area. A mid-course intercept system might employ either a satellite-borne interceptor or a ground-launched vehicle. Intercept during the re-entry or terminal phase probably can best be accomplished by a ground-launched missile.

The "cost squeeze" simply will not permit simultaneous development of optimum systems to engage enemy ballistic missiles in each of the three phases. The question therefore arises as to which portion of the attack profile should receive first consideration and emphasis. A terminal-phase ballistic missile defense, deployed to protect certain selected target complexes, probably could achieve operational status ahead of the other systems. Some authorities advocate expeditious procurement and deployment of a terminal system, primarily on the basis of its early availability. Others believe the only tactically sound approach is to concentrate our efforts first on a boost-phase system, which now is within the technological state of the art. It is believed that a development program on a "Manhattan" crash basis could provide a boost-kill capability shortly after a terminal system could be fully deployed. Which approach is right?

It is basic to the concept of aerospace defense in depth that engagement of the enemy offensive force should begin as soon as possible after he has made a clear-cut hostile commitment. A boost-kill ballistic-missile defense system adheres to this significant principle. This capability will afford all our resources, military and civilian, a basic level of protection with a system of manageable magnitude. Our offensive forces can be actively defended without regard to whether they are fixed or mobile. Our citizens in villages as well as in New York City can be protected. The problem of target priorities for defense, which confronts a terminal system, is virtually eliminated. Furthermore a kill-during-boost system will engage the enemy ballistic missile during its most vulnerable phase—when the warhead is still attached to the booster and the missile is traveling at its slowest speed. At this point the mildest kind of blow can deflect it from its course or destroy it. Decoys, cluster warheads, increasing speed, and variable trajectories will present least difficulty to the defense during the boost phase.

While a terminal-phase defense system probably can be deployed earlier than a boost-phase system, that advantage must be weighed against serious disadvantages. The terminal system immediately raises the obvious question of which potential targets to defend—military forces, population centers, industrial complexes? The cost of protecting all possible military and civilian targets certainly would be prohibitive. The terminal-phase is undoubtedly the most difficult part of the ballistic missile profile to defend against. During re-entry the target is a small, hard warhead traveling downward at terrific speed. Furthermore a number of relatively simple countermeasures could be used by the enemy during the re-entry phase.

Logic therefore indicates that a boost-phase system is the most promising defense concept against the ballistic missile that will give useful kill ratios at an economic trade-off. Its development should be accorded highest national priority, to provide a basic level of active protection for all our resources, military and civilian. A terminal system, designed specifically to raise this basic level at certain vital target complexes and to complete defense in depth, must be considered supplementary. Integration of this supplementary system must not be allowed to jeopardize early attainment of the boost-phase system which sound strategy demands.

There has been considerable controversy in the past concerning the relationship of area defense and point defense in countering the air-breathing threat to this country. Today air defense is based on a concept of defense in depth with a family of weapons under centralized control. This is a sound concept, which will remain valid for the aerospace age. Aerospace defense weapons capable of engaging enemy offensive forces as soon as possible after they are committed against us must have highest priority on the military budget. Such systems will provide a basic level of protection for all our resources, military and civilian. Defense systems designed to increase the level of protection of selected vital areas must be considered as supplementary. Aerospace defense weapons must be developed and deployed in consonance with this concept.

Headquarters Air Defense Command

Aerospace Defense 1970–1975

Lieutenant Colonel Travis M. Scott

DESCRIPTION of our aerospace defense forces of the 1970 time period assumes that we have successfully accomplished our mission up to then—that the forces available have been adequate to ensure national survival. The defensive systems, when considered together with all of our offensive capability, have constituted a credible deterrence to any potential enemy.

The configuration of follow-on defensive systems might be conceived by freeing the imagination and expanding upon the exotic possibilities written into science-fiction today. But for the military planner a more logical approach is required. Theoretical possibilities must withstand detailed investigation before firm development programs are established. A similar inquiry could be directed to such areas of interest as the population, the number of automobiles on the highways, or the value of the gross national product in the 1970–1975 time period. In each case the forecast would be based upon an extrapolation of the current position, after adequate consideration of all pertinent factors.

In like manner the future aerospace defense posture can be predicted by extrapolating from the present position within the framework of the requirements of the basic mission of defending the United States against aerospace attacks. However, the extrapolation of our current posture to that of 1975 certainly must take into consideration the many influential factors external to the United States that will affect the composition of our 1975 aerospace defense forces. Such factors as the world-power position of current allies and potential enemies may change radically in the next decade. Events of nature may change decisively the economic and population status of many of today's established nations. With our rapidly advancing technology we cannot predict exactly the major new developments that will be occurring ten years hence. However, despite the many possibilities of unpredictable events that may occur, the four basic functions of our current aerospace defense system will remain valid in the future —detection, identification, interception, and destruction.

the atmospheric regime

It is axiomatic that development of defensive capabilities is responsive to the configuration of the offensive forces which must be countered. A first step, then, is postulating what the offensive forces will be in the 1970–1975 time period. Until recently the manned bomber has been the primary weapon that could be used to attack the United States. Development of the intercontinental ballistic missile has not negated the many advantages of the manned bomber but has only added a partner with different advantages. It is believed that the manned aircraft portion of the air-breathing threat will continue to exist in the 1970 time period.

Twenty years ago the bomber aircraft was, relatively, "low and slow" with small bomb loads. Through the years of World War II and subsequently, the manned bomber has been substantially improved. The present threat is from aircraft carrying bomb loads of tremendous destructive power at much higher altitudes than the 20,000- to 30,000-foot uppermost levels of World War II. Formerly the manned bomber carried short-range gravity bombs for release and free fall at its lower altitudes. In the future we must expect high-altitude launches of long-range air-to-surface missiles of the Hound Dog and Skybolt types. Hostile aircraft of the B-70 type in the 70,000-foot, mach-3 category and armed with long-range air-to-surface missiles necessitate large increases in the detection ranges of a surveillance system.

Diversification of offensive capabilities has been achieved with the development of submarine-launched ballistic missiles (SLBM). In the hands of any hostile power, these sea-based mobile launch platforms, equipped with ballistic missiles armed with nuclear warheads, provide the means—once they are launched—for an attack against the North American continent from all ocean approaches. The ability to remain hidden until missile launch, coupled with missile flight times on the order of minutes, poses severe problems for the aerospace defense.

Various new offensive weapon systems are being developed to utilize the area between the surface of the earth and the outer fringes of the sensible atmosphere. Typical of this type of equipment is the boost-glide vehicle. Nuclear propulsion will make possible another advanced threat, the supersonic low-altitude missile with around-the-world cruise ranges.

This partial listing of possible offensive weapon systems, which may be expected to be equipped with penetration aids and countermeasure devices, indicates the problem in developing an adequate aerospace defense against potentialities in the atmospheric reaches. The problem has increased substantially from the days of the low-altitude, subsonic manned aircraft, when detection of relatively large incoming targets at ranges of several hundred miles provided hours of warning prior to bombs on target.

The surveillance system of the 1970–1975 time period must embrace the entire perimeter of the North American continent and provide coverage of all hostile forces, varying in size from small to large, in speed from subsonic to hypersonic, and in altitude from the earth's surface up through the sensible atmosphere.

Such surveillance would be a large job indeed, but we have a sound basis from which we can build. The presently constituted system, including all the surface land-based radars, augmented by airborne early-warning and control aircraft, picket ships, and Texas Towers, provides a capability for the subsonic threat. Additional capability will be required to cope with the more advanced atmospheric threats. To provide a detection and early-warning capability against the air-launched and submarine-launched ballistic missiles, we must be able to see over the horizon in those areas presently denied to line-of-sight radars by the curvature of the earth. To do this, we will have both surface-based ionospheric skip radars and low-altitude earth satellites equipped with a variety of sensors designed to locate any moving target. High-powered radars employing the electronic scan phased-array techniques will provide the long-range, precise tracking capabilities required.

Such a surveillance system requires an exceedingly reliable and secure communications system. Adequate communications are required for the commander to utilize properly the detection and early-warning information obtained by the system's sensors. The range and reliability of point-to-point, air-to-air, and air-to-ground communications must be extended. The growing volume and nature of the communications traffic indicate the requirement for increased transmission rates, which appear to be achievable only through wider bandwidths of already overcrowded lower portions of the frequency spectrum. Active and passive earth communications satellites will provide a system of instantaneous communication with any point on or above the earth's surface.

All these communications nets from elements of the total surveillance and warning system must be connected into a centralized command and control center. This system will provide instantaneous early-warning information to the commander of the aerospace defense forces, as well as the information necessary for him to make the proper decisions in exercising command and control of his active defense forces.

The control to be exercised by the commander of the active defense forces will be determined by the capabilities of the individual systems. In the 1970 time period we must continue to have an adequate capability, in terms of manned interceptors, to defend against the manned-bomber threat. Increased capabilities will be obtained by refinement of the fire-control systems to achieve greater detection and lock-on ranges with the airborne radar, by improved electronic counter-countermeasures, by more positive and reliable "identification, friend or foe" (IFF) devices, and by guided longer-range missiles armed with nuclear warheads. Manned-interceptor squadrons will be strategically dispersed throughout the North American continent to obtain maximum support from the surveillance system for interception and control. The manned interceptor, with its flexibility and maneuverability, will not be discarded as long as there exists a threat against which it can be effective.

Interceptor missiles will be an important part of the inventory in this time period, to provide the essential defense in depth against the air-breathing threat. Close control and direction of these short-range and longer-range (several hundred miles) missiles will also be exercised through the surveillance system.

The offensive threat dictates that the defensive forces must also include a capability against the air-launched ballistic missile (ALBM) and submarine-launched ballistic missile (SLBM). An advanced interceptor system must provide a high-speed, quick-reaction interceptor which is highly maneuverable, to provide for flexibility and autonomous operation. Such a system will yield the defensive capability required for vast areas to the north and for over-the-ocean approaches to the U.S. Major advances in technology will enable the system to be capable of nearly automatic reaction within the planned environment, with provisions for positive control by the commander of the aerospace defense forces.

exoatmospheric regime

During the early 1960's the primary threat is expected to change from the manned bomber to the intercontinental ballistic missile. This missile, although somewhat less than the "ultimate weapon" it has been dubbed, is an extremely potent offensive weapon. It has the capability of placing extremely large detonations accurately on targets at intercontinental ranges. The time available for possible interception and destruction is at the most only about 30 minutes. The warhead itself is a relatively invulnerable target and will undoubtedly be surrounded by a variety of exoatmospheric and re-entry decoys, thus further compounding the problems of the defense. Achieving an effective defense against the ICBM is truly a most exacting task.

Difficult though this defense may be, the ICBM is not the only new and potent weapon system to be developed in the next decade. The extensive satellite programs have demonstrated vividly the possibilities of orbiting satellites armed with re-entry weapons. Such armament could be delivered on targets anywhere on the surface of the earth upon command. The recent announcement of successful orbiting and recovery of a manned satellite indicates the feasibility of manned earth-orbital vehicles. From a manned earth-orbital system the transition to true manned space systems with maneuver capability is merely a matter of incremental increases in propulsive energy.

This incomplete listing of possible offensive weapon systems in the exoatmospheric regime is intended to indicate the complex problem faced by the developers of an adequate aerospace defense system. For instance, the detection function requires continuous surveillance of the areas surrounding the defended target outward to any distance from which an attack could be initiated. ICBM's must be detected upon launch and tracked continuously along their trajectory. Hostile actions committed by earth-circling satellites must be known instantaneously. Techniques must exist which permit identification and assessment of the purpose of any earth-orbital vehicle that may appear. The entire volume of space from the earth's surface out to all satellite altitudes of possible interest must be covered. The acquisition and transmission of early-warning information must be in real time (instantaneous) because of the sharply reduced time available for the defense forces to react.

Early-warning satellites of the Midas type will provide the information necessary to alert the defensive systems and to warn the Nation. Surface-based and satellite-borne sensors will provide identification of warheads and determination of hostile intent. Orbiting interceptor systems will intercept and destroy the ICBM in flight. Terminal-phase surface-to-air missile defense may be provided for a few vital, nonexpendable, hardened locations. The development of new, reliable, and secure means of communication will enable command and control of the defense system to be exercised by the commander from his centralized control center.

This comprehensive defense system against the ballistic missile has the advantage of making the interception at the earliest possible time, with succeeding intercepts as required, thus providing the desired defense in depth. In support of the USAF basic concept of area defense, such a system will provide simultaneous defense on a global basis, by contrast with defense of many isolated points. Additionally, actual combat will be conducted in space, and as far as possible from the defended target.

In the 1970–1975 time period the aerospace defense will include manned orbital vehicles. A prerequisite for a manned orbital vehicle is the development of large boosters. Both chemical and nuclear propulsion systems are being developed today that will be capable of orbiting payloads of thousands of pounds in a single package. Orbiting vehicles of this size will permit the incorporation of many individual satellite functions into the one system.

New and improved surveillance systems will be available, utilizing the infrared, visible, and radio portions of the spectrum and exploiting optical, photographic, and radar techniques. High-quality, reliable, and continuous surveillance of the entire earth's surface and surrounding space will be possible. Advanced computer developments will permit rapid data-processing on board the vehicle. Satellite-to-satellite and satellite-to-surface communications will be achieved through secure and reliable channels. This manned orbital vehicle can be equipped with a variety of armaments for self-defense and counterforce missions.

The manned orbital system will be completely self-contained, having all the subsystems required to perform the basic aerospace defense missions of detection, identification, interception, and destruction in space. Secure space-to-surface communication channels will ensure command and control of the manned orbital system from the surface-based command and control center. Space scooters which permit manned departure from and return to the mother vehicle will be part of the installed equipment aboard each of the manned orbital vehicles. These scooters will be used for inspecting unidentified satellites and for intersatellite transportation. One or more of the vehicles of the system will also function as an alternate for the surface-based command and control center.

The men aboard these vehicles accomplish two major functions—maintenance and judgment. The subsystems designed for each specific task will be automatic, but continuous operation for long periods of time in a severe environment dictates maintenance by the man on board. Judgment is itself the unique attribute of man. It is not envisioned that computing machinery will ever equal man's capability for exercising judgment. No acceptable substitute for this capability, so essential to military operations, has been suggested.

command and control

To enable the commander to control effectively the integrated aerospace defense system, information must be transmitted to a control center. The NORAD Combat Operations Center, now under construction, will fulfill this requirement.

As a basic principle, command and control authority should be centralized at the highest level of authority which has the functional capability to exercise control. This principle holds true regardless of any factor or event which may degrade the capability for control, and hence lower the level of command, whether as the result of basic system limitations, a disruption of communications, or saturation of command and control channels because of the magnitude of the attack.

The degree to which control can be exercised by one commander is directly related to the number of decisions required in a particular time interval. When the number of decisions exceeds the capacity of a single commander, authority must be delegated downward to the next highest level which possesses the decision-making capacity. To achieve centralization at the highest level, command

and control development objectives must be directed toward systems which reduce the number of decisions required per unit of time.

The NORAD COC will have secure, reliable data links and communications channels to and from the essential elements of the aerospace defense system. Early warning, on a real-time basis, of hostile actions will be funneled into the NORAD COC from all elements of the surveillance system. High-capacity automatic data-processing equipment will provide essential refined data for simplified visual displays that will enable the commander to control his aerospace defense forces.

THE aerospace defense system of the post-1970 time period will thus include a surveillance system with global coverage from the earth's surface out to at least synchronous orbit altitudes.* This system will perform the detection, identification, and tracking functions required by the defense. Included in the system will be a variety of surface-based and orbital sensors. Information from the sensors will be transmitted by secure, reliable, and instantaneous communication channels to the command and control center where it will be refined and displayed.

Closely integrated with this system will be a variety of active defense systems possessing the capability to intercept and destroy hostile objects anywhere throughout the volume of space covered by the surveillance system. These systems will include manned aerodynamic vehicles, unmanned surface-based missile systems, and manned and unmanned orbital weapon systems, to provide defense in depth on a global basis. Command and control of the entire vast system will be centralized at the highest possible command level. Survivability of the command and control system under combat conditions will be ensured by appropriate methods of hardening, active defense, and redundance.

Attaining the defense posture we have visualized will ensure that no attack against us can disarm this country. The surviving forces will be adequate to prevail, and thus national survival will be secure.

Headquarters Air Defense Command

*[22,290 statute miles, at which altitude a vehicle in orbit may be synchronized with the earth's rotation.]

Maneuverability
Key Tactic in Aerospace Defense

Lieutenant Colonel John W. Bennett

MUCH has been written about the ways and means of waging war. It is safe to say that probably most methods available to man have been tried, with varying degrees of success. But there are certain underlying principles that have withstood the test of time and use with all the methods. One of these is the need to maneuver. The implication is that the operator must have the ability to counter, according to his own desire, any actions that the enemy might employ. In short, the operator retains to the utmost an essential ingredient for successful military operation, namely, tactical flexibility.

maneuverability in defense relative to the offense

The extent or magnitude of maneuverability in defense must be directly relative to the nature of the offense against which the defense is to be committed. This relation holds true in the field of sports, in past military history, and in our present military posture, and we can expect it to obtain in the future. One can imagine the plight of a boxer without the good footwork essential in ring maneuver, both for defense and for offense, or of a football team with a solid, well-built line but static as to ability to maneuver in defense against the opposing team's offensive plays. What if the ends or the backfield players were unable to move rapidly to counter a change in offense? Throughout the field of sports, you expect the winner to have a highly flexible defense for those moments when he is protecting the goal.

Some years ago the French built the Maginot Line as an impregnable frontier fortress system designed to prevent the Germans from overrunning the French homeland. Unfortunately the Germans did not believe it necessary to undertake a frontal assault upon this dug-in, well-gunned, mined, concreted barrier. It was overflown, it was bypassed, and eventually it was taken from the rear. The inflexibility, the lack of maneuverability represented by the Maginot Line, meant ultimate failure for its defensive objective.

Today our aerospace defenses employ high-quality interceptors, both manned and unmanned. If an enemy approaches our area of defense, he must first encounter the longer-range manned interceptors. If he is successful in penetrating these outer defenses, he then approaches the more fixed defenses, such as the Bomarc and Nike missiles. It should be noted, however, that these relatively fixed missiles are effective only if the enemy is successful in his outer penetrations and if he is "cooperative" enough to fly within their range. With his own freedom of maneuver he may be able to avoid these fixed installations, if he so chooses. On the contrary, the manned interceptor is a weapon designed to exploit the human judgment of its pilot, and one by which the defense can assume the initiative over the enemy strike force. From the view of the interceptor pilot he is not only defending, he is in fact offensively fighting, once he has been given a target to attack and kill. Maneuverability becomes one of his basic capabilities. "Attack" is his byword, and "destroy" his objective. The fighter pilot, although part of the defensive team, is really a maneuvering offensive element.

A glimpse of the future extends even further the significance of far-ranging defense. When, in fact, must defense begin? The aerospace has no limit. Can we afford to wait until the enemy is on his final approach, though distant through space, before we make any effort to kill him? Can we afford to allow him many hours of planning and positioning his approach, and still do nothing until he has committed himself to the final attack run? If it is obvious that his intent is one of placing weapons on target, should we not attempt to destroy him at the earliest moment? Is a satellite in orbit, warhead-equipped, but not yet finally committed to target, a likely object for defensive measures? Is our prompt action to destroy this target considered offensive, or is it defensive? Answers to these questions quickly lead to the conclusion that there soon may come a time in which there is no clear demarcation between offensive and defensive tactics. At that time the need for maneuverability will be paramount.

the fixed defense vs. the maneuverable defense

In fixed-defense planning a high capability for maneuvering is not a prime objective. Weapons designed and deployed for a fixed system, although presenting a formidable obstacle, do permit an enemy the great advantage of being able to plan his attack and reasonably to predict the time, place, and amount of resistance that he will encounter. The enemy will know exactly what to expect and can adjust his offensive strikes accordingly, to his advantage. A fixed defense, with essentially tied hands, cannot be effective for long against a shrewd, agile, and fast-maneuvering enemy. The day is past of the old coastal shore batteries, set in concrete, restricted to a few degrees of fire angle and range, to protect the pinpoint of a harbor. That situation represented zero maneuverability.

Another disadvantage to the fixed-installation defense scheme is that any reserves are purely local in nature. They are attrition replacements, and so also relatively fixed and without mobility. It might be possible to produce fixed defenses that could be effective, if the defender were willing to cover every avenue of approach. But since the enemy's method is always subject to change, extensive fixed defenses would undoubtedly be very expensive if they were to be totally effective.

In the search for defensive weapon systems, it would be advantageous to select those that cause the enemy the greatest consternation during his planning and execution of attack. If our defense is fixed to a given point and has a finite range, the enemy has but to find this Achilles' heel, determine the range of our weapons, and circumvent their capabilities. If, on the other hand, we are able to move this defensive system at will so that at a given time the enemy is unable to tell exactly where the strength of the system is, we have added at least one major and complexing factor that he must overcome in his offensive planning and execution.

Basic Air Force doctrine therefore supports the theory of defense in depth, as a major objective. At the moment our minimum objective is continental defense in depth. In the future our objective is to be capable of world defense in depth, progressing eventually to space defense in depth. Such a philosophy will require continuing the concept of a maneuvering force to fight the remote aerospace battle and to provide constant surveillance of any enemy during his attack, never losing contact with him once he has launched his strike. Key factors for weapons designed to this concept require high speed, long range, great endurance, and multiple use or purpose. One may question what values, or quantities, should be put on these key factors. Of course we would desire the ultimate: infinite speed, infinite range, infinite endurance, and multipurpose use to permit countering any target that might appear. But practicality requires that we accept limits on the capability of these systems, commensurate with the threat and the state of the art for a given time period.

As we consider the needs of defense against the increasing new family of offensive weapons to be expected, we can see that the tactics of the tail chase are fast becoming a poor last choice of tactics, if not already an obsolete choice. Time will always be against us. We must attempt to intercept at the earliest possible moment and probably from a relative position as close to head-on as possible.

For example, the high-speed bomber with the air-launch ballistic missile can best be defended against if we kill the bomber before the ALBM is launched; but, failing this, we must kill the missile as soon as possible after it has been launched. The nature of this high-speed target will require that we be able to maneuver quickly toward the enemy's launch position, and preferably to a head-on location. A highly maneuverable force will allow us to relocate defense weapons to meet the concentration of the enemy strike as the true battle area becomes manifest during an attack. Maneuverability will enable us to prevent end-run tactics by the attacker. It will allow us quickly to use those forces that have been held in reserve pending full development of the battle. This concept is, in large part, the reason why aerospace defense has to date employed the "race-horse" or high-speed interceptor approach in preference to the "flying battleship" technique.

As we move into the ballistic missile era and eventually into the true space age, old concepts of time, distance, speed, and endurance must change radically if we are to defend successfully against the threats of new weapon regimes. Distances have essentially shrunk to the point that global ranges at slightly less than orbital speeds are commonplace. The intercontinental ballistic missile is on a target 30 minutes after launch from a distance of 5500 nautical miles; shorter-range submarine-launched and air-launched ballistic missiles arrive in only a fraction of this time. Distances and endurances possible at orbital and greater speeds are soon to be almost without limit. The orbiting satellite with warhead can be called down to target in a very few minutes. Orbits are no longer required to be in fixed planes but can be adjusted during the life of the satellite. The boost-glide vehicle, a potential weapon-delivery system, will be able to maneuver markedly from orbit. As can readily be seen from the nature of these possible new hostile weapons, aerospace defense systems must have a high degree of response and maneuverability in order to be effective.

There is a tendency to think of our ground installations, our ground environment, and our space environment as being relatively immobile, since they are fixed, in some sense, by virtue of their large equipments and bases. Considered in a different light, this environment of complex, large, and essentially continuous volumetric coverage is maneuverable, in that it encompasses the aerospace volume wherein we would expect the offense to maneuver and the defense to countermaneuver. At least it becomes the essential background for a mobile defense force. Such an environment, equipped with real-time, immediate communications, enhances the value of maneuverable forces. Slow-time or delayed communications will neutralize the advantages of maneuverability. Centralized control for the "big picture" approach will thus become increasingly important. At first glance central control appears to be fixed; but its tasks, its nerve center, design, and ability to control the flexing muscles certainly partake of maneuverability. Here again, defensive maneuverability is relative to the nature of the offensive maneuver.

It is reasonable to assume that the defense forces will be subject to extensive attack; hence survivability becomes a great concern. One normally thinks of hardening as a major factor in survivability. This technique of course has merit, in terms of the more nearly fixed installations, communications centers, sensors, and control headquarters. But hardening is not the full answer with regard to weapons. Weapons, to be effective, require that at some time they be exposed. Extensive hardening may delay their exposure when needed for active defense, but hardening must not delay the fighting. It must be used only to contribute to the successful engagement and destruction of the enemy. Survivability thus requires maneuverability in these weapons. It requires the ability to disperse prior to impact of enemy weapons—dispersal to adjacent parasite bases. In the case of interceptors the ability to get airborne, the "quick flush," is a highly desirable characteristic.

FUTURE aerospace defense systems therefore must remain flexible. They must be capable of meeting any shift or change in the enemy's offensive plans. They cannot afford to become fixed and subject to enemy analysis whereby he can call the defensive cards at will. The defense must, instead, play its cards close to the chest and expose them only at the most opportune and effective moment. And this should be too late for the attacker to take effective corrective actions. In short, defense forces must be highly maneuverable. Maneuverability will remain a key tactic in realizing a successful aerospace defense.

Headquarters Air Defense Command

Cartographic Support of Aerospace Operations

Colonel Robert E. Herndon, Jr.

General Thomas D. White, when Chief of Staff, United States Air Force, took notice of the augmented role of technology in national defense: ". . . as air power evolves into aerospace power, our position is being seriously challenged—and challenged in an area in which we have been supreme for years: technology. As a result, we are being hard pressed to retain leadership. The rate at which we advance is no longer completely of our own choosing. Rather it must meet the demands of a deadly serious competition—a competition in which the security of our nation is at stake. If we are to continue to be secure, we cannot allow ourselves to be surpassed in any technical field—particularly the field of aerospace technology."*

Within the broad range of that technology the Aeronautical Chart and Information Center (ACIC) is responsible for providing cartographic and geodetic support for the Air Force in its aerospace activities. It is also responsible for keeping abreast of projected cartographic requirements of the future, so that graphic support media can be designed concurrently with the development of implements of air power, as an integral part of the over-all system.

The design and development of compatible cartographic support can be broken down into several orderly operations. First is the analysis of information that serves to define the problem. Next is the development of the operational environment, the data-collection phase which provides familiarity with actual problems to be encountered by the aircrew—problems of space, lighting, accuracy tolerances of the navigation-guidance system, and the actual work tasks of the crew members in using cartographic products. Finally comes the design of adequate products to satisfy the requirements established in the first step and the related test and evaluation to ensure adequate success of the design. We believe testing and evaluation to be a very important step in the operation prior to production of charts in large quantity or as a chart series. The wisdom of this approach was emphasized as early as 1672 in the conclusion of Sir

*Air University Quarterly Review, XI, 3 and 4 (Fall-Winter 1959), 4.

Isaac Newton after examining a theoretical telescope design by Cassegrain: "I could wish therefore, Mr. Cassegrain had tryed his design before he divulged it. But if, for further satisfaction, he please hereafter to try it, I believe the success will inform him that such projects are of little moment till they be put in practise."

cartography for air systems

Representative of the cartographic media devised for current high-performance aircraft is the F-106 semiautomatic navigation-guidance system. Supersonic speeds and expanded ranges of our newer aircraft, together with the need for all-weather operation, have transcended manual navigation techniques. To provide for this requirement, several semiautomatic chart display systems have been developed and are in use, either for tests or operationally.

The display devices used in these systems present integrated data (Fig. 1) on position and heading, by an aircraft symbol superimposed over a chart image. This symbol, as an automatic function, moves across the graphic on the course and at a rate commensurate with the speed at which the aircraft is moving over the earth's surface. Altitude and attitude of the aircraft are shown on separate cockpit instruments. The numerous charts used in these displays cover extensive geographical areas. The reduced images of the F-106 charts are stored in miniaturized form as monochrome photographic images on film strips. Other systems might utilize glass slides, a cylinder, or a hemisphere for cartographic storage and display. These images are projected either optically or electronically onto the display area located directly in front of the pilot. Selection of charts is accomplished by a simple, manually operated switch, and the aircraft symbol is automatically positioned on the new image.

Charts are provided in three scales. The small-scale chart (Fig. 2) contains only map and textual data required for high-altitude en route or operational area navigation. The medium-scale chart provides scramble and departure routing and return to base data. The larger-scale chart contains only those data required for terminal area penetration or landing operations. Chart scales are established on the basis of the equipment magnification ratio, the distance from which the image is to be viewed, and the amount of information required for the specific phase of the mission. This necessitates close and continued coordination between the system design engineers, the operational user, and the cartographer, to ensure optimum graphic production completely integrated with the over-all weapon system and mission objectives.

In addition to film strips, one of the currently operational guidance systems also requires cartographic support in the form of punched computer tape. These tapes contain preselected navigation

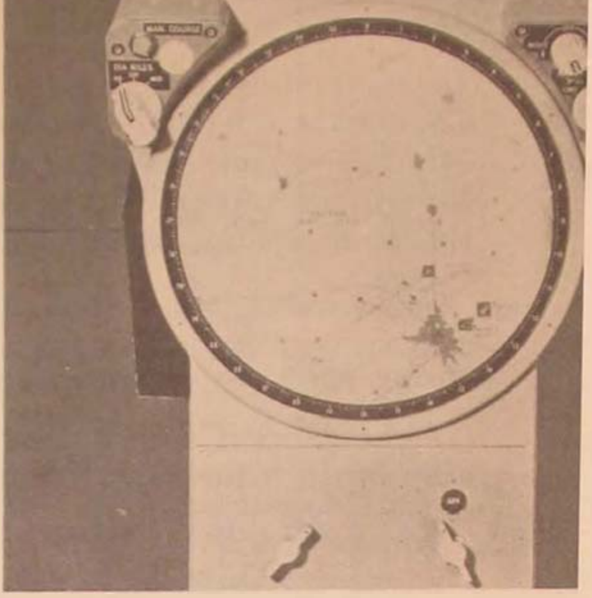
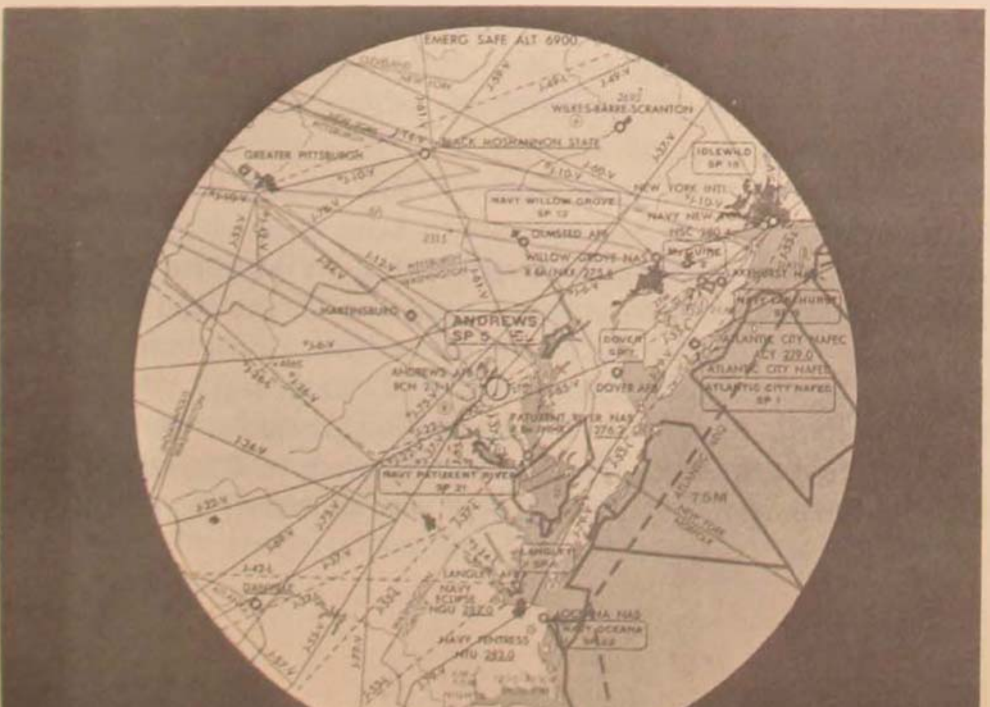


Figure 1. Chart display of the F-106/MA-1 semiautomatic guidance system. A blip representing the aircraft position is synchronized by means of an airborne and/or ground-based computer which reads output data from various navigation facilities and represents continuously computed position on the scope.

information, which is transferred to the magnetic storage drum of the airborne computer. In flight these data provide the primary input to certain automatic navigational functions of the system.

Such advanced operational navigation systems of today are the forerunner of more sophisticated concepts and devices that will be required for space navigation tomorrow. In any discussion of current and future guidance system components, we very soon reach the point where these systems will provide man with the capability of escaping from the earth's gravitational attraction, even if only briefly as in the X-15, and will carry him beyond what we know as winged or aerodynamic flight. ACIC is already providing cartographic support for the National Aeronautics and Space Administration

Figure 2. Typical small-scale chart display for semiautomatic guidance system.



(NASA) and McDonnell Aircraft Corporation on Project Mercury. Commonly referred to as the manned space flight project, Project Mercury is considered by NASA to be a first step along one avenue toward the ultimate achievement of interplanetary space flight, and the Mercury capsule vehicle a steppingstone to larger systems in the future.

cartography for orbital systems

To support some of the planned objectives of Project Mercury, ACIC has provided the following cartographic assistance to NASA:

- developed and produced the Mercury Orbit Chart (MOC), a small-scale Mercator chart upon which orbital information is overprinted
- recommended design changes for the 4½-inch globe in the earth path indicator
- developed and produced a 70-mm film-strip Mercury simulator graphic for the Air Bearing Orbital Attitude Simulator now in use at NASA Space Task Group, Langley Air Force Base, Virginia, for astronaut training
- produced a 1:500,000-scale Mercury Test Chart (MTC-1) for use in the ballistic trajectory test shots in which the Redstone rocket is used
- produced a 1:5,000,000-scale Mercury Test Chart (MTC-2) for use in the ballistic trajectory test shots in which the Atlas rocket is used.

In addition, specifications are complete and production has begun on a ten-sheet Mercury Recovery Chart series. These 1:5,000,000 Mercator charts will be used in the Recovery Operations Control Center at Cape Canaveral and by land, sea, and air forces charged with recovering the capsule and its contents in the event of a contingency recovery outside the planned impact areas.

We are also investigating other possible requirements in the areas of Mercury range and tracking station charts and advanced simulator graphics for use in training on advanced procedures and missions.

Mercury Orbit Chart. The Mercury Orbit Chart has been produced for use by NASA and by the astronaut, both for examining some of man's capabilities in a weightless environment and for use as a backup system to determine an impact position if the astronaut assumes manual control of the recovery procedures. Problems in the development of the chart fall into two major categories:

(1) Portrayal of both terrestrial and orbital information on a small-scale chart for viewing at an approximate distance of 25 inches. The chart scale of approximately 1:52,000,000 was dictated by the neces-

sity to portray the earth's circumference from 40 degrees North to 40 degrees South latitude on a standard Mercator projection within the 7-inch width of a chart holder. The holder has now been eliminated and the chart inserted along with note pages, check-off lists, etc., in a navigational aid book.

(2) Determination and selection of appropriate chart material and printing inks to meet the very rigid environmental factors which might be experienced by the capsule and its contents.

In conferences and discussions with representatives of NASA and McDonnell Aircraft Corporation and particularly with several of the astronauts, general design criteria were formulated for the chart. It was determined that terrain features could probably best be portrayed by the generally accepted technique of landform coloration based on major physiographic features and characteristics of the natural vegetation by geographic distribution. The three-color, process-color terrain presentation therefore gave a kind of bird's-eye view from high above the earth. As a result of opinions by the astronauts and others that shore-line indentations and island shapes and patterns may be valuable check-point aids at the 100-to-120-mile altitude, we have produced an exceedingly precise drainage and island portrayal for a chart of this scale. Its 15-degree graticule provides a satisfactory relationship to the rate of earth rotation and time. Criteria for selection of cities to be shown were derived from such general factors as visibility to the astronaut by day, appearance at night due to artificial illumination, or strategic location in sparsely populated areas. In developing the colors and detail of the base chart, we found that maximum legibility of the orbital information to be printed over the chart was of prime importance.

After the design problems in portraying base information had been resolved, the next task was to determine the best method of portraying all orbital and tracking data. This information was to include successive orbit tracks around the earth, elapsed time from launch along each orbit, retrorocket firing points, retrograde paths, re-entry and impact points, tracking station locations, recovery information, and telemetry and voice communication ranges of each station. Several methods for portraying anywhere from three to nineteen complete orbits were investigated, including the use of colored lines, various types of line symbols, and combinations of the two. Finally, in a more revolutionary approach, a line symbol was constructed of elongated type-style numerals which were placed in single file through their vertical axis to display the orbital track. Larger numerals were placed in boxes along the orbit track lines to present elapsed time from launch in hours and minutes at ten-minute intervals. The remaining portrayal of tracking station and recovery information, such as symbolization of the re-entry, impact points, and tracking stations, posed few problems. The result of our efforts to produce the initial chart for Project Mercury is shown in Fig. 3.

Figure 3. A portion of the Mercury Orbit Chart prepared by the Aeronautical Chart and Information Center for the National Aeronautics and Space Administration.

We encountered many problems in finding suitable materials to meet the stringent environmental conditions. According to McDonnell Aircraft Corporation specifications, the materials in the capsule were expected to meet such conditions as (1) no softness, brittleness, etc., at temperatures ranging between —15° and +200° Fahrenheit; (2) no toxicity or discoloration through this temperature range in a pure oxygen environment; (3) no effects from excessive vibration, shock, and acceleration forces; (4) no effects from relative humidities of 15 to 100 per cent.

This posed problems for us. A chart lithographed on regular chart paper would not be satisfactory, since the paper yellowed and ink colors changed appreciably under a 200°-temperature in pure oxygen atmosphere. The best solution from a standpoint of economy, weight, and processing was determined to be the laminating of a standard lithographed chart between two thin sheets (0.001 inch) of Mylar plastic. After lamination the chart met all environmental tests. To provide a nonglare surface upon which notations could be penciled, the surface was lightly abraded with a fine rouge pumice.

We have continued development of certain aspects of this chart. For instance, after the Mylar surface was rubbed the blue color used for shore lines and rivers became difficult to read. Black has been used on later editions to improve legibility. The elapsed time was placed in a box at regular intervals, and time ticks were marked for each minute along the orbit tracks. As the Mercury mission varies in the future or as the duration of the flights becomes greater, the chart will be changed accordingly. As changes occur, the chart or the means by which it is carried in the capsule may vary from that described here, but the importance of refined cartographic information will remain.

Earth Path Indicator. Cartography is also important to another piece of capsule equipment. This is an orientation instrument called the earth path indicator, which utilizes a 4½-inch globe rotated by a clock-drive mechanism. When the correct rate of rotation and orbit angle to the equator are set in by the astronaut, the indicator will continually present the general location of his capsule over the earth's surface. The final version of the small globe of the earth path indicator will use the same design and portrayal features as the orbital chart.

Mercury Simulator Graphic. Another product for the manned space flight project is the Mercury simulator graphic which we have produced for the Air Bearing Orbital Attitude Simulator Trainer at Langley AFB. This simulator is used to train the astronaut in such factors as manual control of the capsule and navigation and, indirectly, in scientific observation and reporting. The astronaut maintains his attitude and orients the capsule along three axes by reference to an image of the earth below as it would be seen through

Morning sun

Full moon

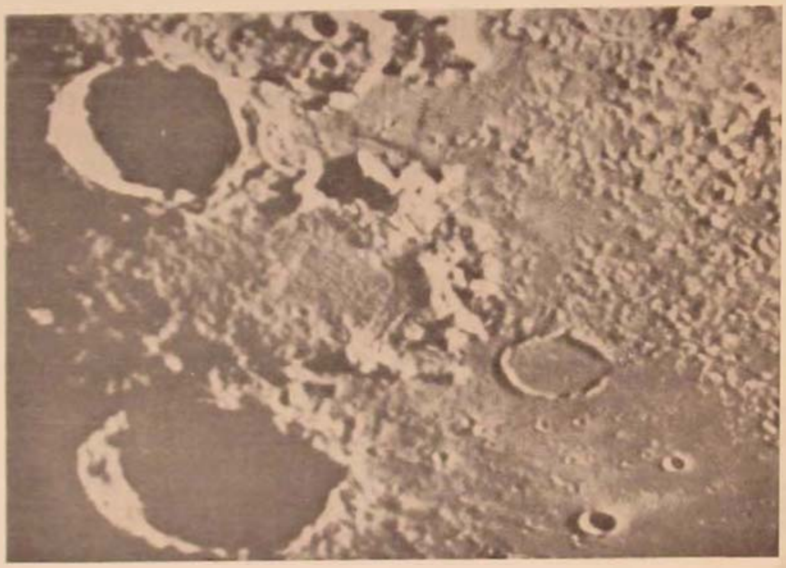
Figure 4. Lunar photography from U.S. Air Force Lunar Atlas. Each of 44 divisions of the visible lunar surface is covered by a set of at least four photographs under different illumination: one morning view and one evening view under moderately

the capsule periscope. At present the earth image produced by the simulator is rear-projected on a ten-foot screen. In front of the screen the image passes through a large fish-eye lens mounted below the astronaut's feet and then through a system of optics which finally presents the periscopelike image. Cartographic input to this space trainer is a continuous 70-mm color film strip which simulates the appearance of the earth from an altitude of 120 miles for slightly more than three successive orbits around the earth. The strip portrays a path approximately 820 miles on either side of the orbit.

In producing this graphic we established each orbit as the center line of an oblique Mercator projection. Land areas were then positioned appropriately, and a join was made at the intersection of each orbit. Only major relief features, major rivers, and large lakes are shown. It may be noted that the original criteria, which called for portraying exactly what the astronaut will see in terms of detail and color, were somewhat difficult to establish in advance.

Evening sun

Low-oblique illumination



high sun, a full moon view with high sun, and a supplementary view generally with low - oblique illumination. The different angles of the sun's rays cause some surface features to become clearer, others at the same time becoming indistinguishable.

lunar cartography

While we look forward to the scientific knowledges that Project Mercury will yield, we fully realize that this venture will only be a first small step into space. In the near future our interests will be increasingly concerned with the earth's natural satellite. In preparation for this eventuality the Air Force initiated several years ago a number of study projects related to selenography and observatory photography of the moon.

USAF Lunar Atlas. The recently issued USAF Lunar Atlas is now being distributed to interested United States Government agencies. This atlas contains the most complete lunar photography published to date, at a scale of approximately 1:1,370,000. Its purpose is to provide the best available photographic coverage of the moon as a basic contribution to the national space effort. Plans for its preparation were initiated in the fall of 1957 by the Air Force Cambridge Research Center (AFCRC).

Dr. G. P. Kuiper, noted astronomer and director of the Lunar Planetary Laboratory, University of Arizona, undertook the task of supervising the work. After evaluating 1200 lunar photographs taken at Mount Wilson, Lick, McDonald, and Yerkes Observatories in this country and the Pic du Midi Observatory in France, Dr. Kuiper selected 280 of the best photographs for publication. These selections cover the visible surface of the moon, which he has divided into 44 fields, with each field covered by a minimum of four photographs taken under different illuminations (Fig. 4). Figure 5 is a page from the Lunar Atlas representing Pic du Midi photography. Thirty-five supplementary sheets provide additional coverage of the 44 fields. There is also a brief text on lunar physical characteristics and motions, as well as tables and identification keys to enable selection of appropriate photographs or identification of individual features by name. Several supplements are being considered, including a lunar orthographic map grid and projection system overprinted on the atlas plates, "rectified" photographs of the limb areas, high-quality photographs of selected areas at double the Lunar Atlas scale, replacement of lesser-quality sheets in the atlas, and a detailed lunar nomenclature.

Distribution of the Lunar Atlas for U.S. Government use is being accomplished by Aeronautical Chart and Information Center. An atlas containing substantially the same information is being provided for nongovernment use on a nonprofit basis through the University of Chicago Press.

ACIC Lunar Charts. To evaluate and determine the kinds of cartographic materials that could feasibly be made from basic lunar

Figure 5. Hipparchus region illustrates the great variety of crater formations.

Figure 6. Section (enlarged) from a lunar reference mosaic to the scale of 1:5,000,000.

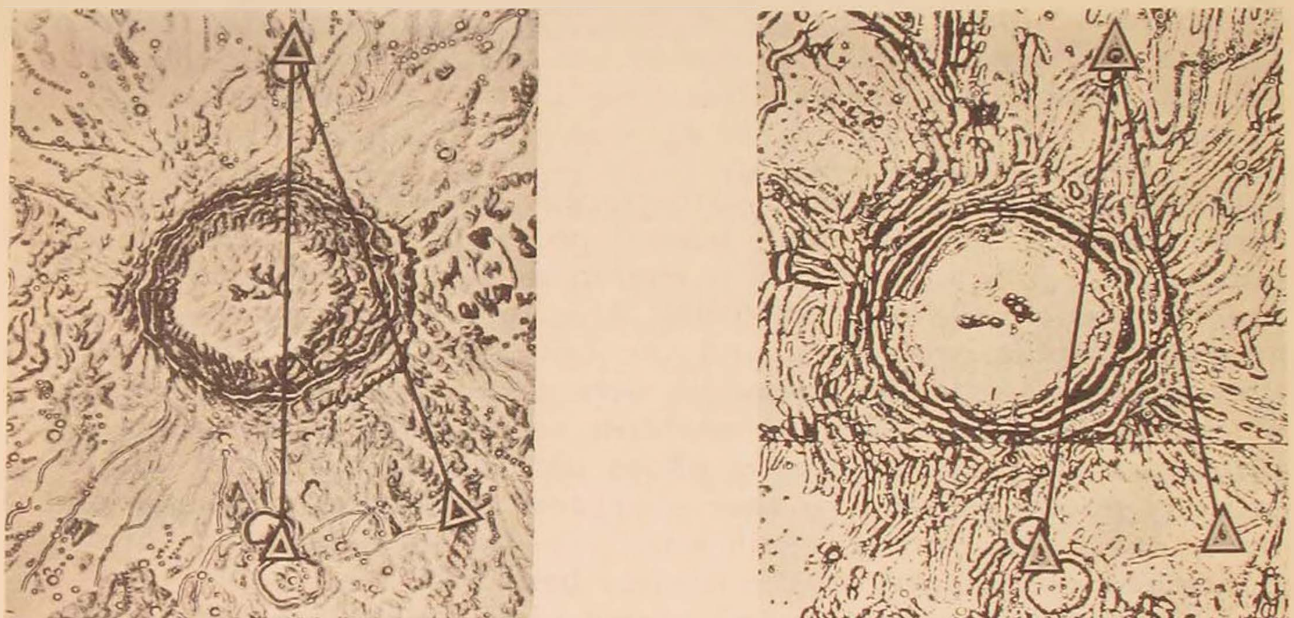
data, using today's advanced cartographic techniques as applied to earth charting, ACIC has made several prototype lunar charts or mosaics. Figure 6 is a blowup of a section of a lunar reference mosaic produced at a scale of 1:5,000,000. This mosaic was constructed on an orthographic projection, and the best photography available at the time was used. Measurements were taken from the intersection of the orthographic lines to establish additional control points. A full moon shot was used as a photo identifiable base, and supplementary photos selected for their sharpness of features were mounted upon the base. Partial rectification of the supplementary photos positioned the imagery to the control base.

Figure 7 shows an enlarged section of the USAF Lunar Reference Chart, also scaled at 1:5,000,000 on an orthographic projection. Outline type features have been rendered by the cartographic artists in generalized shaded relief, relative elevations, and gross surface color

Figure 7. Section (enlarged) of the USAF Lunar Reference Chart, orthographic projection, scale 1:5,000,000. The original chart is in color.

variations. Feature alignment and relief were developed by careful analysis of lunar photography. A color background plate based on analysis of full moon photography was made by airbrush technique to depict the relatively light areas and systems of crater rays. Craters are shown against the background by means of conventional shaded relief techniques, assuming a single light source. Both the 1:5,000,000-scale chart and the mosaic are prototype models and have not been produced in quantity for distribution. A refined 1:10,000,000-scale mosaic on an orthographic projection has been produced for general lunar feature orientation and planning operations.

Figure 8 depicts examples of the detailed, hand-sketched lunar charts available up to this time. The highly regarded Schmidt's work



Fauth Schmidt

Figure 8. Drawings of the region of the Copernicus crater by Fauth and Schmidt represent lunar control available for reference until recent times. Sketched free-hand from telescopic observation, their fault is in inaccurate horizontal control, in distorted feature positioning, and in the sparse recording of relative elevations.

was completed in the latter part of the last century. Fauth was a German astronomer and excellent draftsman, who labored long hours at the telescope. Lunar materials of this kind are still referred to by astronomers in the conduct of their lunar observations. By way of comparison, Fig. 9 contains the same Copernicus region as shown on an ACIC prototype lunar chart at 1:1,000,000 scale. Of course our portrayal techniques for lunar surface characteristics have the advantage of being based on photo coverage of the area, while Schmidt and Fauth drafted their maps as they observed the moon's surface through telescopes.

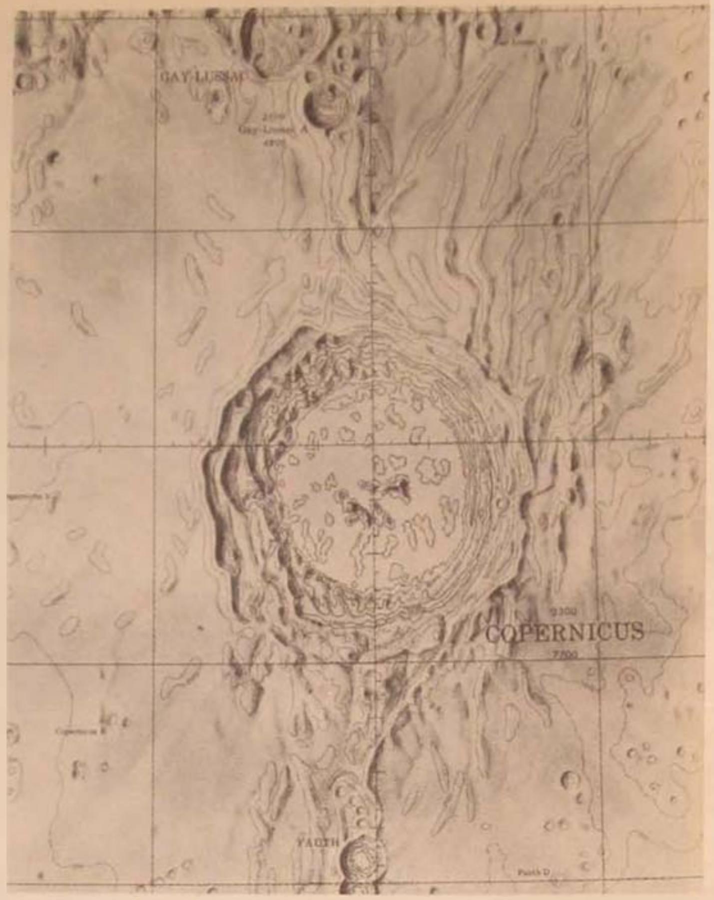


Figure 9. The same crater Copernicus region sketched by Fauth and Schmidt as shown on ACIC prototype lunar chart.

In our lunar prototype effort, surface features are rendered by a combination of shaded relief, contours, and tones representing surface color variations. While the shaded relief is considered representative of the actual lunar terrain, the contours are form-lines with arbitrary values assigned to demonstrate contouring. The chart was constructed by adjusting photo detail to control at 1:1,000,000 scale. A background plate was made, as for the Lunar Reference Chart, to develop the relatively light areas and systems of crater rays. Conventional shaded relief techniques were employed. Rim heights and crater depths are expressed in feet, printed above and below the crater name. Elevations are relative to the level terrain surrounding each crater. Reference documents for these elevations were Baldwin's *The Face of the Moon* and Wilkins and Moore's *The Moon*. Chart detail was positioned by basic control measurements established by J. Franz and S. A. Saunder and published under the auspices of the International Astronomical Union in 1953. The limits of this chart conform to a sheet layout system we have made for the entire lunar surface (Fig. 10). Present prototypes at 1:1,000,000 scale have the conventional 22″ × 29″ sheet size of USAF World Aeronautical Charts.

development of lunar materials

The next question is, how can these basic lunar materials and

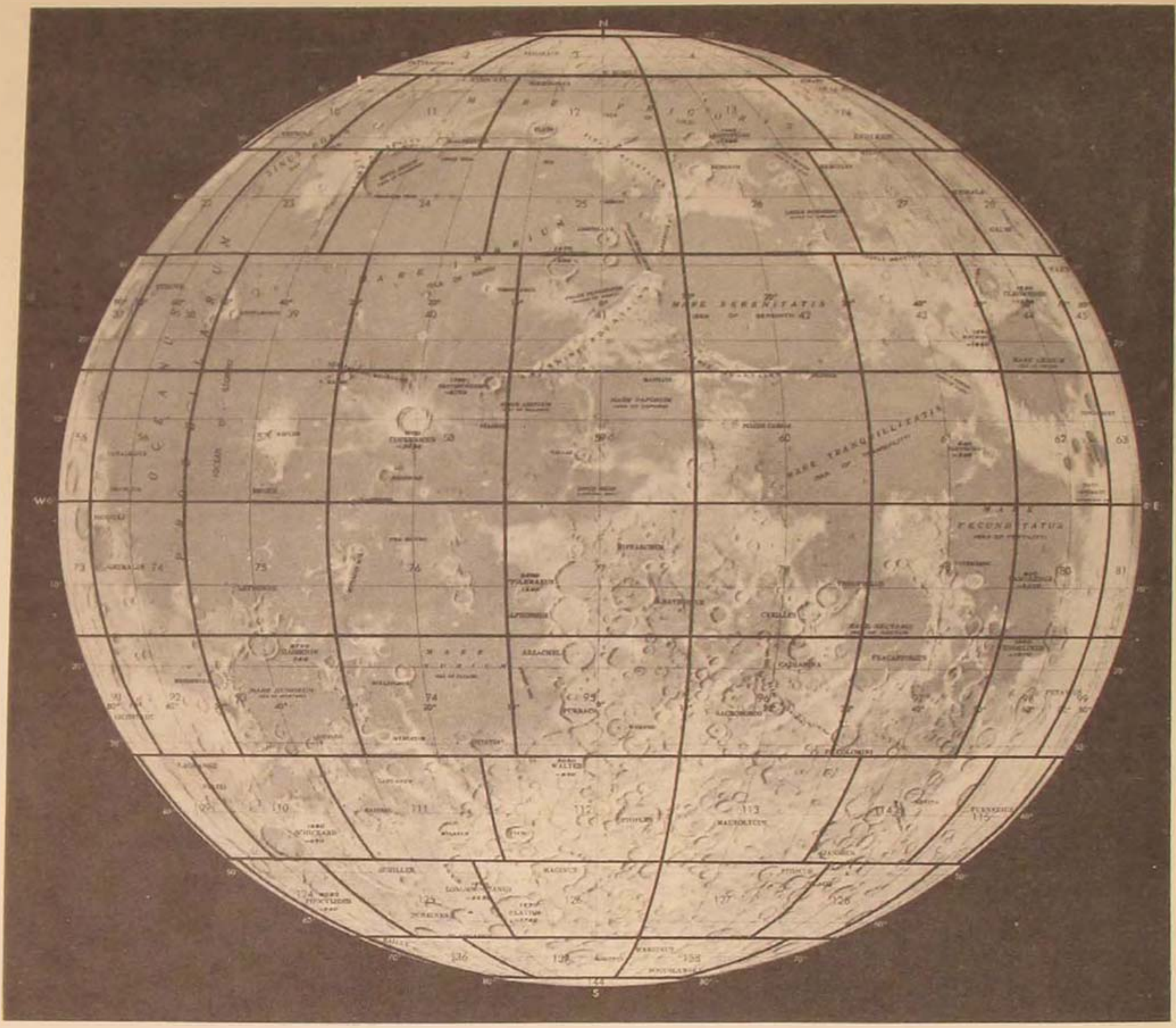


Figure 10. Coordinated layout plan for matching the 144 USAF lunar charts, by number, to cover the entire visible surface of the moon. Such a plan is similar to the manner in which the familiar World Aeronautical Chart Series is laid out.

cartographic prototypes be improved, both in regard to control and in regard to delineation of surface features?

The first and most important way is by improved selenodetic control. The precise determination of the horizontal position of specific points on the lunar surface and the absolute elevation of such points poses a real problem. Referring again to Fig. 8, we see that existing selenodetic control contains sizable positioning errors recognized by present-day astronomers as of a magnitude of two miles or more in horizontal dimension, and elevations that are not referenced to an established vertical datum. The astronomer who drew his maps at the telescope lacked the control normally used by cartographers, and his results, as exhibited by the Fauth and Schmidt lunar maps, show major differences in positioning of features when compared to control now available. Relative heights were indicated for only a small percentage of the prominences.

When we turn to the photography that is now available for the identification and measurement of selected positions, we find that it must be enlarged by a factor of 10 to 30 and that a great majority of it lacks geometric stability* and reasonable resolution of detail beyond the scale of 1:1,500,000. A normal assumption would be that basic position could be resolved through stereophotogrammetric methods. Unfortunately the 240,000-mile distance of the moon from the earth practically eliminates divergent angles. Only a slight parallax is apparent, even on photographs taken at the extremes of libration, or "wobble," of the moon as it orbits the earth. If photographs were taken at opposite sides of the earth's 8000-mile diameter, only an insignificant increase in parallax would result. Consequently stereophotogrammetric reduction is at best difficult.

Although existing source materials are somewhat deficient, they do provide background for lunar knowledges. To form the basis for our work at ACIC, we have assimilated a large quantity of maps, books, documents, reports, and studies and hundreds of lunar photographs in the form of glass plates or stable film negatives selected from the collections of the Lick, Pic du Midi, Mount Wilson, McDonald, Yerkes, and U.S. Naval Observatories. We have evaluated about 5000 horizontal positions and transformed them by electronic computer to selenographic latitude and longitude. We have added some 2000 relative relief determinations to library holdings.

ACIC is collaborating on devising basic techniques for the reduction and integration of various works completed or in process by selenographers of authority, both here and abroad. Several types of control reduction** have been devised to progressively refine existing data and eventually to extend these data. A spherical figure of the moon should be used in the reduction processes, although the moon is assumed by some to be a triaxial ellipsoid. This premise is justified by the fact that elongation of the longest axis is of a very small magnitude, whereas undulations of the surface are relatively large. Selections can be made from the 4500 points expanded by Franz and Saunder from the 8 heliometric-measured basic control points by Franz. All positions are contained in the control list approved by the International Astronomical Union. This control has been transformed by computer to selenographic latitude and longitude and then plotted by electronic plotter. Control can now be measured with precise comparators on lunar photographs and analytically reduced to refine it to a reasonable cartographic accuracy. A concurrent program of relative relief measurements over the visible disc of the moon is necessary to provide worthwhile information in respect to fluctuations of the lunar surface, and these measurements will introduce a significant refinement to basic horizontal and vertical control.

*A result of the fact that geometric relationships have not been maintained between lunar photographs of various sources. No precise method has been established to rectify these differences.

**Calculations to determine precise vertical and horizontal control points on the lunar surface from individual photography.

The Air Force Cambridge Research Center has sponsored the development of a shadow progression technique to obtain relative heights of lunar prominences in the central portions of the visible disc of the moon. This new technique has now been developed under the direction of Dr. Z. Kopal of the University of Manchester to the point that it can achieve relative height to accuracies of 100 to 200 feet. Several thousand photographs for such work are now available to ACIC, and additional photography required is being accomplished at the Pic du Midi Observatory through the University of Manchester. Precise recording microdensitometers are available to make progressive measurement of cast lunar shadows, and electronic computers can then reduce the data to relative heights. The University of Manchester has agreed to provide technical coordination and assistance. It is interesting to note as a result of this work that the moon's surface is not nearly so rough as it appears. Data from Dr. C. B. Watts' moon survey can be used to establish supplementary elevations in the marginal zone.

Height variation in the *maria*—darkish level areas of the moon, as first thought to be water, for example, "Mare" Vaporum on Fig. 7—must also be considered in order to complete the relief analysis. A possible solution is the Van Diggelin method of determining slopes and heights of ridges in the *maria* by measuring the deviations from the mean brightness distribution. Also star occultations

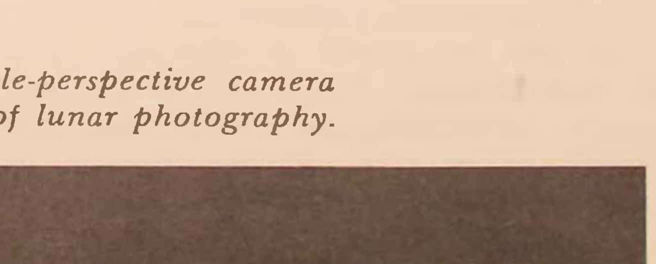
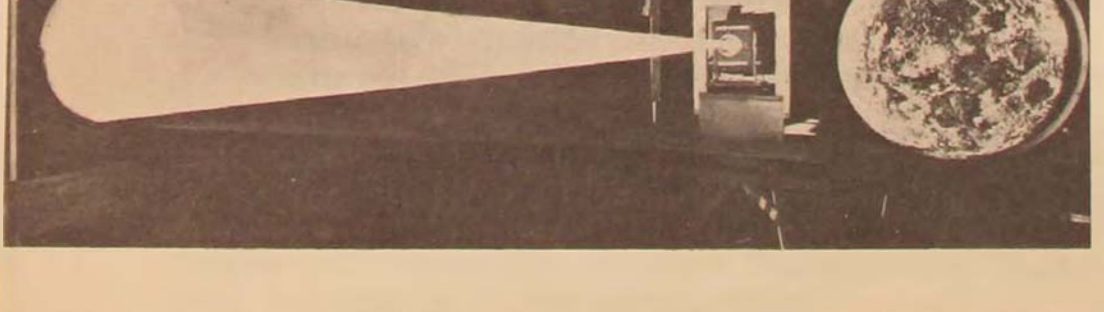


Figure 11. The variable-perspective camera for the "rectification" of lunar photography.



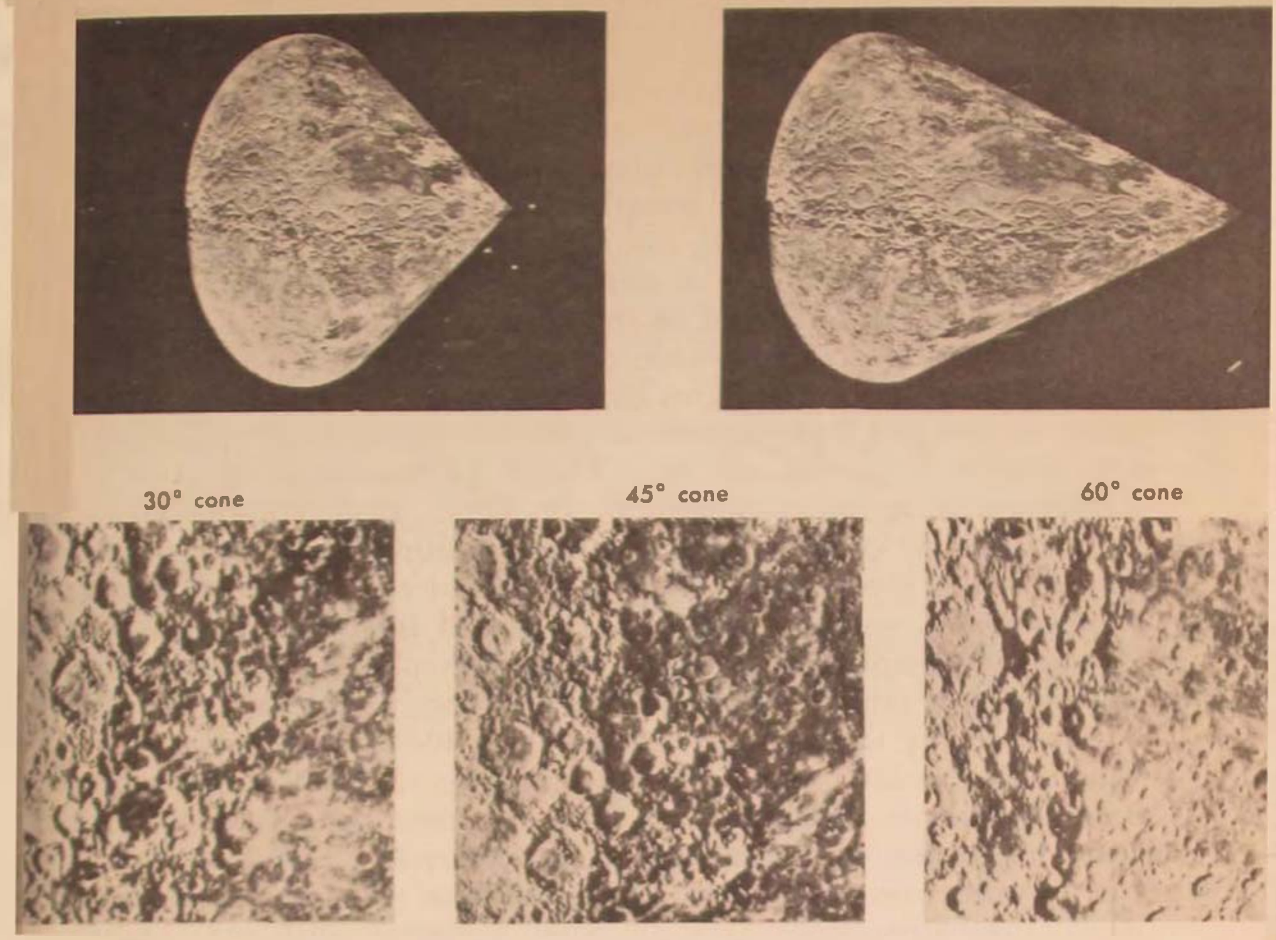


Figure 12. "Rectification" of lunar photography by use of the variable-perspective camera. Conical easels, such as those shown, support photosensitized paper to receive the image projected in the camera system. The resulting prints display in plane perspective the features originally photographed in spherical distortion.

against the *maria* in limb region would prove the degree of flatness.

The ACIC variable-perspective camera (Fig. 11) has been adapted for the rectification* of lunar photographs. The projector lenses are set at the focal plane of a curved mirror, resulting in a column of parallel light rays with a depth of focus that is theoretically infinite. Hemispheres, cones, or cylinders of various dimensions (Fig. 12) may be inserted in the path of the parallel rays and semirectified photo imagery abstracted at desired vantage points up to a perpendicular to the optical axis of the system. Photosensitized paper is placed directly on easels of simple curvature, and rephotographing is accomplished on easels of double curvature. Additional rectifica-

*Methods used to transform lunar surface features in photography to their true shape.

tion can be accomplished through the use of normal rectification equipment to fit plotted lunar control.

The first ACIC prototype lunar charts and mosaics at 1:1,000,000 and 1:5,000,000 scale were completed during the fall of 1959. The Air Staff and the National Aeronautics and Space Administration were briefed on the results of our lunar work during February 1960. With the experience gained in the basic design and development of the Copernicus 1:1,000,000-scale prototype, shown in Fig. 9, as well as the state of the art in terms of our basic lunar data-collection program, we are now in a position to produce selenographic materials of substantially improved accuracy. Figure 13 is a lunar chart of the Kepler crater region, produced in December 1960. For this chart a vertical datum* of 2.6 km below a lunar radius of 1738 km has been established. Three-hundred-meter contours are used, with 150-meter supplementary contours shown by a dashed line. The Kepler chart represents a combination of our best lunar photography, elevations determined through the shadow progression technique, and visual observations by the compiler employing a 40-inch reflector telescope. Visual observations were employed to add and clarify lunar surface detail, primarily small craters, rilles, pressure ridges, valleys, domes, and configurations of the larger crater floors.

We are continuing our 1:1,000,000-scale program, as organized in the sheet line layout (Fig. 10), working closely with NASA and the Air Force on priority areas. While there are other lunar charting interests in the Federal Government, no other charts have been produced to date containing selenodetic control comparable to that of our charts.

cartography for space navigation

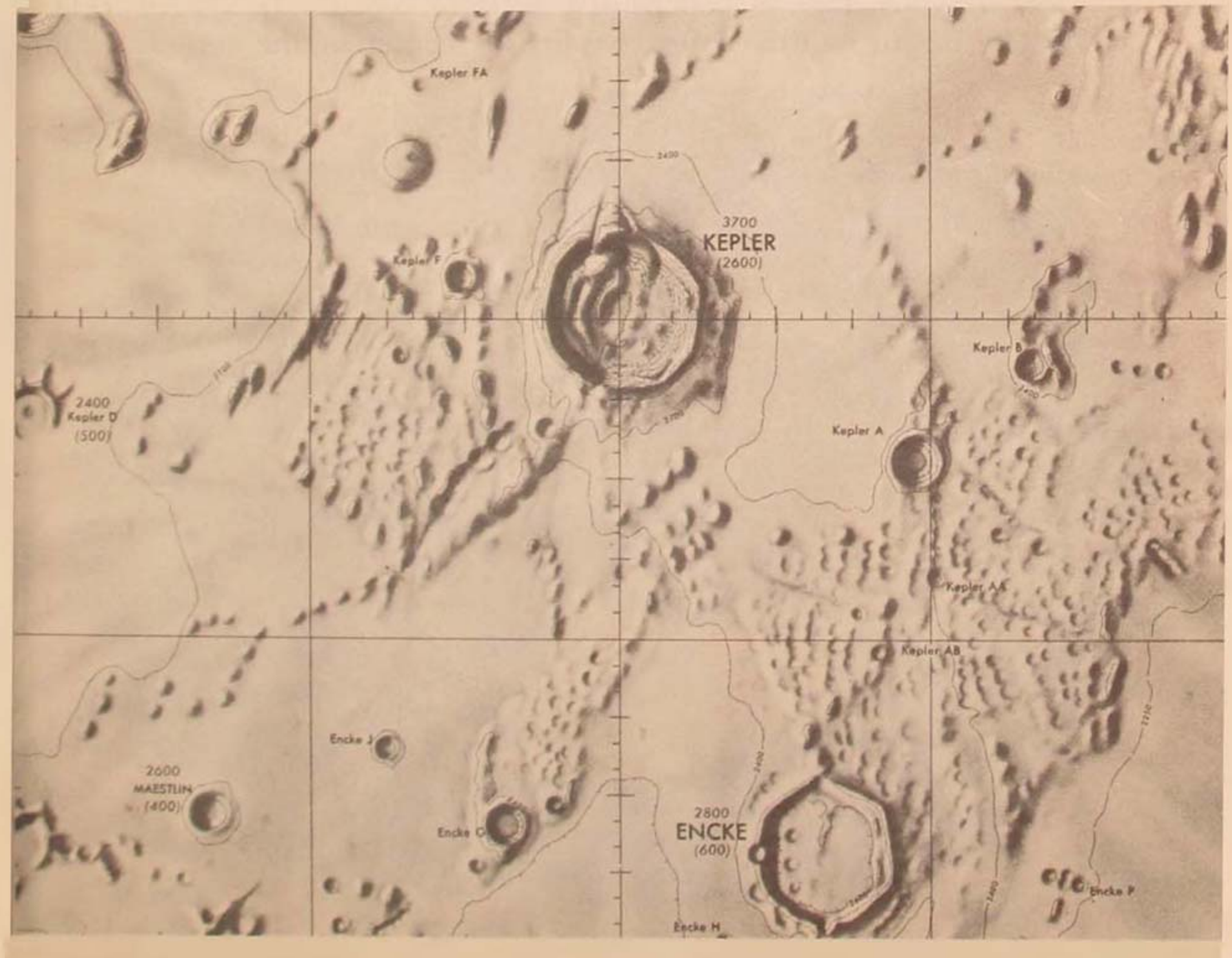
With the advent of the aerospace age, the basic support mission of the ACIC to provide the U.S. Air Force with navigational materials and geodetic data now demands thought for the future cartographic necessities of space navigation. An important requirement which we foresee is for space referencing systems suitable for initial, mid-course, and terminal navigation and also compatible with the nature of the mission.

From past experience and basic knowledge we all recognize that a fundamental difference between navigation in space and navigation on the surface of the earth is that space navigation is a three-dimensional problem whereas earth-bound navigation is basically two-dimensional. In space the third dimension is equally important with the other two dimensions, and there is no provision by nature to distinguish any one of the three dimensions from the others.

Other factors that will bear on the navigational problem in

*A reference or starting point from which elevations can be resolved.

Figure 13. Chart of the Kepler crater region, produced in December 1960, represents today's improved state of the art and the greater accuracy gained from prototype development. Below is an enlargement of the central section of the same sheet. The Kepler chart combines the best lunar photography, advanced measuring techniques, and visual observation by the compiler with a 40-inch reflector telescope.



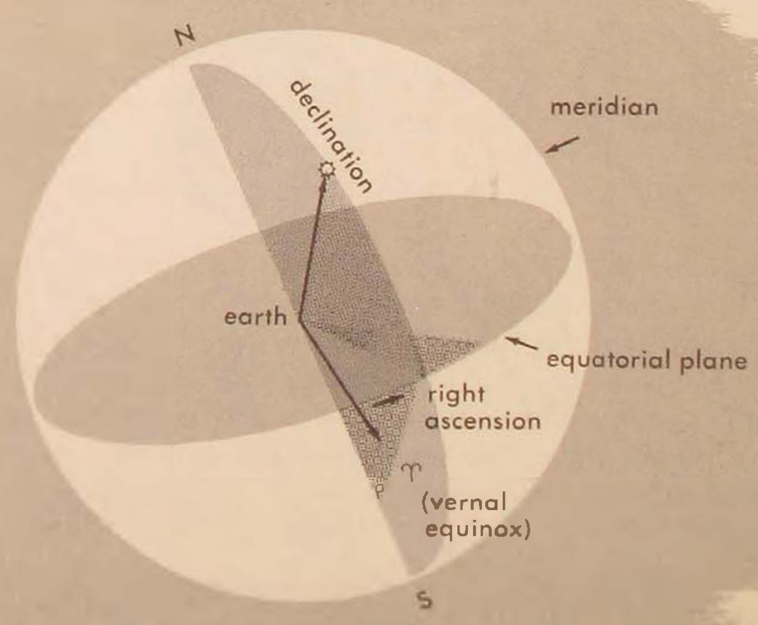
space are (1) ability to precisely measure angular relationships, (2) adoption of a standard unit for distance measurements, and (3) the possibility of a need for a different unit of measurement for time.

As an initial effort we are engaged in a review of the characteristics of several systems that could conceivably meet the needs of space referencing. One of these systems is the geocentric equatorial coordinate system. The origin of this geocentric coordinate system (Fig. 14) lies in the center of the earth, the equatorial plane serving as a reference plane. The position of the body is measured by two angles, one called right ascension, measured eastward from the vernal equinox, ♈, and the other called declination, measured from the equator toward either the North Pole or the South Pole. North Pole and South Pole symbolize the extension of the earth's axis to the point of intersection with the celestial sphere.

With the sun as the center of attraction, an alternative geocentric system used is the geocentric ecliptic coordinate system (Fig. 15), based on the earth's ecliptic plane as a reference plane. One must distinguish between geocentric ecliptic and geocentric equatorial coordinates. The geocentric ecliptic coordinates are called longitude and latitude, like the heliocentric coordinates. The point from which longitude is counted (in the eastward direction) is always the vernal equinox. The latitude is measured from the ecliptic plane along a meridian toward either the north of (above) the ecliptic plane or the south of (below) the ecliptic plane. Above is counted positive, below is counted negative.

Lastly, we have a heliocentric ecliptic coordinate system (Fig. 16). The origin of this system lies in the center of the sun, and the

Figure 14. Plan of the geocentric equatorial coordinate system.



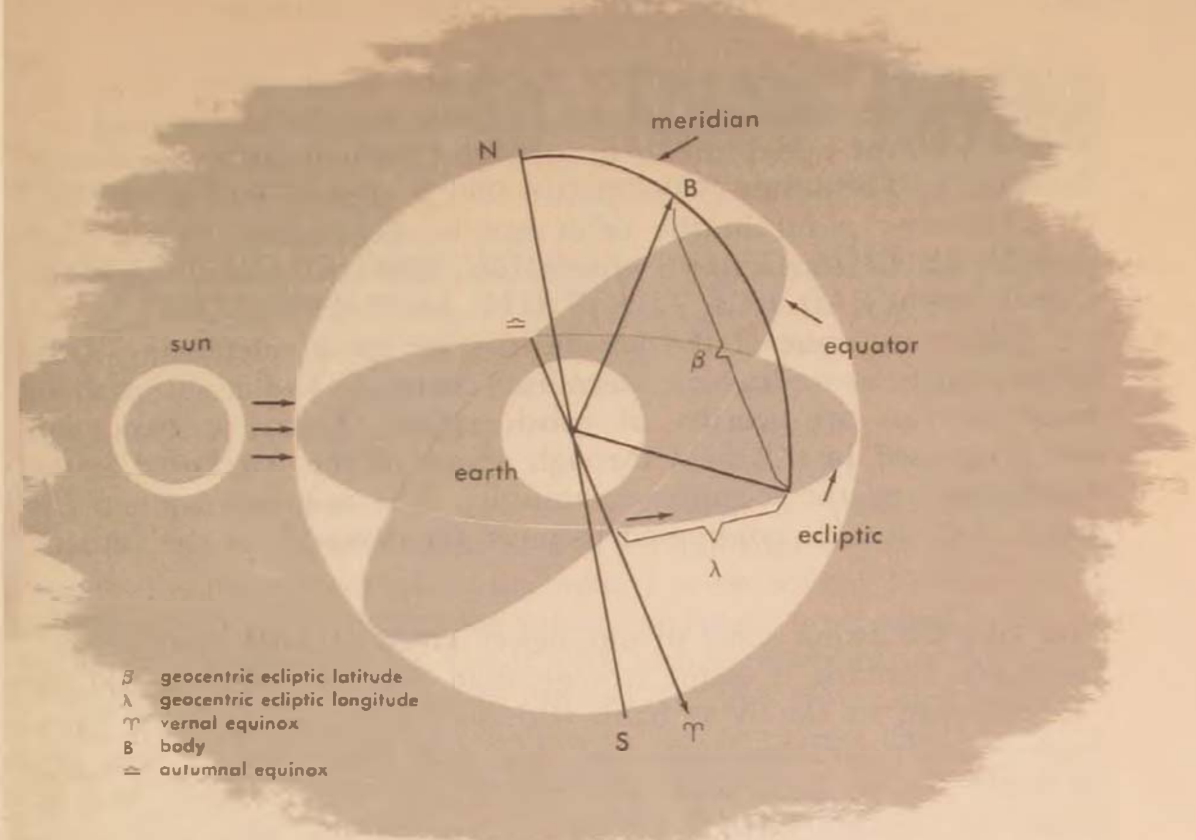
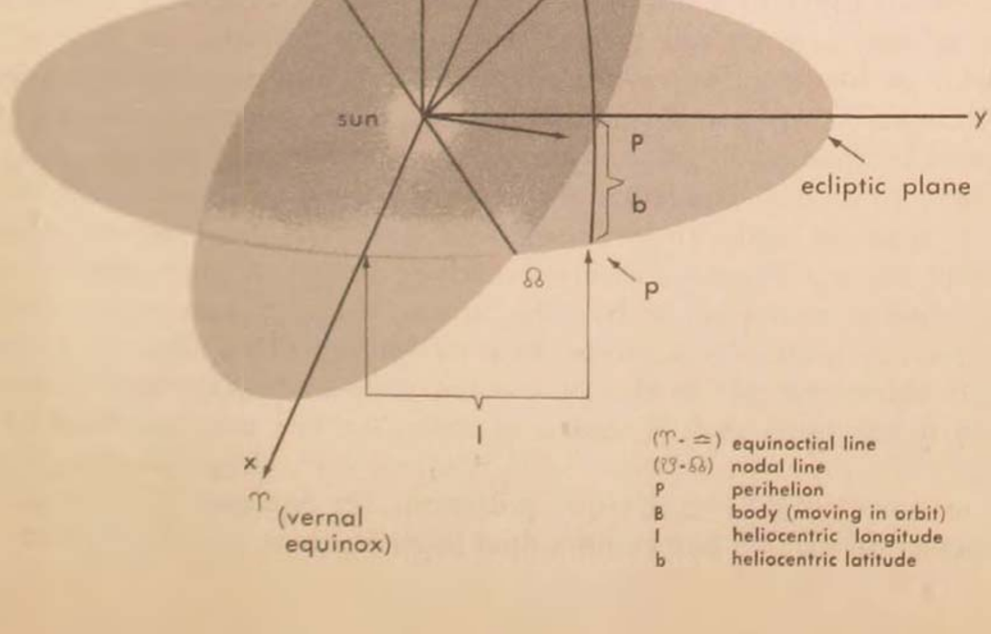


Figure 15. Plan of the geocentric ecliptic coordinate system.

Figure 16. Plan of the heliocentric ecliptic coordinate system.



ecliptic plane, i.e., the plane of the earth's orbit, serves as the referencing plane. Indicated in the diagram are the equinoctial line, ♈ to ♎, and the nodal line, ☋ to ☊, both of which must pass through the sun, *S*. The letter *P* designates the perihelion and *B* the body in orbit. Any point in the orbit can be determined by the polar coordinates in the ecliptic system, i.e., the heliocentric longitude, *l*, and latitude, *b*.

These are some of the possibilities for space referencing. Other systems such as topocentric, terminal centered, and flight path oriented systems are worthy of consideration. Extensive basic work has progressed in this field through efforts of the Air Force Systems Command and the scientific community. The task represents a challenge that must be conquered to meet the demands of the future.

For this discussion some of our newer kinds of work have been introduced. Perhaps it seems strange that the Air Force should now be concerned so closely at hand with such a science as lunar cartography. Experience has indicated that ACIC must have a firm grasp of what can be done with whatever exists. We are then best prepared to provide quickly whatever cartographic data are needed. All our developments in technique and cartographic products represent an Air Force capability in an area of great significance to the national space effort.

As space technology advances and permits more complete fulfillment of the use of space vehicles, the requirements placed on aerospace cartography will become more complex and more demanding. Only through close collaboration with the scientific fields involved can cartography fulfill its role in aerospace.

Aeronautical Chart and Information Center, USAF

QUALITATIVE EDUCATIONAL REQUIREMENTS FOR PROFESSIONAL MILITARY EDUCATION

Colonel William H. Bowers

THE military profession has often been defined as the "profession of arms" or the "management of violence." I have no quarrel with these or similar terms used to describe the role of the military in our society. The more basic question appears to be whether the military profession is perceived by society as a unique occupational group, or if it has blended into other professions to the degree that it can no longer be distinguished as a professional entity.

An approach to answering this question for the present time period lies in a critical analysis of the current functions performed by military personnel and the kinds of competencies required to carry out these functions effectively. For the future we will need to analyze emerging trends in the state of the arts and sciences behind warfare. From such study we can then extrapolate the kinds of educational experiences military personnel will require today in order to be competent in their duties tomorrow. These extrapolations can become the basis for determining long-range qualitative educational requirements. Although our predictions may never achieve complete validity, they should reach a level of confidence which will provide a sound basis for continuing revisions, thus improving our accuracy as we proceed.

One may approach the problem of long-range educational requirements by briefly reviewing the significant trends in education which may be relevant:

1. Formal education is now being viewed as the means for providing the basis for further learning through experience. In this context it can provide the foundation upon which sensitivity to experience is increased and the student is able to assimilate fundamentals within a coherent framework.

2. The kind of education that will best achieve this purpose may be concerned not with the current details of procedures, practices, and techniques but rather with matters of greater permanence and generality. Overspecialization at the expense of a comprehensive understanding of scientific or humanistic fundamentals can produce a less versatile individual. This is particularly significant in the performance of the higher-level direction required in developing, supporting, or operating technologically advanced systems. Specialized knowledges, when required, can be achieved on the job or through short courses if an individual's general level of academic education is adequate. Because of today's rapid changes, military leaders of the foreseeable future will be more adequate and adaptable to change if their education is on as broad a base as possible.

3. Education is reflecting the increasing importance of innovation to the continued growth and productivity of both military and civilian organizations

in modern society. By producing such things as highly integrated systems, automated factory processes, and automatic data processing, innovation has also greatly increased the need for professional and technical manpower. As the need for unskilled personnel both in industry and in the armed forces has decreased, a new dimension of leadership has evolved, requiring greater human understanding, a greater general knowledge of the arts and sciences, and the efficient management of technical personnel and resources.

4. "Pre-automation" decision-making based primarily upon subjective judgments and little precise empirical data is no longer entirely adequate. Needed information of acceptable reliability can now be promptly obtained through the use of computers so that timely measures can be taken to correct undesirable conditions. The transition from subjective decision-making to objective decision-making will require new competencies in utilizing precise mathematical and statistical techniques in exacting, logical analysis to reach decisions and plan operations.

5. All organizations of civilized society are recognizing problems of the increasing rate of obsolescence. Industrial concerns are faced with the problem of what equipment to discard and what equipment to keep and adapt to changing manufacturing processes. The military is experiencing rapid transition from old to new systems. Educational institutions are vitally concerned with the problem of curriculum obsolescence. Educational planners must engage in continuous development and revision of their curriculums to eliminate the obsolete and the least essential in order to incorporate changing concepts and the products of new research. There does not appear to be enough time to give intensive preparation both in theories and principles and in immediate ability in the transient and ever changing aspects of application to the job.

The foregoing trends are not all-inclusive, but they seem to be indicative of the course of future education. In this connection one may ask whether the study of these trends has forecast the need for an intellectual tradition of true military scholarship—an intensive study of military art and science. Heretofore the intellectual aspects of military affairs have largely been the province of university scholars. As some critics have said, the military heritage has continued to pattern itself upon the "touch-saddle" disciplines of the Indian fighter. Greater emphasis is placed upon operating a weapon than upon intellectual research and scholarship, even that closely related to the principles of national defense.

Historically the military intellectual who innovates new ideas has not always been accepted. He tends to disturb the orderliness of tactical planning and upsets the status quo. Our military establishment has produced few outstanding military scholars—and those few often achieved recognition outside the military before they did within their own service.

Current trends appear to indicate an overreliance upon the nonmilitary development of military technology and perhaps even strategic and tactical innovation. To avoid this professional dilution, we must develop an increased capability within the military itself for scholarship in the scientific, technological, humanistic, and social aspects involved in the development, support, and employment of future systems.

In addition to maintaining an awareness of trends in the aggregate of knowledge and in civilian education, the military educator must also remain cognizant of trends emerging in his own service, since any curriculum must be responsive to the changing military environment. For example, he must continuously examine new concepts derived from man's exploration of space and the products evolving from the research and development cycle; strategy and tactics and the changes that will result from the introduction of new systems during the 1961–1971 period; the military structure, or what we look like today and how we will look throughout the next decade; and the changing functions of the Air Force officer.

The Air Force Educational Requirements Board Secretariat at the Air University, Maxwell AFB, Alabama, has conducted a comprehensive inventory of Air Force officer functions and the education required for competency in these functions. This has been a major research effort of a board of senior Air Force officers charged with the identification and description of current and future qualitative educational requirements for Air Force officers. Results of the board's studies show that all officer specialties demand a significant amount of management ability. Also required is a high level of competency in technical functions peculiar to the specific nature of the position. In each instance the weight or the ratio of one requirement to the other depends upon the grade of the individual and the level of responsibility of the position. Of special significance, however, is the fact that these two types of requirements are common to all officer positions.

The competence to carry out management functions may be described as the ability to administer the resources incident to the position and to perform both general and technical managerial functions. Competence to carry out the technical functions can be described as the ability to handle effectively those aspects of the job which are unique to the position and which require specialized knowledge and experience, as set forth in the position standards.

Professional education programs of Air University, those conducted in resident military schools and those conducted in civilian universities, must all be designed to increase officer competence in technical and managerial functions needed today and those identified as long-range requirements.

Although somewhat oversimplified, these two broad areas of officer competency do provide a point of departure for identifying officer qualitative educational requirements. As we study these broad functions and identify their components, we gain insight into the kinds and levels of education needed in our programs. Also we are able to determine when and how our curriculums should be developed to provide instruction to students commensurate with their current and future positions, their experience and maturity, and their present proficiency in a given functional area. Most officer students have acquired varying degrees of technical and managerial proficiency in relation to their individual backgrounds. The military educator must determine the levels of proficiency common to the majority of students and provide curriculums beyond these levels to meet identified current and future position requirements.

THE MOST challenging problem to be considered is educational subject matter that is responsive to developing educational trends, the changing military posture, and the changing nature of Air Force officer positions.

Educational requirements inventories administered to large groups of the Air Force officer population have provided useful information concerning the kinds of education needed to meet effectively both general and specific position requirements. For the purpose of classification these educational needs may be grouped into five broad categories.

First, and probably of greatest importance as viewed by Air Force officers, is a need for skill in the communicative arts. This requirement is found in all officer positions regardless of rank, responsibility, or organizational level. Highlighted is the need for development of skills that will enable officers to acquire clear, logical, and concise communicative ability marked by language fluency and flexibility. A major effort from curriculum planners could translate this need into realistic educational experiences in both our university and military school programs.

The second need is to provide the officer with the fundamental knowledge necessary to isolate problems, analyze cause and effect, evaluate logically the relative values of alternative solutions, and make decisions based on objective determinations. In other words, curriculums should provide educational experiences involving the use of the scientific method of inquiry. Here should be included knowledge of the capabilities and applications of high-speed computers, simulators, and electronic devices for the storage and retrieval of information needed for decision-making and advance programing and planning.

The third need falls rather neatly into the traditional category labeled personnel management or human relations involving interrelationships between and among individuals within a given environment. It implies an understanding of the relevant fundamentals and points of view of psychology, sociology, anthropology, and economics. Here the curriculum orientation should enable the individual to apply his accrued knowledge so as to facilitate the organization of human resources for specific missions.

The fourth need is to provide a broad understanding of the scientific and engineering principles underlying the development, employment, and logistical characteristics of new systems. This understanding also should embrace the trends in science and technology which are indicative of future innovations of military interest. This does not imply that all educational programs must be heavily loaded with course work in the physical sciences or engineering. It does indicate that officer students should be afforded timely orientations or surveys of the state of the art in science and technology and an appreciation for the impact of technology on the over-all military mission. This need can be met through the use of well-conceived weapon and space orientation materials, lectures in our military schools relevant to research and development programs, and the increasing use of appropriate survey courses in our university programs.

The fifth need calls for more knowledgeable management of our military responsibilities by providing officers with a thorough understanding of the defense mission in all its political, economic, and psychosocial aspects in relation to world affairs. Such education should include the points of view from political science, international relations, physical and economic geography, and related social sciences and the humanities.

Our research to date, which has provided the rationale for the foregoing categories of educational need, is but a first step toward the identification and description of future education requirements and the reflection of these requirements in our educational programs. As our studies in depth are completed, these broad descriptions can be refined and delineated.

The following unsolicited comments placed upon one of our educational surveys by a young officer in the Air Defense Command give perspective to the preceding remarks:

> In regard to educational requirements for Air Force officers, the basic problem is not entirely what the officer needs for the specific job he holds, but also what sort of basic qualities we want him to possess. In my job as a radar intercept officer, I could do an average or even better than average job with very little education. However, if I had college courses in electronics, math, and physics I would have a much better understanding of the equipment in the aircraft and perhaps be a much better observer. It is obvious that in any job there is a tremendous difference in what it takes to get by and what is needed to be superior. In the emphasis which the Air Force places on education, I think the stress should be placed on what *kind* of people we want for officers. I know of radar observers who have only a high school diploma but are outstanding because of their character, natural ability, and aptitude for leadership. I know of other people with degrees (and I have one) who aren't exceptionally good, and I wonder if any amount of additional education would be effective. I feel that regardless of whether the job is of a technical nature or not, the Air Force needs the officer with a broad education, a command of the language, and the ability to command the respect of and lead people whether he be in the technical field or not.

These are serious remarks and worthy of examination by the military educator.

If we can be sure of anything it is change and the fact that our future Air Force officers will be the "managers" of this change. We will need the officer who is both a generalist and a specialist—a generalist in the profession of arms but a specialist in those aspects of the other professions related to his particular position assignment. Both these aspects must be mastered to a high degree of proficiency.

The fundamental knowledge to be gained through education should be included in the undergraduate programs for personnel brought into the service. It may be appropriately enriched through both professional military education and graduate university studies as officers grow in stature, maturity, and level of responsibility. This education will not in itself produce outstanding leaders. It will provide the basic knowledges and skills that can be used with confidence and applied with an expected degree of return.

It is the combination of knowledge and understanding acquired through educational and real-life experiences which ensures success, whereas alone neither is enough. The educational process is a continuous cycle of well-conceived fundamental education, based on sound requirements and application in the real world—on the job. The accomplishment of our defense mission demands the highest quality performance. The objective of professional military education must be to make a lasting and significant contribution to ensure the highest attainable levels of such performance.

Headquarters Air University

a military planner asks...

What Is Probability?

Colonel Francis X. Kane

Place: Headquarters United States Air Force.
Time: Today.

PLANNER: Gentlemen, may I begin by expressing my thanks for your gracious response to my call. You have all contributed to the understanding of the term "probability," and in military planning today, probability plays a very important role. In the planning of operations, for example, we frequently choose courses of action after evaluating the probability of events. We plan the development of weapon systems to function with a stated probability of reliability. The budget reflects decision based on probabilities.

While we use the term frequently, I'm not so sure that we all agree on what it means. It has specific meaning for scientists, especially physicists and mathematicians. Statisticians have their definition. We all recognize that planning has elements which resemble science. Planners make extensive use of mathematics, particularly statistics. But I'm concerned that as military planners we may be applying probability out of context, that we may be giving a false sense of authority to our deliberations, and that our decisions may be based on incorrect assumptions. Can you gentlemen shed some light on what probability means in military planning?

Laplace

Probability means exactly what I said in 1820. It is simply a fraction whose numerator is the number of favorable cases and whose denominator is the number of all cases possible.

Planner

Well, I've played enough poker and rolled the dice often enough to understand what that means. But where does your definition fit the type of complex, dynamic events which I have to forecast? I see how you can tell the odds for rolling a seven or the probability of drawing to an outside straight. Still, where does that fit into planning?

RICHARD VON MISES

You have gone from definition to application. In answer to your question of how to use probability, it has application in three areas: games of chance, such as you mention, life insurance, and theoretical physics. A probability calculus applies to mass phenomena and repetitive events in which the same thing occurs over and over again. But let me warn you against trying to apply probability to single events of the type which are at the heart of military planning. Then you are like the traveler who is given the valid but unhelpful information that the probability of his aircraft leaving on time is between 0.374 and 0.376.

CARNAP

Don't be disheartened at what Von Mises says. We have been over this ground before. He is confusing you because he looks at probability from a limited point of view. Really there are two kinds of probability. One concerns the degree of confirmation, and the other concerns relative frequency in the long run. Von Mises restricts his view to the latter, the frequency theory. He is talking about observations of facts.

The other kind of probability doesn't say anything about the facts. It concerns the relation between facts and the hypothesis which they are used to confirm. It is closely related to induction, which in its indirect sense is the same as the problem of the relation between an hypothesis and the confirming evidence.

PLANNER

Now just a minute. I got lost someplace there. We started talking about probability, and the first thing I knew we were discussing induction and hypothesis. What gives?

LAPLACE

It appears, my friend, that a lot has happened to the term since I first defined it mathematically. I'm sure you're interested in more than improving your crap shooting. Maybe we'd better get up to date here.

RICHARD VON MISES

You're right, Monsieur le Marquis. You have to look at more than probability itself if you want to understand it. As you can see, Carnap and I part company when he tries to bring induction into the argument.

Members of the Discussion

PLANNER . . . . . . Member of the Air Staff.

PIERRE SIMON, MARQUIS DE LAPLACE . . . . . . French astronomer and mathematician, 1749-1827. Discoverer of the invariability of the planetary mean motions. *Théorie Analytique des Probabilités* (1812); *Essai Philosophique sur les Probabilités* (1814).

RICHARD VON MISES . . . . . . Austrian authority on probability and exponent of positivism, 1883-1953. "Scientific assertions are nothing but predictions about future experiences." *Wahrscheinlichkeit, Statistik und Wahrheit* (1928); *Kleines Lehrbuch des Positivismus* (1939); *Notes on the Mathematical Theory of Probability* (1946).

RUDOLF P. CARNAP . . . . . . German-born American logician, philosopher, and semanticist, 1891——. Held that all philosophical problems are really syntactical problems. *Der Logische Aufbau der Welt* (1928); *Logische Syntax der Sprache* (1934); *Introduction to Semantics* (1942); *Formalization of Logic* (1943); *The Logical Foundations of Probability* (1950).

NORBERT WIENER . . . . . . American mathematician, 1894——. Creator of term and science of cybernetics. *Cybernetics* (1948); *The Human Use of Human Beings* (1950); *Non-Linear Problems in Random Theory* (1958).

JOHN VON NEUMANN . . . . . . Hungarian-born American mathematician, 1903-1957. Design authority on high-speed computers, expert on games of strategy, and chairman of the famous Air Force Strategic Missiles Evaluation Committee whose recommendation in 1954 spurred the Atlas ICBM program. *Theory of Games and Economic Behavior* (with Oskar Morgenstern, 1944); *The Computer and the Brain* (1955).

PHILLIP M. MORSE . . . . . . American research physicist, 1903——. One of the pioneers in improvement of operations of war by the application of scientific analysis. *Methods of Operations Research* (with George E. Kimball, 1950); *Methods of Theoretical Physics* (with H. Feshbach, 1953).

ERNEST A. NAGEL . . . . . . Czechoslovakian-born American mathematician and symbolic logician, 1901——. *An Introduction to Logic and Scientific Method* (with Morris R. Cohen, 1934); *Freedom and Reason* (1951).

AUGUSTUS DE MORGAN . . . . . . English mathematician and Aristotelian logician, 1806-1871. Author of memoirs (1850-1863) on the syllogism, developing a new logic of relations. *Essay on Probabilities* (1838); *Formal Logic* (1847).

LUDWIG EDLER VON MISES . . . . . . Austrian-born American economist, 1881——. Proponent of praxiology, the general theory of human action. "Thinking and action are inseparable." *Theorie des Geldes und der Umlaufsmittel* (1912); *Grundprobleme der Nationalökonomie* (1933); *Human Action, A Treatise on Economics* (1949).

JOHN MAYNARD KEYNES . . . . . . English economist and mathematician, 1883-1946.

Let's look at the operation more closely. We get a probability value from experience, from empirical sources—tossing a coin, for example. We use induction to obtain that value. But then it is going too far to say that we can use induction in the next step, which is to see the relationship between the value and an hypothesis. Carnap defies logic by using a principle to prove itself.

Believed in planning and regulating economic forces. *A Treatise on Probability* (1921); *The End of Laissez-Faire* (1926); *The General Theory of Employment, Interest, and Money* (1936).

HANS REICHENBACH . . . . . . German philosopher of science, 1891-1953. "The philosophy of science has taken over a function which philosophical systems could not perform." Constructed a new type of logic with three values: true, false, and indeterminate. *Wahrscheinlichkeitslehre* (1935); *Experience and Prediction* (1938); *Elements of Symbolic Logic* (1947); *The Theory of Probability* (1949).

GEORG SIMMEL . . . . . . German philosopher, sociologist, 1858-1918. Noted for analytical studies of the forms of social interaction. *Über Sociale Differenzierung* (1890); *Die Probleme der Geschichtsphilosophie* (1905); *Grundfragen der Soziologie* (1917).

KARL RAIMUND POPPER . . . . . . Austrian-born British philosopher of science, 1902-——. "Will philosophy ever get so far as to pose a genuine problem?" *Logik der Forschung* (1935); *The Open Society and Its Enemies* (1945).

SIR CHARLES FREDERICK GOODEVE . . . . . . British mathematician, 1904——. One of the early pioneers in operations analysis for the British war effort. *Operational Research* (1948).

MAX KARL ERNST LUDWIG PLANCK . . . . . . German theoretical physicist and developer of quantum theory, 1858-1947. "Causality is a heuristic principle." *Einführung in die Theoretische Physik* (5 vols., 1930-1937); *Der Kausalbegriff in der Physik* (1932).

HENRI LOUIS BERGSON . . . . . . French philosopher, 1859-1941. Creator of the philosophic theory of the *élan vital;* critic of the assumptions of mechanistic science. "Reality is a line in the drawing, not the line drawn." *Essai Sur les Données Immédiates de la Conscience* (1889); *L'Evolution Créatrice* (1907); *L'Energie Spirituelle* (1920); *Les Deux Sources de la Réligion et de la Morale* (1932).

MAX WEBER . . . . . . German sociologist and political economist, 1864-1920. The reality of all structural forms rests upon the chance occurrence of certain actions. Human studies are different in nature from science because of sympathetic understanding. *Die Protestantische Ethik und der Geist des Kapitalismus* (1904-1905); *Gesammelte Aufsätze zur Wissenschaftslehre* (1922).

NAPOLEON BONAPARTE . . . . . . Emperor of the French, le Petit Caporal, 1769-1821. Disperser of the French mob with a "whiff of grapeshot."

ALFRED NORTH WHITEHEAD . . . . . . British philosopher and mathematician, 1861-1947. Innovator in modern symbolic logic. *Principia Mathematica* (with B. Russell, 1910-1913); *Symbolism, Its Meaning and Effect* (1927); *Adventures of Ideas* (1933).

NORWOOD RUSSELL HANSON . . . . . . American philosopher of science, 1924——. Concerned with discovery of theories and the philosophical aspects of research. *Patterns of Discovery* (1958).

As I said before, probability has application in three areas: theoretical physics, games of chance, and life insurance. To use it, you need repetitive events and masses of data. But you cannot apply it to a singular event, and for my money military planning today deals primarily with unique events.

PLANNER

Not too fast. I see some ways in which I can use probability. It certainly seems to apply to the life expectancy of equipment, provided I can build up enough experience tables—on the life of engines, for example.

RICHARD VON MISES

You are right there, but don't try to predict that a given engine will fail at a given hour or that a certain missile out of a group will impact within the allowable circular probable error. Most important of all, don't think you can calculate the probability of winning a battle. You have no collective experience, and you certainly do not have an event which is repeated. A battle is a unique event in history.

PLANNER

Well now, you're not talking about probability. You're talking about my use of statistics, about my whole methodology of using mathematics and computers in planning. As you know, I construct mathematical models of future operations and from the computations arrive at my programs and plans.

WIENER

Don't let Von Mises discourage you. The use of computers is widespread and growing. Experience has already shown that they are very useful in constructing and manipulating mathematical models of future situations.

VON NEUMANN

That's right. Furthermore computers are ideal tools for handling large masses of data rapidly. As Morgenstern and I said some 20 years ago, large numbers gave us hope for a theory of games and for strategies resulting from that theory.

MORSE

I would like to interject a word of caution. We in Operations Analysis were most encouraged by your theory of games, and we welcomed Wiener's cybernetics. We're wondering now, however, if there isn't something in what Von Mises says. Mathematical models are fine for physics and for scientific investigations. But solving the problems of tactics and higher strategy goes beyond science and mathematics. We are the first to caution the military planner against using the results of ops analysis unless he makes further interpretation and evaluation from a broader point of view than models of future situations. This is true particularly when the empirical foundations are sketchy or when many assumptions have been made about the future.

PLANNER

Where does that leave me?

NAGEL

Perhaps we had best look at the entire story on probability. The term "probability" is used in five different contexts, and it has not two but three interpretations. The contexts are as follows: first, in everyday use; second, in the field of applied statistics and measurement; third, in physical and biological theories; fourth, in comparing theories with each other; and fifth, in the branch of mathematics known as the calculus of probability.

Then there are the three interpretations. First, the degree of certainty of a proposition—that is, its probability—is the degree of belief in which it is held. We can apply the calculus of probability to this interpretation if we assume that certainty has degrees, that all grades of knowledge can be quantitatively conceived, that degrees of strength of belief can be expressed algebraically. Second, probability is a directly intuitable relation between any two propositions. The relation is not analyzable, but it can have degrees. Third, the interpretation implicit in Aristotle is that the probability of a proposition or an event means the relative frequency of the event in an indefinite class of events.

DE MORGAN

Personally I hold to the first interpretation; but I must insist on two points concerning the frequency interpretation. The first is that probability is a property not of facts or events but of propositions. The meanings of the term and of the evidence for propositions belong to logic, not to physics. Thus when we talk of the probability of an event, we are speaking inaccurately of the probability of a proposition's stating the occurrence of that event. The second point is that probability is not the property of a single proposition but is a relation between propositions.

Ludwig von Mises

This discussion of definition has its value, but, gentlemen, I think we should face the question we have approached several times. How can the planner apply probability?

In my opinion, there are two entirely different instances of probability: we may call them class probability, which is a frequency probability, and case probability, which is the specific understanding of the sciences of human action. The field for the application of the former is the field of the natural sciences, entirely ruled by causality. The field for the application of the latter is the field of the sciences of human action, entirely ruled by teleology.

Class probability means that we know everything about the behavior of a whole class of events but that we know nothing about the singular events which are elements of the class. Case probability means that we know some of the factors which determine the outcome of a particular event but that we know nothing about other determining factors. Case probability is not open to any kind of numerical evaluation.

Keynes

You are right in emphasizing the importance of human action. After all, that is the realm of the planner. The importance of probability is that it is rational to be guided by it in acting.

Reichenbach

I agree, especially because we face uncertainty in everything we do. Therefore when we make decisions we posit the more probable event. This does not mean that we have certainty about a single event. It means only that the decision for the more probable case represents a more favorable action than the opposite decision.

Planner

I see from your discussion that I use probability just as Keynes and Reichenbach have described it. I choose what appears to be the more probable event as the basis for acting. But how do I know that it is the more probable event?

Richard von Mises has shown that I can use experience recorded statistically to calculate the probability of repetitive events. Here the method is analogous to tossing a coin or throwing the dice. Even then there are restrictions which come from the amount of experience I have recorded and the similarities between that experience and the circumstances I face. And I cannot use it to forecast that a unique event will take place.

SIMMEL

Let me take up a point about your methodology. There is more to be said in favor of using model situations in attempting to forecast the future. Experiments in sociology have demonstrated that we can establish models of various environments. We might term these typical models. By studying them we can gain insight into the behavior of the group and individuals in the group. This gives us some hope of forecasting.

PLANNER

I used this idea already in manipulating models of typical battle situations. The use of statistics, based on, say, the experience recorded in numerous missile launchings, appears to have validity in forecasting the course of the offensive part of the battle. Moreover by creating many models of the way the offensive may occur I can compare them and thus have a sounder basis for selecting the most probable course of the future. Finally, this process can be an aid in training commanders and decision makers.

POPPER

Let me add a thought which takes the discussion beyond the individual elements of a typical situation. Before we deduce predictions we need laws and initial conditions.

PLANNER

Well, I have doctrine, which could be considered a type of laws, and I have principles of war. These have been distilled from historical experience, but they don't have guaranteed application to conditions of modern war. Therefore I don't see how I can integrate the various models of limited, individual parts of the problem into a model of a total war.

Goodeve

You can do this if you assume that a calculus of war is possible. In fact the theory of games and the use of computers are based on this assumption.

Planner

Can anyone justify such an assumption?

Planck

I don't see how they can. Remember that there is an irrational element in every process of discovery.

Planner

If I apply this thought to my problem, I must assume that part of the battle situation lies beyond my methodology. Because no one has justified this assumption, I conclude that the sum of probabilities of individual selected parts of the problem does not give me a total probability value for a battle situation.

No doubt that is why everyone seems to agree that I cannot use probability to forecast future human action. What I can do is to state the most probable event and use it as the basis for decisions and action. Science and mathematics can aid me in determining the most probable event. Mathematical models of future situations can help me. For example, I can manipulate models of the air defense battle and conclude that the probability of intercepting the attacking forces is 90 per cent.

Obviously this does not mean that if the enemy repeated the attack 100 times we would intercept him 90 times and fail to intercept him 10 times. The attack will not be repeated. It could mean that of the 100 circumstances involved 90 are in our favor. Correction: it could mean this if we could assign equal weights to the circumstances; but we cannot. The most it can mean is that under the circumstances stated in the model of the situation we have a very high certainty of success. We can use this relative certainty in choosing the ways to operate our defensive forces.

Bergson

Let me present a different point of view. As you have said, you use science and mathematics, particularly statistical data, to determine the most probable event. This methodology has inherent shortcomings and may not give you what you want.

There are other roads to the real world, and there are other methods for gaining an insight into the future. Science must reduce its observations of phenomena to static data. But the world is not static; it is dynamic. You, as a military planner, are the first to appreciate the rate at which circumstances change. The best way to understand a dynamic environment is to live in it. Science at best is only an aid in confirming what you feel and know intuitively. The most probable event is not the one forecast by science. It is the one which you foresee as a result of your knowledge and experience in military affairs.

WEBER

There is another operation by which we attempt to explain human behavior. We understand the behavior of human beings by being able to share their state of mind. This ability is a special knowledge, distinct from the kind of perception gained through tests and statistics. Statistical knowledge without empathic knowledge is superficial and unintelligent.

PLANNER

How do I get this empathy? This knowledge of the state of mind of other human beings?

SIMMEL

That is the point of the model of the social situation. Statistics are only one part of the model. An understanding of the cultural influences, of the historical process which produced initial conditions, a total comprehension of the elements which bear on the situation—all are necessary for the empathy you need.

PLANNER

I assume that I can select personnel who have this ability and that I can train them to forecast the way an enemy will act in specific situations.

BERGSON

You will make a major advance in your methodology if you stress the need for an intuitive approach to the real world. In my intuition I propose a method for gaining empathy, including insight into the irrational elements in the situation.

Napoleon

This is exactly what I meant by the coup d'oeil of the commander.

Planner

From this observation I conclude that I can gain a sympathetic understanding of the experience which bears on the behavior of the enemy. From this understanding I can forecast what he will do in the future.

Whitehead

One element which you as the planner must always keep in mind is that you can never forecast when the man of genius will appear on the scene.

Hanson

Even the most creative genius cannot forecast the time of his creative discoveries, nor the way in which they will evolve.

Planner

These facts lead me to understand once again that all my forecasts are only probables. Therefore, gentlemen, I conclude from our discussion that, regardless of the scientific method I employ to arrive at a probability value, I must use that value as only one element of the total problem. Other values which I arrive at intuitively can be just as probable. The selection of a probability value—that is, the choice of the most probable event—is and must be a question of military judgment.

My thanks again to you, gentlemen.

Headquarters United States Air Force

In My Opinion...

WHO CARES ABOUT DOCTRINE

Major Robert J. Ulrich

Every air officer on active duty has been issued his personal copy of Air Force Manual 1-2, *United States Air Force Basic Doctrine*. Library shelves groan with added copies, and anyone who wants extras may have them for the asking.

But who on earth reads doctrine? Who even knows what it is? Who cares about doctrine?

It is currently quite fashionable to label One-Dash-Two as vague, to berate it as egg-headed, and to file it away with the obsolete office instructions. But it is also quite fashionable these days to argue at length about aerospace power and its applications. Everyone who has even visited an air base or flown by commercial air from New York to Chicago is automatically blossoming forth as an expert on the aerospace. Even children are talking glibly about apogees and perigees.

The fact of the matter is that too many people are doing too much talking and too little thinking about aerospace power. Everybody is interested in aerospace power, certainly, but only up to the point at which the element of doctrine creeps in. For those who have not taken the time and trouble to get their ammunition stacked, the fun goes out of prattle about aerospace power when doctrine is mentioned, because doctrine demands an end to volume verbiage and requires thinking. And thinking is hard work.

We who are intimately interested in the defense of the United States and the Free World through aerospace power ought to stop and take stock of our mental and philosophical position. Why do we, the men and women who daily work with the awesome force of aerospace power, deny the importance of aerospace doctrine? Why are we satisfied to let the British, the French, the Italians, and the Russians do all the thinking and writing on this hugely important subject? Why has only one book on doctrine been written by an American air officer since Billy Mitchell passed from the scene? Why don't our journals and magazines print authoritative articles on doctrine?

Why? Because nobody cares about doctrine. Nobody knows what it is, the claim goes. And so we seem satisfied to let our aerospace forces grow as Topsy grew, and we twist and turn and stop and start and fumble and fuss and wonder where we are heading. Each of us is satisfied to become acquainted with our very own little piece and bit of some vast weapon system, without bothering to think through where that piece and that bit fit into the big picture or where the aerospace power of the armed forces of the United States fits into the big picture. Everybody wants to be a nuts and bolts expert, and nobody gives a tinker's dam about what it all adds up to.

In the United States, ever since the Civil War, we have developed the slovenly habit of letting somebody else think about doctrine. Doctrine has become the sacred preserve of a certain intellectual few at the Pentagon and Air University, and, Q.E.D., nobody else has to bother with it. If enough retired colonels and generals sit about in their clubs writing marginalia on why Washington should not have crossed the Delaware or where Napoleon failed on the road to Moscow, this will be enough doctrine for us. The fact that the Soviets discuss military doctrine with a lively enthusiasm doesn't seem to faze us. The fact that our Allied-officer friends can talk rings around us when it comes to doctrine does not seem to dent our armor of ignorance. For, traditionally, the American fighting man has not been a theorizer; he is happy to be able to remember that a Mitchell or Trenchard or Douhet lived once upon a time and to let the whole matter drop at that.

Tradition, coupled with sheer mental laziness, takes a heavy toll from our doctrinal program. Air Force Headquarters and Air University try to get people interested, but it is like trying to get a healthy ten-year-old boy interested in girls. There's a lot to girls, but the ten-year-old just can't see it.

And then, of course, we find the common excuse that fast-changing weapon systems invalidate doctrine before it can even be set up in type and handed out to the troops. The argument wins converts, even though it stems from an abysmal ignorance of what doctrine is all about.

Perhaps at this point it might be well to discover just what doctrine is. Our Air Force Dictionary gives us definitions which are of immense value:

> **doctrine.** A rule, proposition, or teaching that has such official sanction or authority as to be used to guide and direct those who are bound by such sanction or authority . . .

This simply means that if the Air Force has rules, propositions, and teachings for the use of aerospace power, i.e., aerospace doctrine, we in the Air Force must know that doctrine in order to be guided and directed by it.

Again, from the Air Force Dictionary:

> **basic air doctrine.** Doctrine concerned with the nature of air power, and with what can be, and what cannot be, done with it.

This is the heart of AFM 1-2—the nature of aerospace power, its strengths and its limitations, and why and how the Nation and the Nation's leaders expect it to be used in the national defense.

Of particular interest to many of us is this final definition—

> **operational air doctrine.** Doctrine on how to use air power in particular operations.

Particular operations? Certainly. The One-Dash series beyond One-Dash-Two deals with theater air operations, air defense operations, strategic air operations, and other *specific* doctrine. The progression is from *basic* air doctrine to *specific* air doctrine, and the One-Dash series lays it all out for us, if we would only bother to read. The how's, the why's, the wherefore's, the who's, the when's, the what's are all there.

It seems amazing that we should be derelict in our study of this material, this fundamental material. It strikes one as odd that men and women professionally associated with aerospace power should not be vitally and continually interested in doctrine so that they not only can understand it but also can improve upon it.

In no other field of human activity do we disassociate ourselves from doctrine. In no other area of endeavor do we find doctrine appalling, mysterious, dry, out-of-date, and not worth thinking about. Every Sabbath millions upon millions of Americans, with the professional military included, refresh their understanding of religious doctrine by reciting creeds and articles of faith. They ponder the Scriptures and consider the Gospels and other holy works and search for the applications of this doctrine to their daily lives. In this regard they willingly accept doctrine, even dogma, and believe it to be foundational to their well-being.

A great political campaign has come to a close, but not before at least a hundred million Americans, with the professional military again included within those vast numbers, gave eye, ear, and tongue to the political doctrines of the contesting parties and their standard bearers. No apparent discomfort was suffered. Quite to the contrary, the public at large enjoyed and was motivated by the quadrennial examination of the Nation's purpose—the Nation's doctrine, if you please. One is even tempted to believe that here and there an earnest citizen reviewed the Constitution and the Declaration of Independence in order to remind himself of the form and substance of democratic doctrine—of the nature of democracy and of what can be, and what cannot be, done with it.

But military doctrine? Who cares about that stuff? We might better ask, Who should care about military doctrine, about aerospace doctrine?

The military should care about military doctrine, obviously, just as the lawyer has a care for the law and the psychoanalyst for Sigmund Freud. As a matter of professional pride the military should lead the way in the development and improvement of military doctrine. A man should have enough interest in his profession to understand the basis of that profession. And as a matter of practicality, the professional military should know the why's and the wherefore's of their work. The true professional ought never to be satisfied with knowing only the how's; for if he is so easily satisfied, others less able than he ought to be will take his profession away from him and make him a mere yes man, a lackey who never understands *why* he does what he is told to do, a hireling who is never asked for his opinion. In this mean position the professional abuses his splendid heritage and his sacred trust, for within our democracy the duty of the military is to advise the chiefs of government in military matters. No airman will be able to discharge this duty if he allows himself to be shorn of his capacity to think, if he loses his ability to present to the Nation and its leaders a sound doctrine for the use of the military force with which he is entrusted. The mental eunuch in the military will never be able to convince others of the requirement for a weapon system, or a complex of weapon systems, if he himself does not know and understand the rules, propositions, and teachings which give weapons orderliness, timeliness, and effectiveness.

Statesmen, of course, must understand the why's and the wherefore's of military force. Generally they cannot be expected to know the how's, but surely if they, within our concept of government, are to pass upon requests and grant the money which buys aerospace power (or any other kind of military power), they are entitled to know the why's and wherefore's. They are entitled to be assured that the military men who urge upon them fantastic expenditures are well grounded in doctrine—the why's and wherefore's of such expenditures. For without adequate doctrine, without intelligent interpretation of that doctrine, and without a constant search for its improvement the military can have no plan in mind. They can have no idea of the nature of aerospace power and what can and cannot be done with it. How, without operational doctrine, shall we know the proper use of aerospace power in particular operations? What shall we do, unless we have a plan in mind? How shall we arrive at that plan if we have not bothered to study the nature of the weapons the statesmen permit us to employ? How shall we convince the statesmen that we know what we are doing? They require answers of us constantly. They continually want to know the why's and the wherefore's. They inquire into the efficacy of our military establishment, and heaven help us if we do not know why we have what we have and what we plan to do with it. Neither we of the military nor the statesmen of government can firmly and surely seek out the answers to problems of defense and war unless the doctrinal foundation for our military superstructure is broad and deep.

The citizenry should understand doctrine, because it is always asked to pay the bills. It has a right, therefore, to examine all governmental policies and practices, not the least among which is the manner in which the Nation is being defended by the military. Because the citizenry is inclined to weary of sacrifice when the reasons for sacrifice are not clear, it may withhold the means for what it thinks of as untrammeled military experimentalism. Then when the indignant public calls a halt, the good goes down with the bad. The citizenry, of itself and through its representatives, expects the defense of the Nation to proceed apace without fanfare, waste, competition, or a worship of vested interests. It cares not a whit whether one of the services gains or loses. What it has a right to expect is a national military doctrine, a doctrine which places the nature of all military power in focus and explains what can and cannot be done with it in the national interest.

A national military doctrine, it is suggested, can never come into being until the several services examine their own weapon systems objectively, understand their nature, know what can and what cannot be done with them, and then willingly mesh and meld these weapon systems into a magnificent whole. Only when this much is done will we succeed in overcoming the deficiency of military doctrine which today plagues the defense of the United States.

WITHIN this context, and in the confused doctrinal climate of our times, the professional military must lead the way to clarity and understanding—for itself, for the men who govern, and for the people who are to be defended.

Military doctrine, after all, is the province of the military! That the professional ought to understand and develop doctrine for his own service—as a contribution to a national military doctrine—would seem to be the plainest sort of common sense.

Each man in the Air Force can play his part by understanding that doctrine of the USAF which has already been published. With such understanding he can seek to apply it to his personal station in the Force. But to do so, he will have to put aside his prejudices, overcome his reluctance to think, open up those blue manuals in the One-Dash series, and get down to work.

The thought occurs that we all had better get down to work, thinking about the nature of aerospace power and what it can and cannot do. For if we of the military do not care enough to think in these directions, who in our Nation will?

To be sure, doctrine alone will not give us the strength we need to continue the quasi peace that now prevails. Doctrine alone cannot answer all questions for all men for all time. But if we would be honest enough and earnest enough and thinking enough to give doctrine its due as a rule and guide for sensible thought and action, we might find new and exciting and challenging worlds opening up to us. And with that advent, no one would need to ask, "Who cares about doctrine?"

Command and Staff College

Military Opinion Abroad . . .

THE SOVIET COMMANDER AND THE NEW TECHNOLOGY

Dr. Kenneth R. Whiting

In the Soviet armed forces, just as in every other technically advanced military force, an old problem has assumed a new importance: To what extent must the commander know the equipment of the unit he commands? This problem has apparently become important enough in the Soviet armed forces for the powers-that-be to allow a Colonel Levchenkov to write an article about it in *Red Star** and even to solicit the views of other officers. The response, judging from the letters published in *Red Star,* was vigorous; many of the respondents stated that Levchenkov's articles had aroused great interest in their units. As this problem is not one that applies uniquely to the Soviet officer, it may be of interest to see what bothers Colonel Levchenkov and his friends.

The following is a summary of Colonel Levchenkov's article, which appeared in *Krasnaya Zvezda,* 10 December 1960, p. 2, and was entitled "The Commander and the New Technology."

The problem can be formulated tersely: the commander and the new technology. In other words, to what extent must the commander know the equipment of the unit** which is entrusted to his command? Fifteen years ago the answer was simple: the commander had to know perfectly all the combat equipment his subordinates were using. I was then the commander of an antiaircraft battalion, and it did not occur to me that it was possible to direct subordinates if I knew less than they did. It was not enough for me to be thoroughly acquainted with the ordnance, instruments, and communications equipment of my unit. I personally conducted studies with my officers of the most complex aspects of combat operations. I could check on the condition of the equipment with great exactness. Of course in this respect I in no way stood out from other commanders.

But in the passage of one and a half or two decades much has changed. The technical equipment of the Soviet armed forces has changed qualitatively. The use of modern weapons is unthinkable without the participation of engineers and technicians. They cannot be all-knowing specialists, but they

**Krasnaya Zvezda*, a daily newspaper published for the Army by the Ministry of Defense.

**Colonel Levchenkov uses two Russian words for "unit": *chast'* and *podrazdeleniya;* apparently he is referring to all types of units from battalions and squadrons to divisions and wings.

perfect themselves in some one, rather narrow, technical field. One may specialize in the field of radio electronics, another is an expert in weapons, a third in motors or tractors. All serve in one unit, but it is impossible to change their jobs arbitrarily without the risk of putting them in a difficult situation.

What about the commander? Can you demand of him, as formerly, a universal, profound technical knowledge of all the equipment included in the inventory of his unit? I have heard various opinions on this subject. According to one view, the commander is so burdened with responsibilities in carrying out the Service Regulations that he has no chance to study technological changes in any depth. Therefore it is enough for the commander to know the general principles of the operation of his unit's equipment. Its repair, use, tuning, and regulating are the duties of his engineers and technicians. Following this concept, some commanders do not overload themselves with technical knowledge, but simply supervise the engineering-technical staff. For a time the commander may get away with this, but on the first serious checkup the deficiencies in his professional training become obvious.

Another point of view is that the commander must have technological knowledge on the engineer's level. It is hard to object to this assertion: it would be splendid if the commander had an engineer's technical knowledge. But can he study technical subjects at the same level as an officer receiving a specialized engineering education, without sacrificing the competent execution of his other duties?

Then there is the commander who in undertaking the noble job of knowing all technicality "goes out of his head" studying diagrams and instruments—who wants to know everything in detail, to make sure of everything himself, to touch everything with his own hands. But, you will observe, he lets slip some other, not less important, sectors of his responsibilities.

Of course a commander who has no technical knowledge will not suffice. But neither will he suffice who, in concentrating his interests entirely on the perfection of specialized training, forgets to work with the people who operate the technical equipment and does not fulfill the duties of a leader. How is the commander to act so that his numerous duties do not keep him away from technical matters and technical matters in turn do not keep him from knowing people? Can he distribute his strength and find "the golden mean"?

Perhaps the best solution of this problem is that proposed by those comrades who recommend the appointing to command positions of the already "prepared" specialist-engineers. They do not need additional technical preparation and can wholly concentrate their attention on the supervision of subordinates. I personally cannot agree with this opinion. Of course the commander who has an engineering education is better able to control his subordinates in the operation of technical equipment and to organize its use. However, the commander has not a few other duties, for the engineer appointed to the position of unit commander has to acquire command experience, administrative skills, and an expansion of his tactical outlook. This is not easy, and it is far from being all. Not every engineer has the essential qualities necessary to command a unit. I am all for engineers and technology, but it must be acknowledged that some of them, having consumed many years in technical study, did not learn to work with subordinates. They became to some degree reserved people. And you know the art of leadership consists to a large degree in the ability to attract people to you, to influence them.

In connection with this I want to reproach some of the higher military technical schools. Unfortunately many of their graduates lack command skills. In the last year, for example, into one of our units came an officer, Tkachenko, who had completed his studies. He demonstrated the technical training of a specialist, but from the very first day he displayed a complete inability to work with people. Of course, from such an engineer there will scarcely grow a commander able to cope with the enormous range of duties imposed on him by regulations. And then it sometimes turns out as follows: they push an engineer into a command position; in the course of time his engineering knowledge grows obsolete, but he does not acquire command qualities; as a result, we lose an engineer and we do not gain a good commander.

Experience shows that many commanders by the skillful planning of time can master the technical equipment entrusted to them at the level necessary for them. In my view, the commander does not have to know all the details of the equipment, but he must know the principles, the fundamentals. He must have a clear idea of the functioning and the interrelationships of all the equipment in his command.

In the manuals it is stated that the commander must know about, and must be able to carry out, work on his technical equipment. But in practice this is difficult. The commander, especially the young one, must be careful about how he budgets his time for his personal technological studies. There is no sin in hiding. We still hold too many conferences, commanders' calls, etc., which keep the commander from his main business and prevent him from concentrating his attention on technical studies.

The commander must not only study military technology assiduously himself but also be able to use the knowledge of the engineers and technicians on his staff. He must listen to the opinion and the advice of the engineers and specialists subordinate to him, realizing that he alone cannot know everything. Unfortunately it is sometimes possible to meet commanders who from fear of "injuring their authority" do not want to take the useful advice of specialists, and these commanders sometimes make mistakes.

The problem of the mastery of a deep technical knowledge by unit commanders is a very serious one. It would seem desirable that the readers of this newspaper give their opinions on this problem.

A Major V. Samsonov wrote a letter, entitled "Be Not a Step Behind," in answer to Levchenkov's article.* He first made the point that the com-

**Krasnaya Zvezda*, 22 January 1961, p. 2.

mander had to know more than just the general principles of the structure and operation of his equipment. To illustrate his point, he told the story of his own colonel. One evening he wandered into the colonel's office and found him immersed in a technical book, while his table was piled high with diagrams, manuals, and technical literature. The colonel explained that he felt it necessary to keep up with all the technical changes and new equipment coming into his unit. Once when he was inspecting one of his radar units, he noticed that a technician was making some repairs but not according to the book. The colonel called him on it, but to his embarrassment found that it was a new type of apparatus that called for a different procedure. He was not going to get caught that way again. Major Samsonov draws the conclusion that a commander cannot direct his subordinates unless he knows far more than general principles.

The Major then assails Colonel Levchenkov's antagonistic view on engineers as commanders because he has taken one example and made a general law from it. Major Samsonov, on the other hand, lists a number of engineers who became excellent unit commanders.

The *Red Star* printed about ten letters in answer to Colonel Levchenkov's article, the respondents varying in rank from lieutenants to generals. On the whole, Major Samsonov's letter was typical: the commander must have a detailed knowledge of the equipment of his unit, and there was little sympathy for Levchenkov's worry about the lack of command abilities in engineering officers. Of course the fact that the majority of letters came from either engineering officers or pilots may have had something to do with their favorable attitude toward engineers as unit commanders. One gets the impression that line officers lorded it over engineering officers a bit, and one "engineering-colonel," apparently griped by the adjectival dilution of his title, suggested dropping the qualifying part.

Major-General of the Engineering Technical Service N. Barykov urged that a glance at the historical development of technology in the Soviet Union would answer many of Colonel Levchenkov's questions. In the early days the plants, shops, and even the technical units of the Red Army were headed by "Red leaders," men who knew little of technology but had great leadership qualities. They had to depend upon specialists, often from the old regime, for their technological know-how. But as the Soviet state produced more and more technically educated people, these old leaders could be replaced. This was made even more necessary as the developing military technology grew ever more complex. This same evolution has gone on, and will continue, in the Soviet armed forces.

Research Studies Institute

Books and Ideas . . .

Documentary Collections Related to the U.S. Air Force

A Guide for Military Writers

Major James F. Sunderman

As THE Aerospace Age has caught the serious attention of the American public, a growing demand has arisen for wide variety of Air Force material for both magazine and book publication.

Curiously the interest in space has also stimulated an unusually strong interest in the past—in aviation and air power history. Books and magazine articles dealing with air historical topics—the evolution of flight, pioneer airmen, the technology of aeronautics, World War I and World War II air combat—are eagerly sought by readers of all ages. Increasing numbers of publishers and writers, determined to supply the fast-growing, two-pronged requirement for serious literature on man's conquest of the air and his coming exploration of the cosmos, seek Air Force help to probe into the past as well as examine the present and future.

To meet this demand the Air Force Office of Information, Office of the Secretary of the Air Force, maintains the Magazine and Book Branch and its subunit, the USAF Book Program. The principal function of this office is to bring publishers together with authors writing on Air Force subjects and to assist such publishers and authors in finding mutually interesting subjects for publication. It also lends assistance to military and free-lance authors in getting the necessary documentary and research materials needed for sound, accurate presentation of the Air Force story.

Since one of the first questions that this office receives from almost every prospective author, whether military or civilian, is "Where are the records?" I am offering the following description of the principal collections of aerospace reference and documentary material. This does not pretend to be exhaustive. There are many other smaller or more specialized collections. Help in gaining access to these research sources may be had from the Magazine and Book Branch, Office of Information, Office of the Secretary of the Air Force, Washington 25, D. C., or from the address listed in the individual accounts of the various facilities.

Good research makes good writing!

USAF Historical Division Archives

The Archives, located at Air University, Maxwell AFB, Alabama, is the official keeper of unit histories and supporting documents for the Air Force and its predecessor organizations: Army Air Forces, Air Corps, Air Service, and Aviation Section of the Signal Corps.

Two thousand 4- and 5-drawer filing cabinets house more than one million documents relating to military aviation, constituting the broadest and most valuable sources on USAF history, contemporary and past, existing anywhere. Half the collection covers World War II years, 1941–1945, when thousands of AAF units world-wide—squadrons, groups, wings, numbered Air Forces, commands—prepared monthly unit histories. These unit histories are not of equal merit, but most are remarkably complete, filled with detailed personnel, operational, and housekeeping data of unusual importance and interest. Supporting documents for the war period include general and special orders, intelligence reports, mission plans, target folders, bomb damage assessment reports, mission debriefing files, messages, escape and evasion reports, maps, charts, photographs, plans, evaluations, statistics, and scores of additional memorabilia created by the paper work of modern warfare. The documents dealing with plans and air operations abound with human-interest stories and an abundance of combat lore that has hardly been touched.

Most of the other half of the Archives collection consists of Air Force unit histories and supporting operational documents from 1945 to the present, including the extensive Korean air war materials. New unit histories are received, cataloged, and filed on a continuing basis. The major commands, numbered Air Forces, and comparable-level organizations submit their histories on a semiannual basis; lower-echelon units (divisions, wings, groups, squadrons, etc.), on a quarterly basis. The inflow of current documents to the Archives averages around 22,000 items per year.

The wide range of special sources is exemplified by collections such as War College lectures, minutes of Department of Defense Military Liaison Committee meetings, and a detailed chronology of the U.S. military air arm beginning with the year 1861. In addition the Archives holds private collections and photographs assembled by such noted airmen as Muir S. Fairchild, Millard F. Harmon, Aubry L. Moore, Elmer E. Adler, Martin F. Scanlon, Robert Merrill Lee, John G. Williams, Curtis E. LeMay, H. H. Arnold, and others.

Scores of monographs, on subjects from limited war to strategic doctrine to balloon reconnaissance and World War I aces, have been prepared by the USAF historians from this vast storehouse of primary sources, and these serve as ready references for facts, meanings, and interpretations.

Subject coverage thus is wide, ranging from earliest aviation history to recent developments in the fields of ballistic missiles, earth satellites, and space biology. The Archives spans the life of the USAF from 1907 onward, forming a collection without equal for the student and researcher of American military aviation.

Some of the material in the Archives, largely of post-World War II vintage, is classified, but a continuing program of downgrading is under way. Whole areas of World War II materials have recently been opened. Under certain conditions access to specialized topics still within security areas can be given to writers working on historical projects. Application for such permission should be made to the Chief, USAF Book Program, SAFOI, Washington 25, D. C.

Air University Library

The Air University Library at Maxwell AFB, officially designated Fairchild Library, provides a university-level bibliographic, documentary, and circulating reference operation suitable in quantity and quality to support the requirements of the Air University school system.

The AU Library collection numbers approximately 1,000,000 items and embraces extensive unpublished official matter, military regulations, technical manuals and pamphlets, and U.S. Government publications related to the Air Force, as well as books and extensive files of journals, magazines, and newspapers. All items are at finger-tip availability through the catalog system, which for numerous topics is supplemented by special bibliographies. The Audio-Visual Center of the Library stocks maps, aeronautical charts, films, flat pictures, filmstrips, and slides. The Library's inventory breaks down as 240,000 books; 520,000 documents; 75,000 regulations, reports, etc.; 2500 magazine and newspaper subscriptions; 280,000 maps and charts; 11,000 films, slides, etc.

The 520,000 documents comprise official studies, reports, plans, investigations, orders, policies, and correspondence and other unpublished items such as Air University student theses. Much is classified, all is fully cataloged in the most completely analyzed collection of its kind in the Department of Defense. The 240,000-book collection contains carefully selected titles in all fields of knowledge relating to aerospace power, military science, natural science, political science, economics, engineering. It forms perhaps the most complete book collection on aviation and military air to be found anywhere. The periodical subscriptions provide world-wide coverage, leaning strongly to military subjects, particularly aerospace power. Past issues are available in extensive back files. The Library collection is available to the armed forces, individuals or units, through standard library procedures, including interlibrary loan. Items are readily accessible to other authorized users, consistent with security regulations. Research in the AU Library is permissible for authorized military and free-lance civilian writers. Application should be made to the Chief, USAF Book Program, SAFOI, Washington 25, D.C., or to the Director of Information, Hq Air University, Maxwell AFB, Alabama.

Air Force Museum

While generally known for its collection of historical Air Force aircraft, the Air Force Museum maintains a Reference and Research Division comprising 500,000 documents, films, and books portraying the history of the USAF and recording technological advances in aerospace power. These historical properties are directly associated with celebrated events, important eras, and notable achievements of the Air Force. Thus the materials here cover a vast subject field and the time period beginning with the Wright brothers in 1903 and running to the present age of space.

Since the aerial vehicle itself is the central item of the Museum, the documentary collection fans out from the specific aircraft into detailed presentation of airplanes, components, equipment, and weapons and of the men whose accomplishments, feats of heroism, and sacrifices have made AF history. The materials run the gamut from the A-1 through the X-15. Listed by model of airplane, the documents are categorized under the headings of armament, color-markings-insignia, cockpit, design and modification, drawings, erection and maintenance, empennage, engine equipment (cameras, radio, radar, etc.), fusilage, history (specific flights, log books, units, personnel), instruments, landing gear, operation, performance, photographs, petroleum-oil-lubricants, propellers, specifications, tanks, and wing. The same order and nature of documents are to be found on lighter-than-air craft, helicopters, amphibians, missiles, rockets, and manned and unmanned space vehicles. Reference material also deals in general aircraft areas: engines, components, instruments, equipment, armament, clothing, etc.

The reference files are available for personal research from 9:00 A.M. to 4:00 P.M., Monday through Friday. Facilities are not available to provide research assistance by mail or to copy documents or photos. The required document or photo, however, can be loaned to an authorized applicant for a period of 30 days. Application may be made direct to the Director, Air Force Museum, or to the Chief, USAF Book Program, SAFOI, Washington 25, D.C.

Air Force Branch, Military Personnel Records Center

For writers who are interested in biographical information on military airmen, the Air Force Records Center, St. Louis, Missouri, maintains and services the master personnel records of all officers and enlisted persons who have been completely separated from the Air Force or its predecessor organizations. Additionally it holds prior service records of enlisted men who are currently on active duty. Detailed description of the records can be found in AF Manuals 35-9 (for officers) and 35-12 (for airmen).

Other categories of records include original daily military strength reports and all noncurrent permanent records of long-time value created by AF field organizations, such as (1) claims, (2) courts martial, (3) medical records, (4) morning reports, (5) official publications, (6) research and development studies, reports, proposals, plans, policies, programs, and a host of other R&D items, (7) technical orders, (8) temporary records such as leave, civilian personnel separation, patent and copyright, training directives, etc., (9) organizational records comprising files, correspondence, management, budget, etc., and (10) classified administrative records.

Additional permanent AF records, covering every item of an official nature and having a retention value of ten years or longer, are sent to some 37 record depositories located throughout the 50 States, the Philippine Islands, and Allied countries. A listing of the types and series of these records and their depository locations can be obtained from the General Services Administration. Significant among these, for the air historical researcher, is the

Federal Records Center, GSA, Alexandria, Virginia, which holds, for example, much of the captured Luftwaffe files, the complete files of the Twentieth Air Force and its operations against Japan, and other significant documents in AF history and U.S. air power. Much of this material is still classified; however, research into it is possible upon application to the Chief, USAF Book Program, SAFOI.

The St. Louis Center also maintains a decoration file listing all decorations to AF personnel. The 3-by-5 cards give the man's name and serial number, decorations earned, and the order authorizing them. Occasionally of great value to the writer are personal papers of Air Force notables found in their personal records folders or filed with the records of the organizations to which they were assigned.

Application for research privileges or requests for specific information should be sent to the Chief, Air Force Branch, Military Personnel Records Center, 9700 Page Boulevard, St. Louis 32, Missouri, or to the Chief, USAF Book Program, SAFOI.

United States Air Force Academy Library

This new facility, located on the Academy site 16 miles north of Colorado Springs, provides a well-balanced reference and reading collection of materials generally found in leading liberal arts and engineering colleges and universities. Since its founding less than a half-dozen years ago, special gifts to the Library are developing a comprehensive reference and basic research collection in the field of air power and aeronautical history. A special collection of more than 100,000 unique and rare items relates to the growth and development of the Air Force Academy and its curriculum.

As of 1 May 1961 the Library contained over 130,000 books, 1100 current issues of magazines, and regular editions of 90 U.S. and foreign newspapers. It is a selective depository for United States Government and United Nations documents, a source of technical reports such as those of RAND, ASTIA, NASA, and TEMPO. Its microfilm collection numbers more than 3800 reels. A comprehensive series of pamphlets, brochures, and the like covers data on Air Force installations and units world-wide.

By permission of the Library of Congress and the Mitchell family, the Academy Library has obtained duplicate copies of many items contained in the papers of General William Mitchell. The papers of Lt. General Hubert R. Harmon, the first Superintendent of the AF Academy, are also in its special collection.

Research facilities of the Academy Library can be made available to qualified persons if they will write to the Director of the Library, USAF Academy, or to the Chief, USAF Book Program, SAFOI.

Air Force Information Offices

Air Force Information Offices, from Hq USAF down through major commands, numbered Air Forces, centers, services, and lower-echelon organizations, provide excellent to limited resources for aerospace research, especially on more current aspects of Air Force operations, personnel, logistics, etc.

Each Information Office in the field maintains a file of current official press releases, background data, pamphlets, brochures, monographs on special topics, etc., and a photo file covering personnel in the organization, its operations, and its related activities. The majority of these photos are not duplicated in the central AF photo files at Hq USAF; thus they provide the writer and researcher a grass-roots coverage of the AF at the unit level not available elsewhere.

From major-command level on down, the USAF historical program comes under the Office of Information. Each organizational unit maintains historical files which offer primary sources for research. While security classification of current unit histories precludes open use, special topics from historical documents can frequently be downgraded. Local information officers can also draw on the base photo laboratory for special coverage of AF topics.

Research Studies Institute

The USAF Historical Division, Research Studies Institute, Air University, Maxwell AFB, Alabama, directs the Air Force-wide historical program. This office has published scores of historical studies on special air power topics, such as "Development of the Army Air Arm, 1917–1941." These studies provide detailed and authentic sources for the writer. A listing of the unclassified Studies may be requested from the Director of Information, Air University, Maxwell AFB, Alabama.

Three Air University Research Studies Institute publications provide specialized bibliographic guidance to official and unofficial periodical literature and books and to certain official studies on Air Force, air power, space, and related military subjects: *An Airpower Bibliography,* prior to 1955; *An Airpower Bibliography, 1955–1956;* and *A Space Bibliography, Through 1958.* These are invaluable reference sources to published literature on aviation and aerospace from the early days to the present.*

Air Force Library Service

The Air Force library system consists of some 261 main libraries. This includes a library at every Air Force base, technical libraries at research, development, and other specialized activities, and the academic-type libraries at the Air University and the Air Academy described above. These libraries together with library extension activities, including branch and field libraries which serve Air Force personnel wherever located, total some 6486 library outlets. The total book stock of all facilities numbers 5,202,266 volumes.

The main libraries, together with branch and field library extensions, contain general and reference material with balanced collections covering

*The USAF Book Program, Office of Information, Office of the Secretary of the Air Force, Washington 25, D.C., maintains an up-to-date bibliography of commercial books on aerospace and related subjects published from 1955 to present (both hard and paper cover). Copies are available upon request.

types and subject matter to meet the reading requirements of the personnel served. Most libraries have a working coverage of aeronautics and aerospace books, with emphasis on those volumes that relate directly or indirectly to AF history or the AF story. A book kit of 30 new clothbound titles and a 50-title paperbound kit are distributed monthly to each main library and to library extension activities. In addition to new books of general interest these kits include the principal new air and space titles. Base librarians also have the authority and the funds to purchase recommended air and space books of all types. Most of the Air Force Book Program selections and related volumes, which are not distributed in the monthly kits, are selected and ordered by AF base librarians. Thus each AF library contains a fairly complete collection of all current aerospace publications. Librarians also procure technical, legal, and governmental publications, and each library adds those publications needed to meet specific reader requirements. In addition base libraries subscribe to many popular and technical magazines and file recent issues. Materials in main base libraries are unclassified.

Technical libraries are found at Air Force Systems Command and Air Force Logistics Command bases, centers, laboratories, and other activities. They are also found in other commands at installations which require scientific and technical research as part of the mission. AF technical libraries offer excellent specialized facilities, for example, the libraries of the Office of Aerospace Research and the Office of the Surgeon General at Hq USAF and the AF Cambridge Research Laboratory at Laurence G. Hanscom Field, Bedford, Massachusetts. Such libraries maintain collections of unpublished official reports, studies, and symposium proceedings, as well as officially published pamphlets, periodicals, brochures, and commercially published technical materials in the particular area of the organization's mission. The materials in technical libraries consist of both classified and unclassified items.

Information officers at all levels of command can arrange for writers to conduct research in base and technical library facilities, the latter within the provisions of security regulations.

Air Force Photo Files

The Air Force Photo Files, officially known as the Documentary Photo Library, a branch of the Library Division, Detachment 1, Aeronautical Chart and Information Center, are presently located in the Pentagon. The files contain several general categories of black and white photos.

The "personal portraits" group includes photos of all general officers, aces, Congressional Medal of Honor winners, outstanding AF personalities and leaders, flyers, air pioneers, etc., from 1908 to the present. This grouping numbers around 40,000 pictures.

"Documentary photography" is the second group, and it makes up the bulk of the files. It is organized geographically and by subject: personnel, training, airplanes, maintenance, bases, combat operations, research and development, electronics, WAF's, and a dozen other classifications; and it covers from 1908 to the present, including World War I, World War II, and Korea.

Especially outstanding is the photo coverage of combat in World War II and Korea. This group, as of 1 June 1961, included more than 191,486 pictures, covering military aviation thoroughly and civil aviation to a limited extent. An additional 16,625 color transparencies add to the documentary photography. Photo subjects range from the middle of World War II to the present.

Two outstanding personal collections, both on World War I, are in the AF files: the Major Robert Soubiran collection, taken by Soubiran during World War I, largely on the Lafayette Escadrille; and the Crowel collection which covers air activities and the American Expeditionary Force of World War I.

A limited number of commercial copyrighted photos are in AF files with permission for their use for official purposes only. Owners include *Life*, *Jane's All The World's Aircraft*, the wire services, and other photo media.

The yearly inflow to the Photo Files from AF units world-wide is approximately 125,000 black and white negatives and color transparencies and 9000 prints. Of these, approximately 10,000 color transparencies and black and white negatives and 3000 prints are retained for the permanent photo record.

The entire AF Photo File collection numbers well over 300,000 items, with a sizable annual growth. All are efficiently cataloged in organized photo notebooks, facilitating research and reproduction. Much of the National Archives photo collection is also available through the AF files.

Permission for research in the AF Photo Files may be requested from Chief, USAF Book Program, SAFOI. Normal charge for prints is 55¢ each. If the writer's project is officially approved, limited photography is provided without charge. Color transparencies are loaned for 6 weeks. If permanent retention is desired, a charge of $5.00 each is made.

The Aerial Library Branch, also a division of the Aeronautical Chart and Information Center, is the agency which catalogs and stores the extensive footage of all official aerial reconnaissance film. Much of this is classified; however still excerpts can be extracted on certain subject areas.

USAF Motion Picture Film Depository

This film depository, located at Wright-Patterson AFB, is the office of record for all motion picture film created or acquired by the U.S. Air Force. More than 85,000,000 feet of historical film from the originals of the early Wright brothers' flights to space probes today are cataloged and stored in 99 air-conditioned vaults. The main depository categories include:

The Wright Field Collection, 1920–1949. Film produced by or donated to the motion picture activity at Wright Field. It contains valuable copies of film on the early Wright brothers' flights that were donated by Orville Wright. It also covers the early research and development activities which took place at Wright Field or were photographed by Air Force photographers through the period up to the end of World War II. Included also in this film collection are views of the principal types of aircraft produced by or procured by the Air Force from 1908 until 1949. Wright Field photographers also covered special historical events, such as the early air races and record flights. Additional aviation documentation for the early period was donated by newsreel companies.

World War I, 1918–1919. A small number of films dealing with miscellaneous aviation activities and the activities of several pursuit squadrons.

World War II, 1941–1946. Comprehensive coverage of U.S. Army Air Forces in all theaters of war; also documentation of domestic activities, international conferences, special events. Films of activities of our allies and seized enemy films are included, the latter showing the missile developments in Nazi Germany.

Korean Conflict, 1951–1953. Films made in the Korean theater of operations, with coverage of related international and domestic events.

Research and Development Documentation, 1950–present. Films documenting research and development in military aviation performed by Air Force commands, principally the Air Force Systems Command, and by Air Force contractors, such as Boeing, Hughes, Convair, etc., working under Air Force contracts. This film shows the development and testing of modern aircraft, missiles, rockets, and related components, and research in astronautics, aeromedicine, and other sciences related to space exploration.

General Air Force Documentary Photography, 1950–present. Films shot by Air Force photographic units, principally units of the Air Photographic and Charting Service, in the United States and in all areas of the world where the United States maintains air bases or exercises a friendly interest. These films show world-wide command or base operations and personnel, special projects or special events of national or regional interest, and coverage of missile and space development of general interest for public information.

Official Air Force Film Subjects, 1949–present. These consist of training films, special film projects, film training aids, Air Force news reviews, and film reports containing official Air Force doctrine approved by Hq USAF for training, informational, or promotional purposes.

The total film footage of the depository is cataloged on more than 1,000,000 subject file cards, simplifying pinpoint research to specific areas.

Each year the depository receives 8,000,000 feet of new film subjects. Almost all of this annual input is kept for periods of time ranging from a few months to a few years. Retention timetables govern the various classes of footage received. Film with retention value as historical documentation of Air Force operation and development is retained beyond the first ten years. The most important films, such as air operations during war periods, the Wright brothers' flights, or the first successful satellite launch, are retained permanently at the National Archives after active use by the Air Force has been completed.

Writers, historians, researchers, and publishers can acquire stills from the motion picture footage, or clips, on subjects ranging the entire scope of Air Force growth and operation. Commercial producers of films can likewise obtain film clips or sound effects. A nominal fee is charged for reproduction.

Some of the film comes under restrictions preventing free use, for reasons of prior copyright, security classification, or legal limitation. Aerial views of military installations or other key target areas are restricted. Exceptions may be granted, upon specific request.

Nongovernment requests for film or stills must be submitted to and approved by Director of Information, Office of the Secretary of the Air Force, Washington 25, D.C., Attn: SAFOI-3B.

National Aeronautics and Space Administration

On the science and technology of flight, NASA research facilities are highly recommended for their technical literature, which includes domestic and foreign books, periodicals, documents, reports, and studies. NASA has growing collections on the social impact and education aspects of the space age, as well as rounded motion picture and photograph collections on space technology and sciences. It has no material on weapon systems.

The National Aeronautics and Space Administration, Washington 25, D.C., is the offspring of the National Advisory Committee for Aeronautics (NACA), established in 1915. Its technical collections antedate World War I. With its present space exploration mission, many of NASA's programs are of direct interest to writers and researchers working on launch vehicles, manned space flight, and space science subjects.

The following points of contact in NASA Headquarters at Washington are suggested:

- Office of Technical Information and Educational Programs
  - NASA Technical Library: probably the best single collection of technical literature in the world on all phases of aeronautics and astronautics.
  - NASA Educational Programs: active workshop and science education materials.
  - NASA Historical Office: working collection of NACA and NASA monographs and related materials.
  - NASA Audio and Visual Division: a wide range of motion pictures and still photos about space sciences and flight.
- Office of Public Information
  - In addition to its information desks, OPI has a wide range of informational releases, current photos, space activity summaries, etc.

The following NASA centers and facilities throughout the country offer a useful point of contact for research and writing. The local Director of Technical Information and/or the Public Information Office are recommended as points of contact for leads to information:

Ames Research Center, Moffett Field, California

Flight Research Center, Edwards, California

Goddard Space Flight Center, Greenbelt, Maryland

Jet Propulsion Laboratory (Cal Tech), Pasadena, California

Langley Research Center, Langley AFB, Virginia
Lewis Research Center, Cleveland, Ohio
Marshall Space Flight Center, Huntsville, Alabama
Space Task Group (Project Mercury), Langley AFB, Virginia
Western Operations Office, Santa Monica, California
Launch Operations Directorate, Cape Canaveral, Florida

National Archives

Here is another gold mine for the writer-researcher, especially on the early period of military aviation. Several general categories stand out: all the central files of the Office of the Chief of the Air Service, the Air Corps, and later the Army Air Forces, dating between 1917 and 1944, containing the top-level administrative, policy, and management documents; selected files of the Air Corps Library; AF patent files, 1918–1945; and complete GHQ Air Force files, 1935–1942.

Most important are the complete records of the Air Service in the American Expeditionary Force during World War I. On pre-World War I military aviation, the Archives retains the records of the Office of the Chief Signal Officer, under whom the Air Service was organized. Perhaps the most complete, comprehensive source existing anywhere on this subject is the "Gorrell History," a compilation of materials on the Air Service in the AEF. This monumental work contains more than 300 volumes of documents and narrative histories of Air Service units and supporting activities in France, including photos. It was gathered and edited by Lt. Col. Edgar S. Gorrell after World War I. Other miscellaneous reports and items on military and civilian aviation of the early period are also in the National Archives.

Research can be conducted in the files to the extent security permits. Most of the National Archives collection is unclassified; however classification still applies to some of the later World War II materials, 1939–1944. Permission for access to the unclassified records can be granted, and application should be made to the National Archives. Permission for access to classified AF records there should be made through the Chief, USAF Book Program, SAFOI.

The National Archives also holds a sizable collection of air photos. The significant categories include 6000 World War I negatives of the 1918–1919 period, one-half of which are aerial shots; over 200,000 personal portraits of individuals serving in the Air Force from World War I through the Twenties, Thirties, and World War II, including each cadet and officer and outstanding civilian or military personnel and VIP's; the Erickson collection of aviation activities in California, 1914–1918; several thousand lantern slides from the Wright brothers of 1903 through the Air Service era to 1946; 3000 Scott Field photos covering the period 1928–1937; a limited number of aerial mosaics; the complete file of Air Transport Command photos (25,000 to 30,000) taken over the flying routes during World War II, 1943–1945.

Recently the National Archives acquired the main file of official black and white Navy air photography from the early days through 3 September 1945. This new addition numbers in the thousands. A special "Old File" of historical aircraft contains several thousand items from the early period.

National Archives photos are for sale at $1.00 each in 8 by 10 black and white. Detailed descriptions of the various classes and types of records can be obtained by writing to the National Archives, 7th and Pennsylvania Ave., N. W., Washington 25, D.C.

Library of Congress

Perhaps the most extensive mine for military as well as civilian aviation research is the Science and Technology Division of the Library of Congress. Here can be found upwards of 50,000 published books (in all languages) that deal directly and completely with aeronautics or aviation in the United States and foreign countries. Thousands more deal in part with flight or indirectly relate to it.

Approximately 4000 aviation periodicals, world-wide, (those still being published and those that have been discontinued) can be found in current and back issues. This number includes approximately 1500 U.S. periodical and serial titles such as magazines, reports, and pamphlets. In addition there exists a large collection of technical aeronautical reports, house organs, and trade literature, both historical and current.

For the "digger" into air history, the Library of Congress offers special types of aviation collections, including many rare, out-of-print books. Among these is the Tissandier collection of books and prints, a French collection essentially on ballooning purchased some time ago, which covers the period from the Montgolfier brothers to World War I. For the early period of powered flight there are the Hildebrandt, Hoernes, and Silberer collections, each with thousands of books, newspapers, pamphlets, and scattered primary sources. An extensive vertical file of clippings, preprints and reprints, photos, and related materials on personalities and events as well as aircraft and equipment covers the period from 1930 to 1953.

In addition there are whole collections of general news photos which are largely unorganized but which offer a gold mine of air pictures. Thousands of other photos which came with personal papers, such as those of General of the Armies H. H. Arnold and General Billy Mitchell, have been filed in the Library's general collection of prints and photographs. Since many items are not identified and do not have captions, their use requires a special knowledge of history or the help of an authority. Photos can be copied for a nominal fee.

One of the most important, significant sources for air power and military aviation is the manuscript collection. It comprises the papers of the Wright brothers, Octave Chanute, Charles A. Lindbergh (limited), Grover Loening, Glenn L. Martin, Generals Carl Spaatz, H. H. Arnold, Ira Eaker, Billy Mitchell, Hugh Knerr, Frank Andrews, Hoyt Vandenberg, Nathan F. Twining, in fact all AF Chiefs of Staff, and others. These papers include personal mementos, correspondence, diaries, journals, notes, reports, and a host of miscellaneous items. Access to the private papers usually requires the written permission of the donors, or their heirs, and proper authorization from the Air Force for those sections still under security classification.

The microfilm deposit includes a number of special aviation subjects such as the Von Rohden collection, the historical files of the German Air Force in World War II, the Wright brothers' own scrapbooks, and a score of other items of special nature.

Research in the excellent facilities of the Library of Congress is open to civilian and military alike.

National Air Museum, Smithsonian Institution

In conjunction with an outstanding collection of aircraft, engines, and the hardware items of aviation history, the National Air Museum maintains a library of reference, drawing, and photographic materials.

Published books number more than 2000 volumes, all dealing with aviation history and the evolution of air technology. The photographic collection numbers more than 60,000 items, of which 10,000 have been photocopied. Other reference materials cover aviation subjects of historic value on aircraft, engines, general aviation, and biographies of pioneer airmen.

The Museum's library is available to researchers during normal work hours. Specific information requested will be searched for by the staff. Photo copies can be procured at cost to the correspondent. All requests should be addressed to the Director, National Air Museum, Smithsonian Institution, 10th and Independence Ave., S. W., Washington 25, D. C.

New York Public Library

The aeronautical and astronautical collection of the New York Public Library is strong in historical and contemporary works, magazine articles, and books. General categories include traditional and literary accounts, general works, lighter-than-air craft, heavier-than-air craft, engines, propellers, airplane flights, military aeronautics, World War I and World War II, civil aeronautics, air mail, polar expeditions, associations and conferences, jurisprudence, aeronautics and science, photography and surveying, animal flight, women in aeronautics.

Especially valuable is the Library's collection of military aviation in World Wars I and II. A large group of official narratives, historical studies, and personal narratives is international in scope.

In one area—unofficial Air Force unit histories out of World War II—the Library's collection is unique. A bibliography of the titles was published in 1958, entitled, *Unit Histories of the United States Air Forces: Including Privately Printed Personal Narratives,* compiled by C. E. Dornbusch (Hampton Books, Hampton Bays, New York). Two hundred sixty-eight individual titles are listed. Additional titles have been added to the collection since 1958, making it the outstanding repository of unofficial unit histories.

Other reference aids to research in the Library are *Guide to the Reference Collections of the New York Public Library* (1941), and *History of Aeronautics: A Selected List of References to Material in the New York Public Library*, compiled by William B. Gamble.

Research can be conducted during normal library hours. Request for further information or research should be addressed to the New York Public Library, Aeronautical Collection, Fifth Avenue and 42nd Street, New York 18, New York.

Institute of Aerospace Science Library

The Lester D. Gardner Memorial Library of the Institute of Aerospace Science is cosponsored by the National Science Foundation and the Air Force Office of Aerospace Research, Hq USAF. This library is especially oriented to scientific and technical material. It contains approximately 8000 books, 6000 volumes of periodicals, and 50,000 reports. Included are the published proceedings of conferences and symposiums, individual papers presented at meetings of various technical societies, government reports, and an extensive, indexed collection of World War II German documents on microfilm.

Subject coverage includes all literature dealing with the design, development, testing, and operation of all types of air and space vehicles and with their associated propulsive units, instrumentation, guidance and control components, and support equipment. Large holdings can be found in the fields of fluid mechanics, structures, materials, electronics, and research equipment and facilities. Smaller amounts on special topics include advanced propulsion systems, magnetohydrodynamics and plasma, the effects of extreme temperature and radiation conditions, orbit and trajectory mechanics, inertial guidance, electronic control, and space medicine.

The IAS Library maintains a broad program of publication acquisition, of preparing abstracts and indexes, and of providing circulation, photo-copying, and reference services. Four hundred seventy-five different periodicals are regularly received, from Free World and Iron Curtain countries. Abstracts are prepared and published in *Aero/Space Engineering*, an official monthly publication of the IAS. Each year these are published in a cumulated separate volume.

The IAS Historical Library, a separate section of the IAS, contains an ample supply of published books, periodicals, clippings, and pamphlets on ballooning, dirigibles, early aircraft, famous flights and personalities, and the employment of aircraft in commerce and warfare. It also has an extensive collection of bibliographies and reference tools on aviation and space. These materials are not available for loan.

A useful adjunct is the Sherman Fairchild collection of aeronautical photographs, including more than 50,000 photos of airplanes, balloons, dirigibles, rockets, and persons prominent in the field of aviation. The collection also includes a clipping file on aviation personalities. A print file is maintained, and reproductions are available at $5.00 per glossy print.

The IAS facilities are open to individual and corporate members in the United States and Canada. Publications are loaned for a period of two weeks. Photo copying costs the correspondent 30¢ per page; film copying, 20¢ per frame. Bibliographies on technical subjects will be compiled at a charge of $5.00 per hour.

The IAS Reading and Research room is open to members from 9:00 A.M. to 5:00 P.M. daily (week days only). Catalogs, bibliographies, and indexes are available to assist in research.

The IAS Library is located at National Headquarters Building, Institute of Aerospace Sciences, Inc., 2 East 64th Street, New York, New York. Mr. John J. Glennon is Librarian. Phone TEmpleton 8-3800.

Ross-Barrett Historical Aeronautics Collection

This collection of aviation materials is part of the Denver Public Library, Denver, Colorado. It consists of 3500 items covering the period from man's first preoccupation with flight to the present day.

Books, manuscripts, prints, and photographs range in date from 1524 to the present. The material deals with the science of aeronautics and the historical development of aviation, and includes such items as novels, drama, and poetry which show the evolution of aviation and its impact on modern civilization. Magnificent color prints depict early balloon ascensions and early experimental machines.

The collection is open for research during normal library hours.

Army Library (Pentagon)

Useful and handy for the writer in the Washington area is the Army Library located in Room 1A518, Pentagon. This facility contains 730,000 books, periodicals, documents, and language records covering the subject areas of military affairs, physical sciences, government and politics, scientific technology, and international relations.

The Library maintains subscriptions to 2000 general and special periodicals, 400 of which are in foreign languages from Free World and Iron Curtain countries. Also included are all military and civilian, official and commercial, technical and professional journals, legal and medical periodicals. Back files of many of the periodicals, such as *Saturday Evening Post*, are available from 1942 (the date the Library was organized) to present.

Special collections of documents include reports and student theses of the Industrial College of the Armed Forces; graduate theses of Georgetown and George Washington Universities; and a complete file of official regulations, field and technical manuals. A bibliographic section prepares bibliographies for official use.

Anyone assigned to or employed by the Department of Defense may borrow materials from the Army Library. Other government agencies may acquire them on interlibrary loan basis.

Military personnel and civilian writers can research in the Army Library during duty hours, 8:30 A.M.–5 P.M. Monday through Friday. Only military personnel are authorized to check out material. Adequate facilities exist for research in the Library's reading rooms.

U.S. Army Photographic Agency

The U.S. Army Photographic Agency Reference Library, located in the Pentagon, contains photographs of all Army activities under its command, including a substantial amount of early Army aviation and World War II air-combat coverage.

The Library has two general categories of black and white photos. Yearly input is 20,000 prints. The first category, the "P" group, contains portrait-type photos of all general officers and noted Army personnel, such as Congressional Medal of Honor winners, past and present Secretaries of Defense, Secretaries of the Army, etc. This group contains 66,000 photos. The second category is broken down by subject and geographical location, branches of the Army service, both ZI and overseas, in a cross-reference index. These photographs are in easily accessible notebooks and include such topics as personnel, training, maneuvers, parachute troops, armored forces, Army missiles, guns and weapons, early Army aviation in World War II, and the present-day Army air arm, Medical, Chemical, Infantry, Ordnance, Transportation, etc. These Signal Corps photos number approximately 582,000. The Library has negatives on 468,000 Signal Corps prints in addition to 18,000 color transparencies. The color transparencies are filed under broad subject areas. The Army Photo Library is unique in that it contains microfilm ranging in subject from the Revolutionary War through the Punitive Expedition of 1916. This material is easily identified for selection purposes by its "B" number. Other collections cover natives of foreign countries, foreign military forces and equipment, disaster areas, fires, hurricanes, military ceremonies, religious activities, World War II major conferences including Yalta, Malta, and Potsdam.

The files are open to writers, researchers, and authorized personnel from 8:30 A.M. to 5 P.M. Monday through Friday. Persons desiring access to the files should apply in the Reference Library Branch, 5A 486. Photos are available to authorized personnel without charge in conjunction with a writing venture. For personal collections, etc., there is a charge of 55¢ for a glossy print, 60¢ for a matte print, and $5.00 for a color transparency.

Aerospace Industries Association

The Aerospace Industries Association of America will provide, on request, background information on subjects dealing with the American airframe and missile industry and will give specific addresses to contact in the aerospace industry and affiliated manufacturing fields for further reference on specific subjects. Two comprehensive AIA publications, the annual *Aerospace Year Book* and *Air Facts and Figures,* cover American military and civilian aviation, its industrial base, and the airline industry. Writers should contact the Director of Public Relations, Aerospace Industries Association, 610 Shoreham Building, Washington, D.C.

other sources of air research

Scores of documentary and photo collections are held by private individuals, industrial companies, and various university and public libraries.

Magazine editorial offices frequently offer the researcher excellent materials in their picture morgues and in back issues of the magazines themselves. Among such publications are *Air Force/Space Digest, Flying, Flight* (British periodical), *Saturday Evening Post,* and *Life.* Issues of defunct commercial magazines like *Aero Digest* and *Collier's* should not be overlooked.

Six magazines provide especially lucrative sources. The back issues of two now defunct offer excellent historical coverage of military and civilian aviation. *U.S. Air Services,* edited by Earl Findley, discontinued in the middle 1950's, was a monthly slick aviation magazine that brackets the history of aviation in America. The *U.S. Air Services News Letter,* begun in October 1918 (later renamed successively the *Air Corps News Letter, Army Air Forces News Letter,* and *Air Force Magazine*), was an official bimonthly publication of the Army air arm for internal distribution. It presented a wealth of facts on Army air operations, aircraft, personalities, policy, directives, training, etc. Back issues of these publications can be found in the Air University Library, the Library of Congress, the Army Library (Pentagon), and other major air collections.

Current and back issues of the four still-active magazines are available:

Air Force/Space Digest, published by the Air Force Association, 1901 Pennsylvania Ave., N.W., Washington 6, D. C. A nationally distributed slick monthly dealing primarily with the USAF.

The Airpower Historian, published by the Air Force Historical Foundation, Maxwell AFB, Alabama. A slick-format quarterly carrying a wide variety of articles on air power and AF history.

Air University Quarterly Review (established in 1947), published by Air University, Maxwell AFB, Alabama. A quarterly periodical dealing with aerospace doctrine, strategy, tactics, techniques, and related concepts.

American Aviation Historical Society Journal, published periodically by the American Aviation Historical Society, P.O. Box 2013, Torrance, California. A comprehensive photo-narrative-statistical coverage of air historical subjects and aircraft, dating back to the beginning of powered flight.

The Imperial War Museum, in London, England, is an excellent source for both photo and manuscript research on flight history, especially valuable for military aviation and World War I and World War II coverage.

The documentary and photo archives of the U.S. Navy and Marine Corps contain extensive coverage of aviation activities relating to those branches of the service from the early days to the present. Information on research sources and requests for access to them should be made to the Chief, Magazine and Book Branch, Office of Information, U.S. Navy, Washington 25, D.C.

Access to U.S. Army Archives should be requested of the Chief, Magazine and Book Branch, Office of Information, U.S. Army, Washington 25, D.C.

Headquarters United States Air Force

The Quarterly Review Contributors

Brigadier General Robert F. McDermott (B.S., USMA; M.B.A., Harvard University) is Dean of the Faculty at the United States Air Force Academy. During World War II he served with the Ninth Air Force in Europe as Operations Officer, 474th Fighter Bomber Group. He was Assistant Professor of Social Sciences at West Point from 1950 to 1954, when he was assigned as one of the original faculty members of the Air Force Academy. He served initially as Professor of Economics and Vice Dean, becoming the first permanent professor. In 1956 he was made temporary Dean of the Faculty and in 1959 the first permanent Dean appointed by the President. General McDermott is a command pilot.

Brigadier General Tarleton H. Watkins was Commander, 322d Air Division (Combat Cargo), Evreux, France, until his recent assignment as Deputy for Operations, Ninth Air Force, Shaw AFB, S.C. After attending Texas A&M, he enlisted as a flying cadet in 1938. He was with the 18th Pursuit Group in Hawaii when Pearl Harbor was attacked. He later served with the 79th Fighter Group in North Africa. Other assignments have been as Commander, Fighter Test Section, Proving Ground Command; Commander, Millville AFB, N.J.; Deputy Commander, Shaw AFB, 1947; Instructor, New England Air National Guard, 1949; Deputy Commander, Kindley AB, Bermuda; Deputy Commander, 1602d Air Transport Wing, Wiesbaden, Germany, 1951; Commander, 1708th Ferrying Wing, Kelly AFB; and Deputy for Operations, then Deputy Commander of the 322d Air Division. General Watkins is a graduate of the Armed Forces Staff College and the National War College.

Major General Arthur C. Agan, Jr. (B.S., University of Texas) is DCS/Plans, Hq Air Defense Command. He took flying training in 1937, returned to college and graduated in 1939, then obtained a regular commission. In 1942 he went overseas as Operations and Training Staff Officer, Hq Eighth Air Force. In 1944 he moved to the Mediterranean as Assistant Air C/S for Operations, AAFMTO, then commanded the 1st Fighter Group. After 45 combat missions he was shot down and interned as a prisoner of war. Postwar assignments have been as Chief, Personnel Services Division, Hq AAF, 1946; as Deputy for Personnel and Administration, Hq ADC, to 1949; as Commander, 4th Fighter Wing and of 33d Fighter Wing to 1951; as Commander, 32d Air Division (Defense); as Chief of Personnel and Administration, AC&SS; as student, Air War College, 1953; as Commander, 58th Fighter Bomber Wing, in Korea, 1953; as Deputy for Operations, later C/S, CONAD Forces, Eastern CONAD Region, 1954—1957; as Commander, 26th Air Division (Defense); and as Commander, New York Air Defense Sector, 1958-59.

Colonel Victor C. Wegenhoft (B.A., Texas A&M) is a member of the Plans and Developments Directorate, DCS/Plans, Hq Air Defense Command. Since entering the service in 1941, his overseas assignments have been in the Marshall Islands and Japan, 1947-48; in Germany 1948-49; and again in Japan, 1955-56. He was with the 26th Air Division, ADC, from 1957 until his present assignment in 1960. Colonel Wegenhoft is a graduate of the Air Command and Staff School and the Armed Forces Staff College.

Lieutenant Colonel Travis M. Scott (B.S., University of Texas) is Chief, Future Developments Branch, Directorate of Future Plans and Advanced Developments, DCS/Plans, Hq Air Defense Command. Commissioned in 1942, he was Aircraft Engineering Officer, 348th Night Fighter Squadron, at Orlando, Florida, and Salinas, California, until 1944. He served in the Aircraft Maintenance Division, CBI Theater, 1944-1946, then was assigned to Kelly AFB, Texas. He participated in atomic tests Operation Sandstone, 1948, and Operation Greenhouse, 1951. He served with the Research Division, Air Force Special Weapons Command, 1951-1954, then as Assistant ADC Resident Representative to AFSWC until his current assignment in 1958. Colonel Scott is a graduate of the Command and Staff School.

Lieutenant Colonel John W. Bennett (B.C.E., University of Florida; M.S., California Institute of Technology) is Chief, Advanced Systems Branch, Directorate of Advanced Plans and Future Developments, DCS/Plans, Hq Air Defense Command. Commissioned in the Engineers in 1942, he completed flying training in 1944 and was at Wright Field until 1946. After postgraduate study at Cal Tech, he was with the Air Proving Ground, Eglin AFB, conducting operational suitability tests of fighter aircraft, 1947-1949. For two years he was USAF exchange officer with the RAF in England, flying RAF fighters in service and tactical trials. After attending Air Command and Staff School, he returned to the Air Proving Ground Command, with primary interest in defense interceptors. In the Directorate of Research and Development, Hq USAF, 1954-1958, he worked on development of new interceptors. As Commander, 83d Fighter Interceptor Squadron, Hamilton AFB, he took this first squadron equipped with F-104A's to Taiwan during the crisis there in 1958.

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