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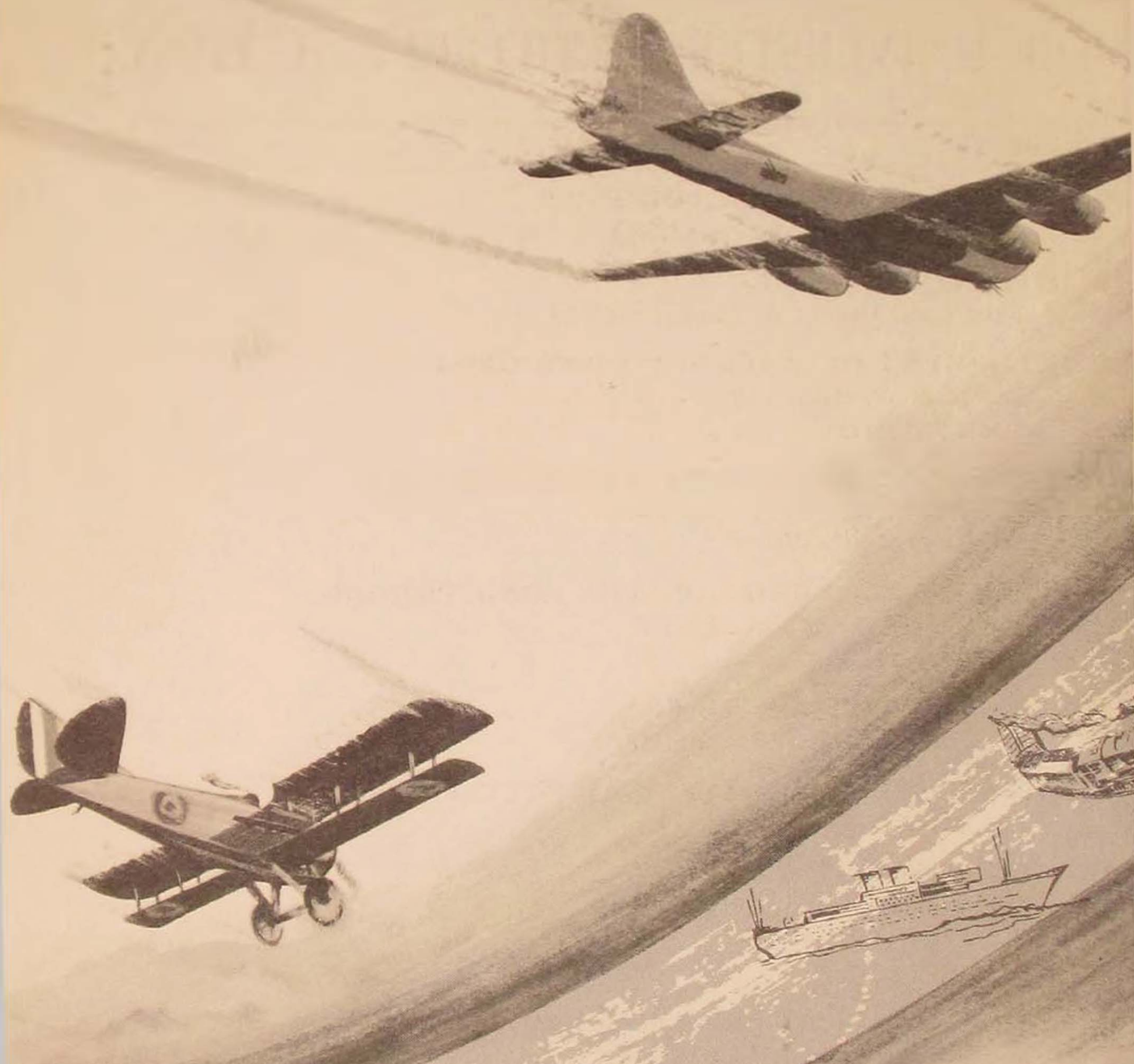
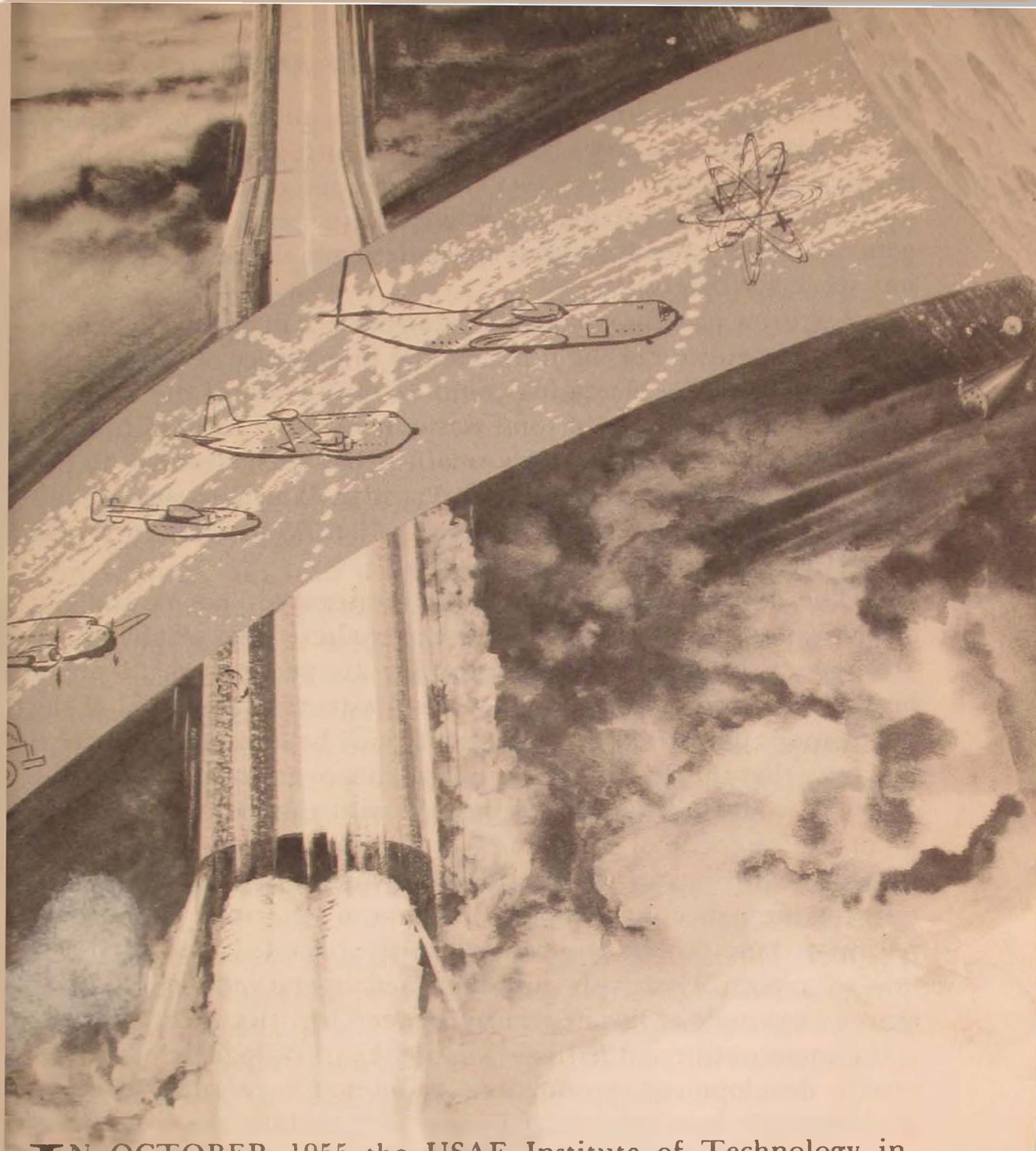


The Evolution of Air Logistics

General Edwin W. Rawlings



IN OCTOBER 1955 the USAF Institute of Technology inaugurated an Advanced Logistics Course for the "training of qualified air logisticians and the development of air logistics philosophy and doctrine." It was a quietly historic occasion, a recognition of the fact that air logistics had joined the strategy and tactics of air power as a distinct branch of military science. It had taken two wars, a technological revolution, and the creation of an independent Air Force to spawn the new science and bring it into sharp focus as a new breed of military support for a new genus of weapons and a powerful determinant of the nation's air strength.

Its roots go back to the wilderness campaigns of our earliest military history. Its future is already being shaped for the exploration of the ultimate wilderness, the trackless, alien reaches of space, where man must carry with him even his own atmosphere if he is to survive. Between these two lies a history of the increasingly critical importance of logistic science in general and the emergence of air logistics as a highly specialized and dynamic element of our space age defenses.

Logistics has always been a vital arbiter of military actions. Yet full recognition of the fundamental importance of logistics has come only with the increasing complexity and cost of the weapons of war. The percentage of total war cost invested in munitions in Napoleon's time was extremely small. It has risen steadily: 10 per cent of the total cost in the Franco-Prussian War; between 30 and 35 per cent in World War I; a towering 70 to 75 per cent in World War II, the first true "logistician's war."

The development of long-range strategic air power and nuclear weapons in World War II radically altered the whole nature of large-scale war and weighted the logistic percentage still more heavily. The speed, range, and massive destructive potential of the air weapons developed in subsequent years have made it a virtual certainty that the decisive phase of any future global war would be short. It would be won or lost largely with the weapons ready to go at the moment of initial attack. For the United States under present conditions of international tension this means the long-term maintenance on alert of a maximum deterrent force of superior striking power. It means a greatly extended logistical prelude to a possibly sharply foreshortened operational phase. The extreme example of this new ratio between logistics and operations is the intercontinental ballistic missile. Years of logistic effort—research, development, production, maintenance on alert—precede the extremely brief operational phase of launching the weapon on its one-way trip to a predetermined target.

For the foreseeable future our total air forces will, of course, contain other weapon systems than ICBMs, including highly sophisticated manned aircraft and manned and unmanned space vehicles. But missile requirements for unprecedented speed, precision, and flexibility of support response will set the pace for logistic developments. The support system will be increasingly tailored to the capabilities and limitations of missiles. It has by now become apparent that the rapid technological evolution of air weapons of the past decade has not only added greatly to the comparative importance of the logistics mission but has also created a distinct branch of logistics, specifically molded for the first time in our military history to the optimum support of air operations.

It is surprising that air logistics as such should have been so long in emerging as a distinctive major element of our military air power. A brief glance at the history of its development may serve to explain some of the growing pains that have complicated its emergence and are still factors to be reckoned with in the present maturing process.

the prelude

In so brief a report as this, logistics for air operations in World War I must be dismissed as negligible. Though the fledgling aircraft industry did turn out numbers of aircraft before the war's end, shipping was tight and comparatively few of the U.S.-produced ones ever reached the battlefront. The flying elements of the American Expeditionary Forces in effect rented a furnished room; of almost 6300 planes delivered to them in France, only some 1200 came from the United States. The range and general capabilities of air weapons still tied them closely to surface operations and there was as yet little clearly defined need for peculiar provisioning of the new air arm.

Even the establishment of the Materiel Division in 1926 had little immediate impact on the development of support logistics. Its emphasis was upon badly needed research and development and a major preoccupation concerned existing inventories that were heavily loaded with World War I surpluses. As late as 1930 the Air Corps still had more than $40 million worth of Liberty engines in its depot stocks, which it planned to use as spares.

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The heavy, relatively long-range bomber became a practical reality in the 1930's. Its strategic possibilities were clear to those who fought for its development. But the logistic implications were less evident. We approached what was to become a war of logistics with little real conception of the scope or crucial importance of the coming support mission and with almost no Air Corps educational emphasis upon the preplanning of logistics specifically designed for the support of air weapons.

The impact of the coming conflict was felt first in production. Circumstances gave us an opportunity to gear ourselves for production logistics before we were committed to world-wide support of our own combat elements. In meeting the challenge of production logistics we naturally set the pattern of support logistics for global war—mass stockpiling to back a strategy of saturation.

The problems of logistical support of air power in World War II were tremendous. Inventories then included some 500,000 items that had to be shipped overseas. Stocks that had been considered adequate for a month's support of a fighting unit could be consumed in a few days of concentrated action. New strategies and tactics being developed under pressure created sudden emergency needs. Whole air complexes had to be created overseas to bring strategic targets of the enemy within reach of the big bombers. And the problems of supporting forces on two fronts simultaneously created rapid and confusing diversions of materiel from one front to another as action alternated in critical intensity.

Under such conditions centralized logistical forecasting and tight control of inventories became a practical impossibility. Slow and unwieldy supply techniques necessitated the buildup of extensive overseas stockpiles to cover the contingencies of operations. Stockpile logistics worked, and no other approach could have under the circumstances. It kept the Air Force flying, but there could be no illusions about its costliness. During the last year of the war the AAF maintained approximately 24,000 planes overseas. This was almost twice the prescribed unit-equipment strength of the combat groups. Around the world large stocks of support equipment had accumulated only to present the new problem of postwar surplus disposal.

the need defined

While such surpluses were not peculiar to the Air Force, they did serve to focus postwar concern upon the development of a more precise, rapidly responsive air logistic system. The Unification Act of 1947, making the Air Force an independent service, seemed to promise a favorable climate for sifting the logistical lessons so recently learned. Two factors, however, militated against the prompt application of those lessons. With war's end and the pooling of advances in technology made by both victors and defeated, the "jet age" had begun. The art of weaponry was already outstripping the logistic techniques matured under fire. At the same time, in a wave of relieved reaction to the end of active hostilities, the American people were liquidating their armed forces, optimistic in the hope of a lasting peace. By the summer of 1947 demobilization had reduced Air Force strength from a wartime peak of 2,400,000 men and 80,000 planes to 310,000 men and 12,000 planes. The global support complex that had mushroomed with growing air strength during the war was pruned back to the quick. The problems of disposal of $13 billion worth of surplus and the mothballing of quantities of other weapons and production resources moved into center stage.

There followed a hectic interregnum of changing force requirements and budget allotments, of accelerating technological flux, and of confusion and conflict concerning the relative missions of the newly coequal services. As new tensions developed in international relations and the "cold war" battle lines of the free and Communist ideologies began to emerge, it was difficult even to define clearly what type of possible future war our air power should be shaped to fight or to prevent.

When the Communists invaded South Korea in June 1950 the USAF was still working its way back toward a 48-group Air Force. The aircraft industry was far from recovered from its postwar eclipse. In July 1950 it produced only 215 planes as compared with 2461 in December 1941. The difficulties of both programing and production were compounded by the technological transition from the weapons of World War II to jets, on which both quantity-production experience and combat experience were conspicuously lacking.

Meanwhile the logistic mission braced to take the brunt of rearmament under pressure. The slim active-aircraft inventory was composed of a little over two thousand jet planes and a heavy preponderance of World War II leftovers. B-29's, B-50's, B-26's, and F-51's were brought out of retirement to supplement these active forces. The longest aerial supply lifeline in history was set up to support the air war in Korea. A plane took off from the West Coast for Tokyo every 75 minutes. In Japan the Korean Combat Cargo Command took over the shuttle job to the constantly shifting front.

The procurement mission, reflecting both the immediate exigencies of the war and the longer range race for future defenses, increased from $2 billion in FY 1950 to $11 billion in FY 1951 and $16 billion in FY 1952. Funds for aircraft procurement alone rose within months from the $900 million annual average that had obtained for the three previous years to $10 billion as the Air Force moved into a 95-wing program.

Dollars alone, of course, could buy neither time nor logistic capability off the shelf. Some 73,000 machine tools—many of them long-lead-time items—were needed for the production push. Only about 20,000 of the tools in the mothballed reserve could be applied to the production of the new weapons. Shortages of critical materials presented a problem in the balance of a "guns and butter" economy. These difficulties were aggravated by the lack of firm priorities and the general revolution in manufacturing methods for new types of weapons.

Problems on the production front were not the only indications that the logistics system was overdue for extensive overhaul and modification to bring it abreast of rapidly advancing air weaponry and strategy. Immediate support of the air effort in Korea inexorably spotlighted system inadequacies. Persistent difficulties cropped up in spares support of the weapons being used to fight the war. Procurement of spares for many of the reactivated, obsolescent World War II items had been discontinued. Follow-on spares for some of the new weapons and equipment lagged far behind the introduction to combat of the weapons themselves. Provisioning was frequently inadequate because of the lack of experience factors and of combat rate consumption data on the new weapons. Effective maintenance support likewise often trailed arrival of equipment in the staging area, a serious impediment as new and complex electronics began coming off the production lines. It was increasingly obvious that a tight functional integration at early sources of all elements contributing to the operating weapon had become a necessity with the new complexity of air weapons and their supporting equipments.

Korea was, in fact, a timely test ground of air power in transition. It brought home to us, as no theoretical studies could have done, the changing imperatives of logistic support. What it could not do was cast a detailed mold of the logistics of the future, for it was plain by now that change itself was the only reliable constant to be anticipated. Even as the new jet aircraft began to replace in effective numbers the "retread" equipment of World War II in Korea, a whole new breed of weapons was already appearing on the drawing boards. The missile era had begun.

emergence of a new capability

It is difficult, viewing the immediate past in short perspective, to identify major turning points in so big and complex an operation as Air Force logistics. But sometime between 1952 and the end of 1955 what we might call the first true air logistics system began to take shape. We had passed through a World War I phase of largely indigenous support of extremely limited air operations. We had experienced a tremendous—and in some respects random—expansion of Air Force logistics in World War II, a phase of emergency forced growth characterized by massive stockpiling for support of global operations. Now we entered a third phase: logistics precision-tailored to match evolving air weapon capabilities and having as its objective long-term, reflexive *direct support* of world-wide air operations from carefully limited materiel inventories.

The nature of the evolving weapons themselves, as well as certain policies, concepts, and techniques reaching or approaching maturity during this period, facilitated the transition to the new logistics. The Korean War, climaxing other international developments, had helped to clarify our necessary national defense objectives of the future. We now knew that we must maintain on alert for the indefinite future the capability for fighting *both* global and limited wars. Further, the National Security Council, meeting late in 1953 for a "new look" at our defenses, affirmed that air power combined with nuclear power was the primary force to be employed in modern warfare and that the United States Air Force was the first line of military defense of the nation and the free world. Finally, in September 1955, the President, upon the recommendation of the National Security Council, gave the intercontinental ballistic missile program the highest national priority.

For the first time since its establishment as a separate service the Air Force now had a clear "fix." It knew what it was to prepare for, what its major responsibilities in the defense complex were, and—as far as possible in the exploding technology of the era—the specific weapon emphasis of the immediate future. Logistically it was now possible to begin drawing together, integrating, and focusing upon these firm objectives the many piecemeal advances and improvements that had been made in the logistics system during the years just past.

These had taken many forms. In 1951 and 1952, as a basic organizational approach to the problems of mass and complexity, we began the decentralization of procurement, supply, and maintenance functions from the log jam of Headquarters Air Materiel Command to the major depots in the United States. Our primary objective was to quicken the tempo of response by relieving operational bottlenecks and bringing materiel sources and users into more direct contact. This was necessarily a lengthy process, carefully time-phased to prevent disruption of logistic readiness at any point in the process, but it was well under way before the Korean War ended.

As decentralization marshaled the logistic workload into more manageable segments, we began an organizational realignment in accordance with a basically new principle of logistics management —the weapon system concept. This treated the entire weapon system, including necessary ground environment, as a functional unit from its earliest design phases. A Weapon System Project Office monitors its progress through research, development, and production stages, ensuring continuous correlation of all elements of the system. Decentralized primary responsibilities for specific weapon systems are delegated to the depots.

Within the changing structure of the system new techniques and tools were developed and applied to promote speed, precision, and flexibility of support. Action was begun to sift and tag the million and a quarter separate inventory items as low or high value and to give them priority accordingly. Routine scheduled airlift of high-value items, such as engines, was inaugurated to reduce the resupply time cycle and the total quantities of new procurement needed to fill the pipelines. In 1954 the first electronic data-processing system was installed at Headquarters Air Materiel Command, to be augmented in the years that followed by a growing complex of electronic equipments throughout the whole logistics organization in the zone of interior. These superhumanly fast and accurate systems have been pushed into ever broadening applications in many areas of logistic effort. In 1955 precise, high-speed communications became a reality with the creation of the electronic-wire transceiver network.

While the new concepts, tools, and techniques were whittling down the long supply pipelines and quickening the tempo of response to the needs of the combat units, a continuous management program aimed at increasing the over-all effectiveness and economy of the logistics system began to make itself felt. Monetary inventory accounting and industrial work measurement methods were introduced. Maintenance of the active inventory was streamlined, tightened, and accelerated by programs like BENCHCHECK and IRAN, by the introduction of quick-change repair kits, and by the establishment of flying mobile maintenance teams. Executive Control Meetings of depot commanders at Headquarters Air Materiel Command were set up as a means of isolating weaknesses and inadequacies in the system. Competitive standards of depot performance were developed as a spur to continuing improvement.

The increasing speed and precision of logistic response during this transition period and the emergence of direct support as an operational reality have enabled us to phase down and streamline the massive logistic plant. This objective was furthered by Air Force action in 1956 and 1957 placing depot facilities in the European and Pacific theaters—traditionally the responsibility of the theater commanders—under direct jurisdiction of Air Materiel Command. By 1958, when the big jigsaw pieces of the new logistics had begun to fit together into a cohesive new capability, we had within a period of five years closed 23 AMC installations within the ZI and overseas and eliminated 53,000 positions from our manpower rolls. Further reductions planned for the period ending in 1962 will bring the total number of deactivated installations to 41, total manpower reduction to well over 65,000. The latter is better than one fourth of our entire manpower requirement of a few years ago.

Solid proof that a new caliber of logistic capability is indeed maturing is evidenced by the support statistics. In spite of the reductions in facilities and manpower and an increase in flying-hour requirements, the rate of aircraft out of commission awaiting parts (AOCP) has remained low—in some cases has been drastically reduced. At the same time initial procurement, notably of high-value aircraft engines, has been reduced by millions of dollars, and the normal theater resupply pipeline time from the United States under the direct support concept has been cut to between 10 and 15 days. This abbreviation of the pipeline, demonstrated in the Middle East and Far East crises, is in striking contrast to former surface resupply of theater stockpiles in which average total pipeline time was over 90 days.

These are the hallmarks of the new logistics that support our present forces in-being, the active inventory—primarily of manned weapon systems—which constitutes our immediate readiness. Perhaps still more significant for our future defense posture is the fact that the logistic transition is being accomplished in time to provide a new order of support for the powerful unmanned weapons which are already changing the complexion of our air power.

It is no coincidence that the weapons and the capacity for their support are being developed simultaneously. The awareness of the growing importance of logistics was at an all-time high when we were vouchsafed the first advance glimpse of the coming revolution in weaponry. Many of the techniques and concepts already being shaped to optimum support of increasingly sophisticated manned weapon systems could be fitted to the new missile weapons from the outset. Moreover the very technological advances that made possible at last the complex guidance and control of the big birds had also created an exceptional tool for their logistic support. Probably for the first time in the history of military logistics, the imperative, the perspective, and the raw materials are meeting at the same point in time, enabling us to create in advance a custom-tailored support environment for a whole new species of weapon.

The Ballistic Missiles Center, very recently completed at the San Bernardino Air Materiel Area in California, is a prototype result of such advance planning. A kind of solar plexus for ballistic missile support, it incorporates the latest large-scale electronic data-processing equipment, to be linked by a network of nationwide high-speed communications direct to missile manufacturers, storage sites, other depots, and actual operational sites of the missiles.

The growing capability for support of both manned and unmanned weapon systems is of course by no means perfected. Its flaws and shortcomings are numerous. But we have reached a point where the major guidelines are drawn, where it can be clearly identified as a departure from its traditional beginnings—different in its concepts, its techniques, its present competence, and, above all, in its potentialities. Most of the changes and developments cited here are still under way, will be undergoing continual refinement, perhaps major revisions, for many years to come. The logistics system must of necessity remain fluid and dynamic to keep abreast of the swiftly expanding technology of the space age.

a look ahead

It is extremely important at this time that we retain our long-range perspective in air logistics. The present highly competitive pace of developments in weaponry and the exploration of space gives fair warning that the growth of the support capability must be unfailingly synchronized with that of the operational capabilities of our weapons. We cannot afford to sacrifice any margin of weapon readiness or effectiveness to lagging logistics. A brief forward glance in the light of present and past logistic developments shows certain areas that will warrant particular consideration and effort in both the immediate and more distant future.

The first of these is the problem of sifting and settling the organizational structure of the logistics system for its greater homogeneity with the new concepts, tools, and techniques introduced in the last decade. The trend toward contraction and consolidation of the physical plant will unquestionably continue as we progress to more limited inventories of high-yield weapons and increasingly precise and flexible semiautomatic logistic controls. It must be accompanied by an organizational recognition that the integral relationship between logistic functions is also altering. We now have within the structure vestigial remnants of organizations on the verge of outliving their functional purpose. For instance, the arbitrary breakdowns between research and development, procurement and production, maintenance, supply, and so forth, will not be realistic tomorrow. The weapon system approach in itself is already breaking down these sharp lines of demarcation. The changing patterns were clearly foreshadowed in a recent realignment of the Headquarters Air Materiel Command Directorate of Procurement and Production, which established permanent maintenance and supply specialists in the project offices of the new Aeronautical Systems Center. We have recognized them in embryonic form by the creation of Logistic Support Managers in the Air Materiel Areas. Change is inherent in the shifting and merging definitions of missile supply and maintenance, as we feel our way toward the most economical and effective balance between repair and replacement of nonfunctioning components of these one-way weapons. Electronic data-processing equipment is also proving a powerful force for fusion and integration of functions.

The deep, organic adjustments which these symptomatic changes forecast cannot be undertaken abruptly in a system that must be prepared at all times to respond instantly to a war emergency. But the metamorphosis must be foreseen, planned, and phased-into-being in smooth stages, before the organizational mold can become a constrictive strait jacket upon the growing potential of the new logistics.

Closely allied to this basic problem is the task of working out the most effective compromise between weapon system and commodity management. How far should we go in vertical alignment of logistic support for the obvious advantages of centralizing all elements of support for one weapon system or family of weapon systems? To what extent should we balance this, for greater economy, by horizontal alignment by commodity classes that are common to all or many weapon systems? How can we intermesh the two approaches for maximum responsiveness? Answers to these questions also must be hammered out of our progressive, practical experience to come.

A third area of unremitting future effort should be the search for new tools and techniques that can be applied or adapted to logistic operations. The scientific and technological revolution which has given us both our new weapons and a new support capability is still gaining in momentum. The breakthroughs of the next ten years may well provide us with logistic tools beyond our most optimistic present conceptions, permitting tremendous advances in data systems, in the physical handling and transport of materiel, in the powerful, high-speed communications so crucial to the successful support of man in space. A primary emphasis of logistic management of the future should be the systematic seining of this flood of new knowledge.

These are all efforts which, if approached with progressive vision and perseverance, promise steadily increasing logistic capability. But we should note also certain current trends which threaten to stunt that evolving capability. They exert a centrifugal force for the partition of the logistics mission or divergence from its primary governing objective of support of military operations.

One of these trends is the increasing use in logistics of single managers and working capital funds of the stock and industrial types. The single-manager technique creates one manager for a commodity or service used by several departments within the Defense Establishment, such as petroleum or clothing. The stock fund technique deals in some specific function as though it were a private business "selling" its products to those whom it serves. Both techniques have been favored on grounds that they increase the business efficiency of the logistic operation. Extended beyond their present applications, however, they could impair the effectiveness of logistic response by interposing between the combat commander and his primary military goals secondary considerations and supply channels beyond his control.

The same objection applies even more strongly to a second disruptive pressure for the delegation to industry on contract of an increasingly large portion of the maintenance mission. The percentage of depot-level contract maintenance has been climbing steadily since 1951, is now roughly 50 per cent of the total depot maintenance workload. Certain of the original factors that made this advantageous to the Air Force in the past no longer apply. Industrial pressure for the increase of contract maintenance has stiffened as mass procurement of new weapons has been reduced and as missiles presented new maintenance considerations. Here again it is of vital importance that we preserve the functional integrity of the logistics mission. We must retain an in-house capability for maintenance of our first-line and combat-committed weapon systems. This is fundamental to discharge of our support responsibilities. To dissipate it would endanger the ready striking power of the Air Force.

Some of these problems will undoubtedly be solved as the catalysts of evolving weapons and strategies bring about a genuine coalescence of our defense forces. Our concern in this formative period is to ensure that they do not now create irrelevant diversions from our primary objective, do not check the momentum of our growth toward maximum responsiveness.

Air Force logisticians today have a particular obligation to build well for the future. This first true air logistics which we now have in our grasp is itself, characteristically, only a transitional form. It is the beginning of the space logistics of tomorrow, the light-year lifelines to new worlds. It is the unfolding prototype of the unified powerful capability that will one day support land, sea, and air forces so finely geared together that they move as a single bolt of military power for the defense of the nation.

Headquarters Air Materiel Command

Blueprints for Space

Brigadier General Homer A. Boushey

IN THE country of the blind the one-eyed man is king.

The writer of this oft-quoted adage has expressed, in a poetic and dramatic way, the basic truth of relativity. Some of us see better than others. And as regards "seeing" I refer to the ability to more clearly foretell the future—and specifically to predict the role which the space age will occupy in our future. I would like to summarize my beliefs. This is not to say that I consider myself a superior prophet. It is only that my work has led me to study and think a great deal about this subject and that the possibilities are so startling and limitless that we need as many views on its potentialities as we can get.

In twenty years, I believe both the moon and Mars will have permanent, manned outposts . . . but perhaps that is getting somewhat ahead of myself. Working up to these achievements, I believe you will agree, we will launch and utilize many, many scientific and military satellites. Even a few commercial satellites may prove economically desirable. Satellites will not only circle our earth but will also orbit the moon. And we will probably give Mars three or four small moons to add to her two natural ones. Even Venus will probably rate a satellite. Each will relay information back to the earth, or perhaps to the moon, since I believe the moon will prove to be a better site for electromagnetic reception. Probes to the near vicinity of the sun will undoubtedly be used. Perhaps there will be a need to explore the outer fringes of our solar system with unmanned space vehicles. And all this effort will surely increase our scientific knowledge.

uses of satellites

But what are some of the practical uses of satellites—specifically earth-circling satellites? Perhaps the most obvious is as a global weather detecting and reporting satellite. Even rather crude television will provide enough resolution to determine cloud coverage and accompanying wind patterns. This should permit storm warning and accurate air-mass weather prediction.

Another use will be for communications. Either a simple reflector type of satellite which merely serves to bounce a signal back toward earth can be used, or a relay type might be employed.

The passive, or reflector-type, satellite has one great advantage: all the payload can be devoted to the reflecting surface. There would be no power-supply problems or electronic failures to cope with, and during the very extended period it would remain in orbit—perhaps hundreds of years—*it would function!* Another type, the delayed relay type of communications satellite, would receive messages in electronic "fast time" while, say, over New York and store them on tape. About eighteen minutes later, over Paris, the satellite would spew out, again in electronic "fast time," the messages addressed to that location. At the same time it would receive a batch for delivery to other cities—and so on, as the satellite circled around the world.

Here it is interesting to discuss the possible advantage of a retrosatellite, one fired westward rather than eastward. Since the earth at its equator has a rotational velocity of about 1000 miles per hour toward the east, it is only sensible that rocketmen make use of this "free" initial velocity provided by our earth's eastward spin. In the case of a communications satellite, however, the speed of delivery of the messages might make a retro-orbit desirable even though more chemical energy would be required to place it in orbit. The difference in ground speed between the retrosatellite and the normal or east-moving one would be 2000 mph, or twice the earth's rotational velocity. At an orbital altitude of 1000 miles, for example, the time for orbit going eastward would be two hours, whereas if moving west the time for one circuit of the globe would

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be one hour and forty-six minutes, or an improvement of almost twelve per cent. Such an improvement seems attractive enough for us to consider employing a "wrong-way sputnik."

A navigation satellite is another very practical use. The desirable features for a navigation satellite are: constancy of orbit so that precise forecasts of its future positions can be tabulated, large reflecting surface so that the satellite can be readily seen visually both during daytime and at night when sun-earth positions are right, and a strong radio transmission signal so that the satellite can be identified and tracked accurately through clouds or even in clear weather during sun-earth positions when the satellite could not be seen visually.

Think how navigation could be simplified by a few such satellites. Imagine if you will that they are placed at an orbital height which is best for navigational observations. Each satellite would of course have an identification. For visual use, a pair of binoculars might be all that would be needed to identify the object as, say, "Navigational Satellite Number 3." By use of sextant, a chronometer, and a prepared ephemeris for these "navigational satellites," the precise latitude and longitude could be readily determined. Or if you prefer, a small radio receiver could be used. It would tell by a triple beep or other code that the object viewed was "Navigational Satellite Number 3." If the satellite would frequently broadcast its own latitude and longitude (which it could easily do by playing back a tape recording), even the chronometer and ephemeris could be eliminated. Only angle measurement would be required. This would certainly be a help to small surface craft and airplanes.

Next, I believe satellite vehicles can prove immensely useful to mankind. Appropriately utilized, they could provide a manned space patrol for peaceful purposes. They can provide attack warning and assist in mutual inspection programs. They can be of use in enabling us to improve our geographic knowledge of the world. A similar satellite could, through mapping and charting, provide information leading to far greater accuracy in positioning our continents relative to one another.

Another use would be purely military—bombardment—and accomplished by space vehicles. I use the term vehicles rather than satellites because I believe these weapon systems will be manned. By usage we seem to be adopting the terms *satellite vehicles* and *spacecraft* for man-carrying machines, and *satellites* or *space-probes* for the unmanned. Now, what would be the purpose of manned, bombardment-type space vehicles, and how could they function? Obviously they would serve as a deterrent to armed aggression, just as our Strategic Air Command bombers safeguard the peace of the free world today. But could they bomb, and would such bombardment be accurate enough to be practical? It has been claimed that the idea of bombing from orbit is ridiculous, that "one can't drop anything from a satellite—things *won't drop* —they will remain in orbit and circle along with the satellite vehicle itself."

To cause objects to re-enter the earth's atmosphere and fall, energy must be applied to the bomb to reduce its velocity so that gravity will overbalance centrifugal force. And so it has been stated, that unless quite a lot of energy were applied the bomb would need to be released halfway around the earth and the accuracy at the target would be off by perhaps hundreds of miles. Why not, say the critics of space bombing, do things the easier way, and fire ICBMs?

Let me give you my reasons. First, our government would surely not launch its intercontinental ballistic missiles on incomplete information. But if it waited for full confirmation, our launching sites themselves might be destroyed. This problem is certainly a serious one. It is eased somewhat by the use of man. A manned vehicle can be launched on only partial, or even garbled information, for without a definite command confirmation some 15 to 20 minutes after launch the man would not press home an attack but would peacefully return to a U.S. base.

Next, I do not share the misgivings about "not being able to drop anything from orbit." Certainly energy would be required to bring an object out of orbit—a considerable amount. But if a sufficient rearward impulse were imparted to a bomb, it would plummet earthward along a vertical trajectory, and the time of fall to the earth's surface from an orbital altitude of, say, 150 miles would be only four or five minutes.

But it would not be necessary or even desirable to program a bomb or warhead to fall vertically. If the warhead were merely slowed down in proper degree, it would fall to earth in a steepening curve, traveling forward under the moving space vehicle. As the warhead entered the atmosphere, it would decelerate more rapidly. But the important fact is that, if the amount of rearward impulse were properly selected, the pilot of the space vehicle could guide the warhead during its fall and increase its accuracy considerably. It is true that today we have very little excess payload capacity in a satellite vehicle to allocate to fuel for the deceleration of a warhead. But I think such arguments are much like those faced by Wilbur and Orville Wright.

In 1903 it was difficult for them to lift one man into the air, let alone transport any useful load. Today just one of our operational aircraft can take off with over 300,000 pounds of useful military payload. Likewise, as we improve our capabilities to operate in space, the loads which we can carry into orbit will be sizable, and the operational advantages which I have mentioned will predominate.

I believe space will be used effectively for both military and civilian purposes. The uses which I have briefly discussed—weather reporting, world-wide communications, navigation, surveillance, and bombardment—are all vital military uses and in my opinion can best be accomplished by space satellites and space vehicles. But one thing is certain: for each new offensive weapon, a military opponent will attempt to provide a defensive or counterweapon. Thus it appears logical to assume we will have antisatellite weapons and even space fighters. These and other counterweapons will become highly specialized and, I imagine, also highly lethal. Each new fantastic space weapon will probably generate a requirement for an equally fantastic defensive weapon. Thus we could go on and on in our imaginations, playing such a checker game of the future—with weapons and counterweapons and even counter-counterweapons.

But I believe it will be sufficient to sum up my views by the simple statement that space will prove immensely useful from a military viewpoint. Our very security depends upon our military abilities; and while scientific or commercial exploitation of space is certainly desirable, there is not the overwhelming urgency as for a military space capability.

manned outposts in space

Now I would like to discuss manned outposts on both Mars and on our moon.

From one standpoint Mars poses a somewhat easier problem. It has an atmosphere, even if it is roughly equivalent to that at the top of Mt. Everest. Entry through the atmosphere of Mars, because of the lesser gravity and more gradual density changes, is easier than re-entry through the atmosphere of our own earth.

On the surface of Mars, temperatures are well within the limits of survivability. A few pieces of protective equipment will provide ample insulation against the extreme cold at night. I imagine an atmospheric compressor will be necessary to maintain a livable pressure. It is hoped that free oxygen in the Martian air will be available, and perhaps the atmosphere will be of such composition that one only needs to compress it for use by man. Water is probably present in sufficient quantity. The biggest single problem appears to be survival during the voyage. Estimates of the duration range from 57 days to as long as 244. Keeping man, or men, alive during such prolonged voyages in sealed, closed-cycle containers is not an easy task. All other aspects of establishing a habitable site on Mars seem to me to be easier of solution. But even this formidable problem I believe will be overcome, and within the next twenty years we shall have a permanent, self-sustaining outpost on Mars!

The moon in many ways poses some even more difficult survival problems than Mars. But since the moon is only perhaps two to five days' travel time from the earth, I believe the establishment of a lunar base will precede a Martian site.

a trip to the moon

To better understand the problems involved, let us exercise our creative imaginations in describing a single pioneering venture: the landing of the first human observers on the surface of the moon and their return to earth.

Essentially what we are dealing with here is the reconciliation of two opposite environments. We are sending men on this trip. Therefore with them we must send a capsule of the earth environment to which the human organism has become adapted through the millenniums of its evolution. We are sending these men through a strange—perhaps hostile—environment, so they must be protected completely from all foreseeable hazards. Finally, unless these men can do something useful, there is no reason for landing them on the moon in the first place. So we must give them a goal, a job to do. And it must be a job that will contribute to scientific and military colonization of the moon.

Now since the critical element in this flight is the men themselves, let us think for a moment about them. After more than ten years of ingenious and fruitful research, Dr. Hubertus Strughold and his associates at the Space Medicine Division of the Air Force's School of Aviation Medicine have formed some rather definite ideas about these space-age Marco Polos. Biologically they will have to be exceptionally well adapted to this sort of adventure. They will have to be economical organisms, so to speak. They need not be heavily muscled, for example. Weight is a handicap rather than an advantage in space. The desirable attributes are coordination and physical endurance.

Psychologically they will have to be free of any mental quirk or habit which would detract from their usefulness. Obviously confinement in the limited room of the space vehicle would rule out anyone who might be subject to claustrophobia, and this doubtless means that the first space travelers will never have served a Pentagon tour.

Given these human packages of qualifications as raw material, we then process them through a rigid qualification program. You may safely believe me when I say that no training for anything before in history will compare with this program for thoroughness. Every detail of physical conditioning will be covered. Every move these men will make, every action they will be called on to perform, will be rehearsed repeatedly to ensure success of the mission. Perfection! That is what we must expect of the men entrusted with this work.

Concurrently with the selection and training of these men we will be conducting the final testing and assembly of the vehicle itself. A few simple calculations show us that the gross design weight for such a vehicle will be on the order of one million pounds. This gives us an option. Either we can wait until we have developed and accepted a propulsion engine capable of lifting this mass and sustaining it throughout the voyage, or we can adopt a smaller unit and utilize it through a series of space refuelings. This space refueling idea seems to me to be highly practical and to offer an earlier realization of the moon flight project.

All of you are familiar with the history of refueling in the air. You will remember the crude beginnings of the idea, and some of the endurance flights that were made using any old way to get more fuel aboard the airplane. And you know that refueling in flight is now a highly refined technique, one that is practiced successfully in the Air Force about every three minutes around the clock.

There is no reason why space refueling could not be accomplished. We could place a cluster of propulsion units (fuel tanks with a rocket engine) in orbit around the earth a month prior to the actual launch of the space vehicle. The launch trajectory of the vehicle itself could be predetermined so as to intercept the power package in the orbit. Pick-up could be accomplished in any one of several ways and the new units attached to the space vehicle for the voyage out to the moon and back.

This permits us to consider the use of a fairly small space vehicle—something on the order of 15 thousand pounds, or about the weight of an F-86 fighter. This vehicle could be mounted on the present ICBM boosters. And having tracked the orbiting power units and having established a meticulously accurate interception curve, so to speak, we are now at the beginning of the final countdown.

In the last critical minutes, the physically conditioned crew goes aboard, suited up and ready to undertake this challenging voyage into the not unknown but little-known extraterrestrial reaches of space.

When the countdown ends, the surge of the rockets against their supported and protected bodies gives them a nine-g initial thrust upward and outward. After the burnout of stage one, the vehicle coasts upward for about five minutes, and then is kicked along again with the nine-g thrust toward orbital speed.

Here is where our crew members find themselves for the first time in a prolonged period of weightlessness. This is one of the critical problems that must be explored and solved before lunar flight can be considered. Can a man work, can he do the numerous tasks involved in this project, when he seems to have no substance at all? This condition cannot possibly be simulated on the earth. Nothing short of free flight in space itself can tell. And that is why we are involved in other projects to gain priceless experience and knowledge prior to launching the manned lunar flight.

Consider these men. Once an orbit is established, they have work to do. The intercept with the power unit has been practically perfect. Only a few hundred yards—perhaps a few miles—now separates the rocket from the power package it must now pick up. It will have been accomplished in practice many times before. But like parachute jumping, you have to be perfect every time. Otherwise the crew will find that they have picked a very poor place to run out of gas.

The automatic controls will have to be turned off and the manual controls engaged for this refueling maneuver. Vernier rockets can be used to bring the space vehicle up into close contact with the orbiting power package for the final adjustments.

How long will this take? Will it be one half an hour? One hour? Or more realistically, will it require several orbital periods around the earth? While this is a vital phase of a lunar voyage, the time required for accomplishing the refueling is not critical. No expenditure of fuel is needed to circle the earth once an orbit has been established. So except for the moderate consumption of air, food, and water there would be no critical penalty involved in orbital refueling.

For the lunar course there is a certain minimum energy curve, so to speak, which must be precisely calculated. But here again we enter a new field. Precisely calculated with reference to what?

At launch, and to this point in the flight, orientation is naturally gravitational; the center of the earth is the point of reference. But now this orientation is losing all usefulness. This flight is projected beyond the predominant influence of the earth, and the only useful reference becomes a mathematical concept—the ecliptic of the orbits of the earth and the moon. Obviously this is no slide-rule exercise. This is the time to yell "Hey, Doc!" and to get an answer. "HaDOC" is the oral shorthand designation of a computer, specifically the Handy Dandy Orbital Computer designed and built by John Miller of the Minneapolis Honeywell Regulator Corporation. First mechanized on an analog machine, this small device seems capable of developing the accuracy of a digital differential analyzer—and it will need this degree of accuracy to be effective on this flight. A pilot can feed into HaDOC the values of thrust, direction, and duration and get back results on a repetitive basis. With it the commander of the space vehicle can always tell what action is called for and when. It will also feed him the cost of the action in terms of energy needs. Naturally such a computer in the cockpit would be invaluable.

After the hook-up of the power plant the commander computes the precise point along the orbit around the earth where he must fire the first unit so as to depart this orbit and set off along course to his destination, which is the surface of the moon. You will recall that during the maneuvering to pick up his power units the crew commander would probably cut off the automatic controls and put his spacecraft under manual control. But for earth departure and for the long voyage to the moon it will be most likely that the automatic control systems will be engaged during the entire time, with the crew merely monitoring for override actions if needed. At any rate the commander has determined time and trajectory from his computer by now. At the precise instant indicated, he fires the first of the five rockets in his power package. The actual flight through space is now under way.

Here is where we have to consider the two opposite environments we mentioned in the beginning. Within the spacecraft itself we will have a cabin environment bringing along something of the earth environment, enough of it to keep our crew alive and functioning. Weightlessness? During the flight proper, since there will be no up-and-down-and-sideways orientation with respect to anything but the cabin itself, it may be possible to use a slow rotation of the craft to create at least a fractional g force. It would not take much. Just enough, in fact, to keep the few movable objects from going adrift and floating aimlessly around the cabin. By movable objects, I mean such items as the highly concentrated foods, packed either in plastic containers as liquids or in collapsible tubes in paste form. After all, nobody wants his steak-paste to float away from his faceplate in the middle of a meal, nor is it easy to round up a weightless blob of milk floating like a monstrous amoeba across the interior of the cabin. Let us at least have a way to make things behave. There are enough new experiences to deal with on this trip without building others into the plan.

Of course the cabin interior will be pressurized, but not like passenger airplanes are. Pressures will be low, approximately that of an altitude of 15,000 feet or lower. And humidity, initially low, will begin to build up, simply as a result of human physiology. The humidity can be controlled to within acceptable limits. I am sure, for instance, that we can keep the humidity within much closer limits than what we find to be normal for a summer in Washington, D. C.

Yes, the internal environment will be sufficiently man-directed, biologically and physically, to enable our crew to function efficiently. But on the outside, just a shell of metal away, things will be very different. And there is a possibility that a chance contact with some object from that tremendous void outside the craft would change the inner environment abruptly.

Consider the meteorite and how it flies, for example. A pinhead-sized meteorite, just a grain of celestial sand, so to speak, moving through space at a speed of 20 to 60 miles per second, could easily puncture the steel hull of our craft. As a matter of fact, it would be less a matter of puncturing it than of blasting its way through it. The heat generated by the impact would cause a minor explosion of the site of the hit. Result? Decompression within the craft, with a span of perhaps 15 or 30 seconds for the crew to act before losing consciousness. Even that short time would be enough for the crew to plug the hole and gradually bring the cabin pressure back to the desired level. But all this is a lot of effort to have to expend for a collision with a grain of sand.

What about the larger ones? There is little doubt that a collision with a meteor weighing just one ounce would end this voyage at once. This sobering fact prompts us to ask what the probabilities are of such an encounter. And the information we have now, from instrumented satellites and other sources, leads us to believe that the probability is so small as to be inconsequential. A spacecraft of the size we are talking about could cruise for hundreds of years without meeting such a catastrophe. Meteors of this size are just that rare in space.

Other information relayed to us from our satellites indicates another hazard to space travel. This is the radiation encountered there. You have all read of this layer, so powerful that it overran the radiation counters in the first satellite. It is believed, but not yet proved, that this is a layer which can be traversed at high speed with no danger to the crew members. Proper shielding of the craft, coupled with short duration of exposure within the layer, would cancel the hazard completely. What we all want to be sure about is that it is, in fact, a layer. Should this zone extend indefinitely into space, we might be confronted with a serious barrier.

Cosmic rays alone are a serious consideration. We have found heavy primary particles in the course of our upper atmosphere studies, particles ranging up to an atomic weight of 40 or more. These rays can be very dangerous. The particles crash into the atmosphere with energies millions or even billions of times greater than can be produced in our laboratories. To keep them out of our spacecraft entirely, the craft would have to be sheathed in steel armor plate at least two inches thick. And such a weight of steel is out of the question for an early spacecraft. So the crew must accept the fact that they will be exposed to a certain amount of cosmic radiation, not only of the heavy primary particles but of powerful secondary particles and gamma rays. Again, and fortunately, these particles of such tremendous energies are rare. Their density in space is extremely low. Cosmic radiation dosage would be safely low for short trips, such as our lunar flight. But in the more distant future, when we are concerned with interplanetary or even interstellar travel, this possible danger must be considered.

Now, having placed these hazards in what we believe to be their proper perspective, let us look for a moment at what our crew is doing while en route. The velocity attained at burnout of the first rocket engine should bring them within the pull of the moon's gravitational field in approximately two days. It is during this free-flight period that the presence of human minds trained for this work takes on added importance. These minds can form judgments from complex data. They can make decisions based upon many and diverse information inputs, some of which may not have been anticipated initially and hence could not be fed into the electromechanical programmer. Valuable work can be done in monitoring and analyzing the different sources of navigational data. Radio aids, celestial fixes, and inertial equipment will all be in use. The human intellect alone can evaluate and select the data from each. And if by any chance a change in the original commitment becomes necessary, the human mind can make the change.

All of this will be done, of course, within a schedule of time-allocation for each crew member. Relaxation, sleep, and work, on a schedule unlike the normal earth routine, will be ordered into effect once the craft has left the earth orbit. The commander must bring his crew to destination in the best possible condition.

At the end of two days of free flight, the ship approaches the moon, fires its second rocket as a lunar retrorocket while entering the gravitational field so as to establish an orbit. The sole purpose of orbiting is to study the surface of the moon and to interpret data previously furnished by unmanned lunar probes. One problem will be the selection of the most advantageous landing place. Several tentative points will have been selected, but the final choice will rest with the commander. Let us assume that he decides upon a polar landing, since it appears that this may permit the best use of the moon's quota of solar radiation. At an altitude of over 1000 feet at a lunar pole the sun would be continuously in view. At this location solar power would not be curtailed by the two weeks of lunar night. But will the crew actually land on a peak? Some of the peaks are thought to rise 30 thousand feet above the lunar plains. Or will they select one of the adjacent plains, or "seas," or perhaps a level crater bed? And what is the nature of the surface selected? Is it rocky, or dusty? And if dusty, how deep is the dust? Inches? Feet? Well, let us go in and see!

But only after we have carefully disconnected one of our refueling packages, leaving it to orbit the moon. This is the round-trip part of the ticket for this trip, and the orbit must be very carefully established. It would not do to lose this fuel package now.

When everything is right, then the craft goes on in with a rocket approach. Because of the lack of atmosphere, no aerodynamic approach is possible. Retrorockets will have to be used

Development of Space Suits and Capsules

Dr. James W. Heim and Otto Schueller

THE space environment, totally lacking in life-supporting properties, would be fatal to the unprotected man in less than a minute. For over a quarter of a century this challenged the scientists of many nations to attempt to provide airmen at high altitudes with an independent microenvironment. Although attainment of this goal was never in doubt, none of the efforts were completely successful until recently. The basic life-supporting properties could be provided without great difficulty. The obstacle came in trying to build these into a garment that would not excessively limit the wearer's mobility. Following World War II the U.S. Navy conducted a vigorous program to solve this difficult problem, and in 1954 the Aero Medical Laboratory of the USAF initiated a similar undertaking.

The exacting performance required to fly modern military aircraft, with their increasingly stressful cockpit environment, placed upon the design engineers the tremendous burden of developing a suit which would not only provide the protection required but also be acceptable to the flying community. In response to an urgent need for such protection, comprehensive design studies and developmental competition were pursued on a system basis. The result was a functional system for the X-15 aircraft and other suborbital vehicles. This system also served as a prototype for a true space suit.

Production of the basic garment solved only one problem. Accessories such as helmet, oxygen-dispensing system, and ventilation garment had to be developed almost *de novo* and integrated not only with each other but also with the aircraft, parachute and survival equipment, other cockpit accessories, and, of course, the wearer himself. Also the entire assembly had to withstand the windblast and other forces encountered during high-speed ejection and had to be easily donned and doffed. All this proved to be a truly monumental task, enlisting the best talents from a number

of scientific disciplines—electrical, mechanical, chemical, and textile engineers; physicians; physiologists; anthropologists; psychologists; etc.

In the course of the undertaking, many unique and unorthodox design approaches were imperative to achieve the required protection and mobility. Ingenious components such as distorted-angle fabrics, ozone-resistant plastics, multipurpose pneumatic controllers, airtight zipper closures, lightweight communications equipment, and fogproof helmet visors had to be developed and integrated into a completely functional system whose bulk and weight did not interfere with the pilot's activities.

The development of the helmet itself proved to be an extremely difficult undertaking. Proper vision, neck mobility, communication, crash protection, size, oxygen supply, carbon dioxide removal, feeding, integration with garment, windblast resistance, and heat removal had to be provided with minimum weight and minimum reduction in comfort.

Before the physical, physiological, and psychological evaluations of the completed garment could be undertaken at Dayton, Ohio, in the High Altitude Facility of the Aero Medical Laboratory, Wright Air Development Center, many new testing procedures were devised and instruments and equipment specially modified or developed. The first suit, the MC-2, was accepted in November 1957 as meeting most of the characteristics for life support at extreme altitudes (see photo). Here then for the first

Dr. John W. Heim, Ph.D. Harvard Medical School, is Chief of the Physiology Branch of the Aero Medical Laboratory, Wright Air Development Center, Air Research and Development Command. Before taking his doctorate in physiology in 1935, he had received the B.S. and M.S. degrees in electrical engineering from Pennsylvania State University and had taught that subject at Harvard University from 1926 to 1929. Dr. Heim assisted in the founding of the Aero Medical Laboratory in 1936. He is the author of numerous publications in physiology and aviation medicine. Otto Schueller has degrees in electrical engineering from the State College School, Linz, Austria, and in physics from the University of Vienna. During 27 years with industry and the German Air Force embracing the fields of ultraviolet and infrared radiation technique, automatic control, aeronautics and autopiloting, and high-vacuum technique, he produced numerous inventions leading to patents. Since 1956 Mr. Schueller has served the Aero Medical Laboratory as technical consultant in human protection against aeronautical and astronautical flight hazards. The Air Force has applied for patents based on his work on systems for operating space capsules. In 1958 he received a commendation from Wright Air Development Center for outstanding academic achievement in nuclear engineering.

time was a device that could be considered as a component of a protective assembly for extravehicular use in space.

Meanwhile data received from orbiting satellites concerning the physical parameters of space environments provided additional information necessary for the design of true space suits. Rapid development in rocketry, indicating the real possibility of flights to other planets, signifies the future necessity for life-support provisions on these extraterrestrial bodies.

A space suit will be needed for certain missions outside the vehicle such as assembling space stations and spacecraft, loading and unloading supply vehicles, repair and maintenance work on reconnaissance platforms, relay stations, and observatories, and operating weapons and instruments. Various types of space suits have been suggested, ranging from the silvered rubber garments of space fiction to serious engineering proposals of a metal suit with a heat dissipater and a translucent capsule with remote-controlled tools. Regardless of the final configuration the space assembly must protect the occupant from such hazards as extremes of temperature, lack of oxygen, radiation, and accelerative forces. It must provide food, water, waste disposal, propulsion, and communication and enable the performance of useful work.

The following proposal represents a concept of the Aero Medical Laboratory, Wright Air Development Center. It is based upon experience of the United States Air Force during the de-

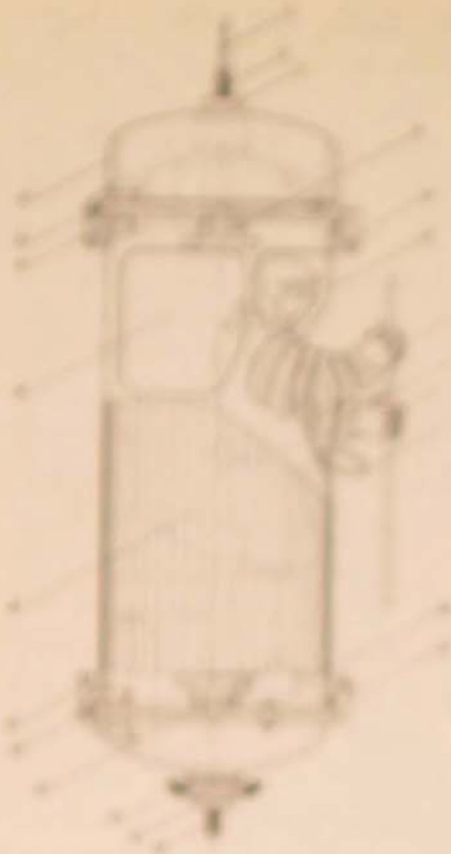
A modified MC-2 suit is shown in combination with a recirculating oxygen-conditioning system. This unit has a cooling capacity of 10,000 British thermal units (BTU) for heat removal during the re-entry period of flight. The exhaled water and perspiration are also utilized for cooling purposes.

velopment of pressurized cabins, pressure suits, and other related components in the complex field of human protection against the hazards of high-altitude and high-speed flight.

Competition between pressurized cabin and pressure suit has existed for many years and appears to arise again as a space suit becomes necessary. The fact is that each presents its own problems and that neither a pressurized cabin nor a pressure suit alone offers sufficient protection. Loss of cabin pressure (decompression) would be as fatal for the man as would rupture of his pressure suit. Yet mobility and comfort are by nature considerably restricted with pressurized suits. The USAF has solved this dilemma by providing the man in modern high-altitude, high-speed aircraft with a ventilated pressure suit having anti-g protection as previously described. The internal pressure in the suit is kept at approximately the same level as the cabin pressure. Thus double safety and unrestricted mobility are achieved during normal operation. In an emergency (decompression of the cabin or ejection at high altitude) the suit inflates, and the internal pressure is no longer balanced by the external pressure. This reduces mobility but still allows the activity necessary to bring the man back to the ground safely. This combination of a pressurized cabin and an emergency pressure suit has saved the lives of several pilots in the past. Considering the high risk of space flight, application of this well-proved principle seems reasonable.

The extreme environmental conditions and hazards of space flight necessitate a heavier weight of personal protective equipment. In the state of weightlessness a heavy mass is even advantageous, since it gives more stability to the motions of the man. On the other hand, the high fuel and weight penalty of the vehicle for transportation into space demands the utmost restriction of payload. One solution is to design the protective assembly as an integrated, multipurpose part of the transport vehicle.

As an example of this approach, which must be considered as only one of a number of possibilities, a multipurpose space capsule with pressure-compensated arm portions will be described. This assembly can serve as a space-worker suit, as a swiveling transport capsule to direct the man in the optimal transverse position against accelerations and decelerations, as emergency escape capsule during launching and re-entry, as recovery capsule, and also as entrance capsule to space stations. The capsule would be the only pressurized compartment for the man in the transport vehicle. This approach would make the design of the transport vehicle considerably easier and promises utmost reduction of total weight of

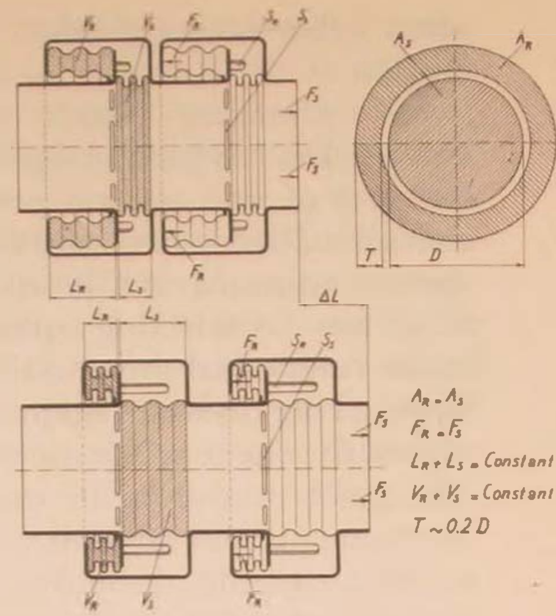


the vehicle and highest possible safety and comfort for the man during his entire mission.

The proposal is illustrated by the two drawings. Two problems of major significance, mobility and propulsion, will be discussed in some detail. Other details and explanations may be taken from the legends accompanying the drawings.

The first shows the capsule with the man in a working posi-

A_r cross-section area of convoluted rings
A_s cross-section area of sleeve
F_r elongation force on convoluted ring section
F_s elongation force on sleeve
L_r length of convoluted ring section
L_s length of convoluted sleeve section
S_r communication slits between capsule and outer space on rigid ring case
S_s communication slits between sleeve and convoluted ring section
T radial thickness of convoluted ring section
D diameter of sleeve
V_r volume of convoluted ring section
V_s volume of convoluted sleeve section



Drawings by Mr. Schueller.

tion. He wears an emergency pressure suit with ventilation garment similar to that described earlier. The helmet visor may be closed for safety during the working phase. The pressure in the capsule is approximately the same as in the suit, about 5 pounds per square inch (psi). Mobility and comfort are not restricted. Wide armholes are provided instead of complicated shoulder joints so that a large part of the complex shoulder and arm motions can be accomplished freely inside the capsule and the sleeves.

The second shows a cross section of the capsule with the man in relaxed position. He has opened the helmet visor and is drinking from a spring-loaded container designed for the state of weightlessness. The covers of the armholes can be locked for safety.

Above is a schematic diagram of the elements of the pressure-compensated arm portions. The most important physical tools of the space worker are his hands. The development of easily movable arm portions is therefore one of the major problems. The forces which act to extend pressurized members are surprisingly high. The elongation force on the trunk section of a pressure suit, pressurized with 5 psi, is approximately 1000 pounds. At normal atmospheric pressure (14.7 psi) these forces would be three times as great. Many attempts have been made to compensate these forces by use of capstans or to support the arms by cables or cords. Efficiency of all these devices is limited principally by the high friction of the cables when tightened around the capstans or along the curvatures of the body joints. The friction increases exponentially according to the same physical law which prevents a belt from sliding when it has been tightened around the wheel of a power transmission.

To eliminate friction entirely, a new pressure-compensated arm portion has been designed without sliding parts or cords. The elements of such an arm portion, as shown previously, consist of convoluted sleeve sections with convoluted ring tires around the sleeve, connected and protected by rigid (metallic) overlapping ring cases. By selecting equal cross sections, the elongation forces in the rings equal those in the sleeve and are directed by the overlapping ring cases one against the other. The internal pressure will extend the sleeve while the pressure in the rings acts to shorten it. The basic condition for easy mobility—constant volume during operation—is also satisfied. Any elongation of the sleeve causes an equal shortening of the rings and vice versa. Thus each change in the volume of the sleeve is compensated by an equal change in the volume of the communicating ring, and the total volume remains constant. Hence no work is required against the elongation forces caused by the pressure. Only the elastic forces and tensions in the convolutes have to be overcome.

Compared with remote-controlled manipulators, these pressure-compensated arm sections have the advantage that much space and weight are saved and that the work is accomplished within the arm's normal reach. These arm sections can also be used as pressure locks to take parts inside the capsule, e.g., instruments for repair. For this purpose one of the arms can be hinged on the outside of the capsule. A small relief valve would serve to equalize the pressure after the arm has been opened to outer space. But remote-controlled manipulators require full controls within the capsule if they are to perform the entire work range of human arms; also manipulators increase the distance of the man from the object of his work. Vacuum-tight, frictionless sleeves of the manipulators through the capsule walls also present some problems. A special pressure lock would also be necessary.

As long as the space worker is in contact with the vehicle or space station, he can move around by means of cables or hooks. But he should also be able to move independently away from the vehicle or space station. While assembling a space station or repairing it later, he will have to carry tools and parts and to place them in their right position. It would probably be impractical to do this by connecting each part and tool with the space worker, with the transport vehicle, and with the space station. This would result in a continuous pushing and pulling around of all the parts.

tools, men, and vehicles because each action would cause an equal reaction in the opposite direction. If a cable should slip or tear off from a moving part or even from the man, the part or man would move away forever, since there is no friction in outer space to stop any motion once induced.

Movement by walking or swimming motions is not feasible in outer space. Each motion of the body will cause turning or tumbling reactions, but its center of mass will not move one inch. Man can move in space only by using a propulsion system. A single swiveling reaction pistol would not be quite satisfactory. It would be too difficult to direct it always against the center of the mass, and if used in any other direction it would cause tumbling. To enable the space worker to move in any desired direction and distance without tumbling, a complex propulsion system would be necessary, consisting of a number of small rockets, or jets, and retrorockets with a control and stabilizing device. Any impulse given to the man would move him along infinitely until another impulse of the same magnitude but in opposite direction was applied. The control and stabilizing device should therefore provide with each impulse an equal counter impulse that can be released by the man at any desired instant. The control device could be actuated by a stick or pedals to free the arms for working.

Feet and legs are useless in space. The legs can only be used to induce some turning or tumbling motions of the body. But turns can also be effected by the propulsion system or by revolving masses or gyros. The movements of a space worker will be clumsy in any case because of the absence of gravity, even if in time he should acquire some skill. Therefore complicated movable leg sections on a space suit are not necessary, and leg room should be provided inside the shell. This makes the design simpler and increases safety and comfort.

Movable leg sections may eventually be attached should a suit for use on the lunar surface be desired. The types of suits that will be needed later for the exploration of the moon and planets will differ in a number of details from a space-worker suit for earth satellites because of the great differences in environmental conditions encountered on each of these new adventures.

Wright Air Development Center

The Past and Present of Soviet Military Doctrine

Dr. Kenneth R. Whiting

THE RISING influence of the Soviet armed forces—in the U.S.S.R., in the world, and out of it—demands the closest examination of Soviet military doctrine. It is, like other military doctrines, a hybrid of past and present. This bifocal view of the subject underlies the division of this article into Part I—the permanent factors in Soviet military doctrine and its historical development, and Part II—present-day doctrine insofar as our information and reasonable conjecture will take us.

Part I.
Permanent Factors and Historical Development

What is Soviet military doctrine? What has emerged as Soviet military doctrine is an interaction of the permanent geographical and historical factors with the philosophical tenets of Communism and the economic-technological development of the Soviet Union in the last forty-two years. The geographical and historical factors, inherited by the Bolsheviks when they came to power in 1917, were so firmly embedded in the national fabric that they could not be discarded. The economic inheritance could be, and was, transformed to a considerable degree. The philosophical tenets of Marxism, which assumed a chameleonlike flexibility in the hands of Lenin and Stalin, were also adjustable to some degree. These four factors provide the underlying strengths of Soviet military doctrine as well as its limitations.

permanent factors

Geography. The Russian homeland (i.e., European Russia) is a great plain with practically no natural defensive barriers in the east or west. From the earliest historical times the Russian plain was a highway for migrations and invasions, and the Slavs were usually the victims. Until the fifteenth century the invasions were usually from Central Asia through the Ural-Caspian gateway, the Mongol invasion being the outstanding one. Later attacks came from the west—Poles, Germans, and Swedes—and finally the Turks invaded from the south. That is the negative side of Russia's geographic position. On the positive side Russia has been an expanding power since the fifteenth century and the frontier has moved in much the same manner as that of the United States.

In the middle of the fifteenth century the nucleus of what became the Russian Empire consisted of the rather meager holdings of the Grand Dukes of Moscow. By the end of the sixteenth century the Grand Duchy of Moscow had extended its holdings across the Volga Valley and up to the lowlands of Western Siberia. All of Siberia was included in the Russian state by the end of the seventeenth century. In the next two centuries the Russians pushed into the Caucasus, conquered Finland and Central Asia. By 1914 the map of Russia resembled that of today.

Unlike the United States with two great oceans as protective moats, Russia had to fend off invasions and protect acquisitions by developing into an enormous "armed camp." The whole structure of the Russian state came to resemble that of an army in a continuous state of war. Like all armies it required a unified command to act effectively; the Tsar was primarily a military commander.

The great plain of Russia may have few natural barriers but it does have vast space. Russian strategists have been able to trade this space for time—time to mobilize their enormous manpower.

Climate. "Father Winter" has been a staunch ally in time of need. Few people fully realize how much a "northern power" Russia is. In addition to its position in the upper latitudes, nature seems to have conspired to make things even worse. Mountain ranges stretching from the eastern end of the Black Sea to the

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Chukotsky Peninsula cut off the warm air masses from the tropics. If these mountain ranges along the southern borders of the Soviet Union and in Eastern Siberia are visualized as bleachers extending from third to first base around home plate, then the great plain of European Russia and Western Siberia is comparable to the ball field. Since this great plain slopes away to the Arctic Ocean, there is nothing to stop the Arctic air masses from flowing over it. It is not surprising that Alexander Nevsky in the thirteenth century defeated the Teutonic knights on the ice of Lake Peipus, that Napoleon's Grand Army froze to death in 1812, and that Hitler's panzer divisions were frozen to a halt before Moscow in 1941.

Manpower. Because of the fecundity of the Slav, large masses of manpower have always been available. Thus the natural strategy has been to overwhelm the enemy rather than outsmart him. In World War I the Tsarist generals ground up millions of men on the Eastern Front to offset the German superiority in armaments and strategy. In World War II the Soviet generals returned to the bone-crushing Tsarist strategy—the use of superior manpower to get victory.

Russia was always backward economically under the Tsars. Peter the Great strove mightily to rectify that condition and succeeded temporarily, but his successors let things slip. The disastrous defeats suffered in the Crimean War and at the hands of Japan in 1905 showed that even unlimited manpower could not cope with technological superiority. As shall be seen, Stalin took that lesson to heart when he came to power in the 1920's.

historical development under Communism

What happened, from 1917, when a new philosophical base was put under the geographical, historical, and economic factors just discussed? At the outset the Bolsheviks had an entirely negative approach to the military problem—their goal was to destroy the army as the bulwark of the Provisional Government, and they succeeded. By the clever dodge of advocating an immediate redistribution of land to the peasants, they caused the peasant army to melt away. As Lenin put it, the army voted for peace with its legs. But this left the new state naked in a world that had little respect for those lacking the instruments of military power. It was necessary to build a new army, the Red Army, to face the resurgent Whites and the intervention of the Allies. There is not space to go into the strategy of the Civil War and the creation of the Red

Army except to mention that Trotsky's genius as a military organizer plus the sheer stupidity of the Whites and the Allies enabled the Reds to emerge victorious.

Frunze's doctrine. At the end of the Civil War there ensued a doctrinal hassle of monumental proportions, the only open doctrinal struggle in Soviet military history. In the process of fighting the Civil War the Red military leaders developed many new ideas, or at least thought they had. One group, led by Frunze and including Tukhachevsky, Voroshilov, and Stalin, asserted in 1924 that the new proletarian state called for a new military doctrine. Trotsky and most of the former Tsarist officers who had joined the Red Army held that the new army had all it could do for the time being to assimilate the best of foreign military doctrine.

According to Frunze, the whole character of a nation's army—its organizational structure, training, tactics, and strategy—flowed automatically from the class character of the state, above all from its economic structure. Therefore the military doctrine of the newly fledged proletarian state should have these provisions:

- The main emphasis should be upon the offensive, especially in anticipation of the aid to be expected from the proletariat of the enemy bourgeois states.
- Armies should be made up of small units and have a minimum of cumbersome centralization, thereby stressing maneuverability.
- Preparations should be made for carrying on guerrilla warfare in the probable theaters of war within the Soviet Union.
- Great emphasis should be put on cavalry because of its mobility (later, mechanized forces replaced the cavalry in this concept).

This doctrine obviously reflects the horror of emulating the costly positional warfare of World War I on the Western Front, and a fondness for the guerrilla warfare of the Russian Civil War.

Trotsky and his professionals hit this doctrine in its weakest spot—its derivation solely from the strategy of the Civil War. Said Trotsky: the strategy of maneuverability was followed by both the Reds and Whites and thus did not flow automatically from the class character of the proletarian state. In truth, as a result of the enormous areas of the combat theaters, the small numbers of combatants engaged, and the poor communications, the strategy of maneuverability had been inevitable. Furthermore the poor officer material was the reason for the many rapid advances and retreats that made it necessary to fight two or three times over each area. Trotsky also argued that extreme emphasis on the offensive was out of the question for some time to come; the backbone of the army was the peasant and he would not fight well except in defense of Russian soil. (In 1941 Stalin found this to be a profound analysis —fight for Holy Russia, the Motherland, yes! For the Party and Communism, hardly!)

Frunze's doctrine in operation. Frunze and his group won, if for no other reason than that Stalin wanted Trotsky out as Commissar of War. From 1924 to at least 1937 the Red Army was nurtured ostensibly on Frunze's military doctrine. Frunze died in 1925 while undergoing an operation "ordered" by the Politburo, becoming perhaps the victim of the first "Doctors' Plot." He was succeeded by Voroshilov, a friend of Stalin, who sat a horse beautifully, but the brains in the Commissariat of War were supplied by Tukhachevsky, the Deputy Commissar.

There had been influences running counter to Frunze's somewhat naive doctrine. Most of the high-level teaching was done at the Frunze Military Academy after 1925, and it was largely in the hands of former Tsarist officers. Shaposhnikov, a former Tsarist staff officer who was reputed to have masterminded much of the Civil War strategy, was so brilliant that even Stalin and Molotov attended his lectures in the 1930's. Under the influence of such teachers it was not long before foreign theorists were being read in the Soviet military academies. Clausewitz, the favorite of Engels and Lenin, was again in high esteem; Jomini, von Moltke, Fuller, and Douhet were also carefully studied, and there was even a Douhet group in the air force. Finally, the real head of the Red Army was a former Tsarist officer, Tukhachevsky. Although an ardent Communist, he never let dogma stand in the way of his military judgment.

During this period there were also close ties between the Red Army and the German Wehrmacht. Most of the top personnel of the Red Army went through the German General Staff School in Berlin, and, although many of these officers were purged in 1937, their influence and teachings lived on. Thus on the eve of World War II the doctrinal concepts of Frunze had been modified by the teachings of the former Tsarist military leaders, the study of foreign theorists, and the close association with the Wehrmacht.

Frunze's integration concept. Frunze left another and more potent legacy as part of his military doctrine: the concept of the complete integration of all the elements of power within the state so that the leaders could exert the entire strength of the nation upon any goal they chose. In a speech to the Red Army Academy in 1924 he stated that "future work must be concentrated on planning for the mobilization of the economy of the country . . . it must militarize all our Soviet work from economy to education." In his essay, "The Front and Rear," Frunze asserted that the Soviet Union needed a strong military force both to defend itself and to carry the revolution abroad. He insisted with equal vehemence that the rear was as important as the front, even more so in modern warfare, and very hard to demarcate since the advent of the aircraft. The industrial buildup of the rear must precede a war, as materiel in-being would probably be the decisive factor.

Stalin in 1928 went along with this concept and saw to it that the economic objectives of the Five-Year Plans gave the military a high priority. Heavy industry, badly needed if the Red Army was to attain technological parity with West European armies, got all the emphasis. Its primacy over the shortchanged consumer-goods industry has been a continuing trend in the Soviet Union. By 1934 the results of the First Five-Year Plan were being felt in the Red Army. From 1923 to 1934 the poverty-stricken Red Army consisted of a cadre army of half a million and a territorial militia of a million and a half. But from 1935 the situation was reversed. The weapons and supplies were now available to increase the size of the regime's favorite child.

Party supremacy over military. Giving all to the favorite child is one thing, but how well the indulged brat behaves is another. Ever since Trotsky dragooned a number of former Tsarist officers into the Red Army, it had been deemed necessary to have political commissars within the army to ensure the loyalty of the troops to the regime. The commissars were the eyes and ears of the Communist Party within the army, as well as its mouth—in short, they were spies and propagandists. As the officer corps became more professionalized, it came to resent these political busybodies. By 1937 Stalin felt that the nonpolitical officers in the Red Army had gotten out of hand. He attacked the army leadership with insane fury. When the purge of 1937-38 was over, the Red Army had lost three marshals, including Tukhachevsky, most of its Supreme Military Council, about 90 per cent of the officers above the rank of colonel, about 80 per cent of its colonels, and some 30,000 officers of lower rank. Whether this hurt the Red Army in the long run is a moot point. Certainly nobody could complain of an overage, fossilized upper echelon of officers in the Red Army after Stalin got through with it. Furthermore no one any longer questioned the Party control of the army after 1938, since only the Party faithful among the army leaders survived this holocaust.

Demise of Frunze's doctrine. The supreme test of Soviet military doctrine came in June 1941 when Hitler's Nazi hordes came crashing over the Soviet borders. In spite of all the balderdash about new doctrine and concepts being automatic with a change in the social structure, the Soviet strategy and tactics of the "Great Fatherland War" differed little from those of their German opponents. The much-vaunted Stalin formula for victory really came down to the advantages of ruthlessly exploiting superiority in numbers (tanks, guns, planes, and men). Neither side showed any originality in its use of air power, and even the Frunze-Tukhachevsky dictum of avoiding positional warfare went by the board; the only places where Soviet armies could stop the German onslaughts in 1941-42 were at fortified positions such as Leningrad, Moscow, and Stalingrad. By 1943 and 1944 bitter experience had made a shambles of the Frunze doctrine so confidently put forth in 1924. The Soviet leaders were back to the bone-crushing Tsarist strategy —the use of vast quantities of cannon fodder and metal to gain victory.

Stalin also found that another of Trotsky's arguments was valid—the Russian peasant was not about to fight to the death for Communism, and the mass surrenders of 1941 proved it. A quick switch was made and every stop on the patriotic organ was pulled out: the Motherland was being violated by the Fascist beast! The Nazis, for their part, did their best to make the "Fascist beast" of the slogan a reality.

Stalin's doctrine. As soon as the war was over Soviet propaganda media began attributing the victory to Stalin and the Party. The outstanding hero of the war, Zhukov, was quickly hidden in the provinces and "operation rewrite" went all-out in the glorification of Stalin as the greatest military genius of all time. Stalin's military doctrine was credited with guiding the Red Army to victory. The old tiger had not shed his stripes, and just as in 1924 he had backed the doctrine that derived its tenets entirely from the Civil War, now he evolved a doctrine based solely on Soviet experience in the "Great Fatherland War." He decided there was no need for Soviet theorists to look at the strategies of the Americans and the British, for after all they had played only a minor role in the victory. All the military theorist had to do was apply Stalin's "permanently operating factors for victory" to the Soviet-German part of World War II and he would have all the answers.

Thus from 1945 to 1955, a whole decade during which the instruments of warfare were undergoing their most rapid evolution, Soviet doctrine stood still. Even more strangely, the Soviets themselves were developing weapon systems that cried out for new doctrine—jet fighters, nuclear weapons, and long-range jet bombers. In the midst of this plethora of radically new weapon systems at home and abroad, the theorists continued to chant the litany of Stalin's five "permanently operating factors for victory":

- stability of the rear,
- morale of the army,
- quantity and quality of army divisions,
- armaments of the army,
- organizational and leadership ability of the command personnel.

These factors were neither original with Stalin and the Russians nor hardly the sole property of the Communist world.

Stalin's doctrine in operation. But was Stalin's doctrine quite as backward and obtuse as has been generally assumed? An examination of the actual situation from 1945 to 1953 reveals that the Soviet Union had few nuclear weapons and no real delivery capability during this period. Furthermore, toward the end of the war the main Soviet objective was to occupy as much of Europe as possible. They got plenty but not as much as they wanted, as their little gambits in Greece, Turkey, and Iran indicated. Having obtained this huge territory and needing time to digest it, did the Soviets need a new doctrine? Their main goal was to keep control of the newly acquired regions until they could incorporate them solidly within their orbit. Large land forces and a preponderantly tactical air force were the ideal instruments for accomplishing this task. Even since Stalin's death (1953), the uprisings in East Germany, Poland, and Hungary have been best put down by masses of hard-hitting, highly mobile troops.

Were Stalin and his close advisers quite as stagnant even in their preparations for modern war as their public doctrine implied? This question poses the perpetual dilemma in assessing Soviet doctrine—the difference existing between public expression and secret action. If Stalinist thinking was stagnant and his doctrine backward-looking, why were so much research and development money and so many technical personnel committed to weapons not encompassed by the doctrine? Official answers are nonexistent. A possible answer is provided by Lieutenant Colonel Tokaev, an aeronautical engineer, who was engaged in the Soviet counterpart of our own Operation Paperclip (the rounding up of German technicians and scientists). He states that while he was reporting on this project to the Politburo in 1947, Stalin interrogated him very closely on the Sänger Project. This concerned a German engineer's plan for an aircraft with better than intercontinental range. According to Tokaev, Stalin said:

> We need aircraft of the Sänger type and, if this project can be realized in practice, we must do it. If we have such aircraft, it will be easier to talk to Truman. We may be able to quiet him down.

At a meeting with Malenkov and Khrunichev, the Minister of Aviation Industry, Tokaev says that Malenkov asked Khrunichev how rocket development was coming along. Khrunichev replied that he thought they ought to finish up their tests on the V-2 before going into other commitments. "V-2's," cried Malenkov, "I am not satisfied with your V-2's. Do you think we are going to fight Poland? What we need are missiles capable of crossing the Atlantic."

This is certainly dubious evidence, but when it is juxtaposed with Soviet weapon developments at least the spirit seems correct even if the documentation would hardly satisfy academic standards.

The actual hardware development in the Soviet Union since 1945 refutes those who label the period 1945-53 as one of Stalinist stagnation. By 1949 the Soviets had an atomic device and by 1953 were in the thermonuclear business. We know from our own experience that such programs are not initiated, developed, and successfully concluded without the diversion of enormous sums of money, hordes of scientists and technicians, and a large segment of material from the other facets of national production. This was even more true in the Soviet Union, which was trying to recover from the hideous damages of World War II and which even today has far less national income than the United States. In this same period the main line of aircraft development was jet interceptors —understandable for a power confronted by SAC. But even more to the point, sometime in the late 1940's, during Stalin's regime, plans were developed for long-range bombers such as the Bison, Badger, and Bear. These did not come into being in a day, even if we give the Soviets credit for a much more rapid development from concept to production than we have, and I think we have already sufficiently exaggerated their agility in this field. Lastly, the state of Soviet missile development in the past few years is positive proof that missile planning and development must have been making good progress under Stalin. All in all, there is little basis for the stagnation view.

Does it not appear, then, that the "permanently operating factors for victory" of Stalinist doctrine were merely clichés and hardly the basis for an imaginative use of the new weapons in development or in-being? Stalin seems to have operated far more wisely under the facade of this doctrine than has been generally assumed. He obviously devoted a great deal of material and personnel to the development of new weapons at a time when both were extremely scarce in the Soviet Union. For the military needs of the 1945-53 period, the forces blessed by the Stalinist doctrine were very adequate.

Stalin's integral concept. Above and beyond that which is generally encompassed in a military doctrine, however, the really important legacy that Stalin handed on to his successors was the highly integrated political-economic-military unit called the Soviet Union. He had carried to the ultimate Clausewitz's dictum that war is a continuation of politics by more forceful means. Stalin's concept was that a state should have an integral strategy: all the elements of power should be so compounded in the state as to facilitate their concentration in carrying out the objectives of the state with the least possible confusion and friction. This integral strategy took the whole of Soviet industrial production, education, propaganda media, and diplomacy and welded them into a well-synchronized political-military machine obedient to the direction of the leader.

Part II. Current Soviet Military Doctrine

Historians tend to divide Soviet history into convenient periods, and Stalin's death on 5 March 1953 marks the end of the period dubbed "Stalinist Socialism." There can be little doubt that in his last years the aging despot had fossilized a good bit and was attempting to cram the whole Soviet Union into a mold consistent with his own pathological conceptions. In spite of the general relaxation that followed his death, the military theorists, at least in their published writings, still gave obeisance to the Stalinist quintet of factors. Thus on the surface the 1953-55 period looked much the same as the preceding decade.

modernizing Stalin's doctrine

Recognizing foreign doctrine. But beneath the surface placidity a storm was brewing. In the top Soviet military periodical, *Military Thought (Voennaya Mysl')*, an article by Major General Talensky, the editor, set off a debate over the "laws of military science." Talensky advocated looking abroad for information and ideas on military theory, apparently believing that the Stalinist doctrine could stand such an infusion. Fundamentally it was the same question that Trotsky and Frunze had so hotly debated in the early Twenties: Could the Marxist military thinker learn anything worthwhile from the capitalist military thinkers? Were Stalin's "permanently operating factors for victory" the ultimate stage in military thought, and were the strategical lessons of Soviet operations in World War II sufficiently timeless to provide the basis for all further strategy? This debate, coming as it did when the Soviet world was just emerging from under Stalin's heavy hand, was earth-shaking in its import.

Then in February 1955 a number of significant events occurred: Marshal of Tanks Rotmistrov, head of the Stalin Armored Forces Academy, published an article in *Military Thought* entitled "On the Role of Surprise in Modern Warfare"; Marshal Sokolovsky, Chief of the General Staff, published an article in *News (Izvestia)* on the importance of surprise and the value of studying the military doctrines of foreign powers; Marshal Zhukov was made Minister of Defense; Malenkov was ousted and succeeded by Khrushchev. The relationship of these events and their importance in changing Soviet military doctrine need examination.

Recognizing surprise. Rotmistrov's article brought the so-called "transitory" factor of surprise out into the open. He did not assert that it was a decisive factor in the outcome of a war but that with long-range aircraft and nuclear weapons it could be extremely important. This being the case, Soviet strategy must consider how to lessen or even eradicate this threat. A "preemptive" blow against the enemy's air bases seemed to be the only answer that promised security from surprise. Of course, a "preemptive" blow is only delivered when the enemy is definitely set to attack you and you beat him to the punch. In March 1955 Rotmistrov completed his demolition of the tyranny of Stalin's five constant factors in an article in *Red Star (Krasnaya Zvezda)*. He stated bluntly that studies which barely mentioned the factor of surprise could hardly be termed a creative approach to military doctrine.

Sokolovsky took the same line. It was no longer feasible to base your strategy entirely upon history and the experience of past wars; the recent developments in weapons and strategies in both the Soviet Union and foreign countries must be studied and their lessons applied. Surprise had become so important that the enemy must be deprived of that advantage.

Changes in leadership. The probable reason for this new approach in Soviet military literature was Zhukov's promotion to Minister of Defense in February. Apparently he stepped in and threw his weight on the side of the "new doctrine," thus forcing *Military Thought* to publish Rotmistrov's article and end the vigorously contested subsurface battle that had been going on since Talensky's opening move in 1953.

Digging even more deeply, we come to Soviet politics. All the evidence seems to indicate that Malenkov was convinced that the Soviet acquisition of long-range aircraft and nuclear weapons meant that the age of "mutual deterrence" had come. It would be safe beneath this shield to ease up on the military budget, to lessen the overemphasis upon heavy industry, and to turn increased attention to the output of consumer goods. In 1954 he even went so far as to speak of the "mutual destruction," not just the destruction of capitalism, that would occur if a nuclear exchange took place. Khrushchev took the diametrically opposite tack. He advocated an even bigger military budget and continuing emphasis on the development of heavy industry. The net result was that the military opted for Khrushchev. Malenkov was officially dumped in February 1955. Incidentally, the only part of the military that seems to have been in support of Malenkov was the Zhukovsky Air Academy. Malenkov, in line with his policy of reliance upon nuclear deterrence, had been in favor of more emphasis on the air arm at the expense of the sister services.

Thus the series of events that took place in February 1955 was conducive to letting a little fresh air into Soviet military doctrine. That the concepts had been extant in the upper echelons of both government and armed forces would seem to have been borne out by the weapon developments since 1945. But now the time had come to let everyone in on the new ways of thinking and acting.

"Active defense" thesis. Another piece of evidence of the changing attitude toward the factor of surprise was the new way of looking at Hitler's surprise attack on the Soviet Union in June 1941. One of the six departments of the General Staff is the Historical Section, and it plays an important role in the evolution of

Soviet military doctrine. From 1945 to about 1954 its main job was to study the strategy and tactics of the Soviet-German conflict in World War II and to bolster the perfection of the Stalinist "permanently operating factors" and show how they led to victory. One of its most difficult tasks was to account for the disastrous events that occurred between June and December 1941 when half of European Russia fell into German hands. Under the Stalinist whip, the historians rose to the task and developed a thesis of "active defense." According to this thesis the Russians drew the Germans deep into the heart of the country, bleeding them white in the process. Once they had them far from their bases and their supply line greatly overextended, the Soviets used their superior reserves to destroy them. Neat, but a mighty expensive way of fighting a war.

In 1956 the Ministry of Defense published a book entitled "The Most Important Operations of the Great Fatherland War." Its authors, all generals and colonels, demolished the "active defense" thesis. This is how they saw it:

> . . . it is necessary to mention that in the early period of the war the German-Fascist army succeeded in gaining the initiative, occupied an enormous amount of territory, cut through to the vital centers of the country, and achieved great results. The combat operations of the Soviet armies in this period had the character of retreating actions and not active defense as it is incorrectly asserted in our literature. The retreat of our armies into the depths of the country was caused by the fact that the attack of the Hitlerite army on our country caught the Soviet armies of the border regions unprepared to stop the aggressor. The calamities which befell the Soviet armies early in the war were the consequences of the mistakes of a strategical and operational-tactical character, and of faults in routine training for conducting a particular type of operation against a strong and technologically well-equipped enemy.*

And this is from a book that has since been unfavorably reviewed in the Soviet press for not being more critical of the "cult of the personality," i.e., condemnation of Stalin.

current official doctrine

Fortunately it is possible to get out of the realm of conjecture to some extent in summarizing the Soviet military doctrine that is official today. On 12 August 1958 a Colonel I. Korotkov published

*Col. P. A. Zhilin, (editor), *Vasheyshie Operatsii Velikoy Otechestvennoy Voyny* (Moscow, 1956), p. 11.

an article in *Soviet Aviation (Sovetskaya Aviatsiya)* entitled "About the Fundamental Factors Which Determine the Course and Outcome of War," which presents current official doctrine in some detail. Korotkov points out that although Stalin's "permanently operating factors" were good in their day and a contribution to Soviet military science, they are not fixed once and for all. Any one of these factors can change in its importance or new ones arise. With the appearance of atomic and rocket weapons they have changed, and changed radically.

Korotkov then divides the factors determining the course and outcome of war into two groups: sociopolitical and military. In the sociopolitical group are (1) the economic power of the state, (2) the social and political structure of the state, and (3) the position of the country (or group of countries) in world affairs.

Sociopolitical factors. As far as economic power is concerned, Korotkov thinks the Soviet Union is doing very well indeed, especially since it has broken out of the "capitalist encirclement" and now heads a world system of socialist states. It is gaining on the capitalist world because of its emphasis upon the tools and means of production. Being a planned economy, it can maximize the use of modern science and technology.

The social and political structure of the Soviet Union, writes Korotkov, is the best form of organization for utilizing the production factors in the preparation for and the conduct of war. Economic conditions, however favorable, will not lead to victory if proper guidance is lacking. Fortunately, he says, the Communist Party supplies this in the Soviet Union. It had the foresight to build up heavy industry and the armed forces before World War II, was able to mobilize and lead industry and the population during the war, and since the war it has continued its emphasis on heavy industry and the strengthening of the defensive capability of the country. The triumphant teaching of Marx-Leninism is the basis of the ideological unity of the countries of the socialist camp.

Finally, the international situation has an enormous influence on the course and outcome of war. Korotkov states that "the demands of the progressive forces for peace played a colossal role in stopping the aggression of the imperialists in Indo-China, Korea, and Egypt." The concord between the Soviet Union and China on one side and the Soviet Union and the Warsaw Pact countries on the other has enhanced the position of the U.S.S.R. as a world power and thus its influence on the course and outcome of war.

Military factors. In the group of military factors Korotkov enumerates the usual Stalinist factors but gives some of them a new twist. In discussing the quantity and quality of personnel, armaments, and technology, he devotes most of his space to technology. The state must have large numbers of scientists, engineers, and technicians to produce the tools and technological equipment needed in modern war. The Communist Party has put and is putting great efforts into training these groups more rapidly than is being done in capitalist countries.

In addition to the Stalinist factors, Korotkov has three new factors: space (distance), surprise, and time. Space, in future warfare, will not lose its importance in spite of nuclear weapons, rockets, and supersonic aviation. A large territory allows a wide dispersal of industry and population and lessens their vulnerability to destruction by nuclear weapons. In this respect the Soviet Union, as other countries with a relatively low density of population, is in a favorable position compared to West European states.

The factor of surprise has especially increased its role in modern war. Unexpected attack using the new weapons on a mass scale, unexpected maneuvers, etc., are all possible at present. The improvements in offensive weapons make surprise operations much more dangerous in their consequences.

The factor of time has also been strengthened, in both Soviet and the opponent's calculations. The basis of all military operations is a calculation in time and distance. The mobility of the various military services and the increase in the destructive power of weapon systems mean that the outcome of operations will depend to an ever greater degree upon the ability to use the factor of time. For example, to be late with counteroperations could in many cases mean strategic as well as tactical defeat.

All these sociopolitical and military factors are interdependent to an extremely high degree. For example, the findings of the sociopolitical scientists must be taken into consideration in military science. Such sociopolitical factors as the training of cadres of technicians, the amount of investment in the various branches of industry, etc., must be calculated carefully with military objectives in mind.

Korotkov's summary of Soviet military doctrine brings the present doctrine much closer to that of the Western world. The main differences would seem to lie in the greater synchronization of Soviet economic and social life with the military effort and the continued emphasis upon large ground forces.

doctrine and Soviet world strategy objectives

Self-preservation. This assessment of Soviet military doctrine as it exists today must of necessity be related to the over-all objectives of Soviet world strategy. The most fundamental of these strategic objectives seems to be the preservation of the Soviet Union relatively intact. This derives both from the primary urge toward survival and from the ideological concept of the U.S.S.R. as the homeland and main fortress of world Communism. A corollary of this would seem to be that the Soviets will not unleash an all-out nuclear war unless they are reasonably certain that this first objective is secure. However, as Garthoff has pointed out in his latest book,* the Soviet Union in the relatively short period of the last six months of 1941 became the only major power to have undergone anything similar to a nuclear holocaust and emerged victorious. Thus "relatively intact" may have a different meaning for the military strategists in the Soviet Union than for their opposites in the Pentagon. The most spectacular civilian tragedy within the limits of the United States during World War II was a B-25 collision with the Empire State Building.

Expansionism. The second over-all objective of the Soviet Union is to expand its empire. This expansion may be a continuation of the imperial expansion of Tsarist Russia, or a more grandiose scheme for world dominion with an ideological base in the Communist version of the Church militant. One thing that does seem certain is the fundamentally realistic way in which the Kremlin leaders have used the ideological weapon. When Stalin asked how many divisions the Pope had, I think he showed his own evaluation of ideology versus force in the present scheme of things. Maybe at the end of four hard years of murderous conflict Stalin tended to downgrade the value of ideology. His concept seemed to be that Communist expansion would come in contiguous areas and largely through military help from the Soviet Union. When he chided Tito in 1948 for bragging about the communization of Yugoslavia in contrast to the work of the comrades in France and Italy, Stalin pointed out that the French and Italian comrades had no Red Army help so had to rely solely on ideological weapons (which he apparently thought were insufficient).

Matching strategy, doctrine, force. The ideological and the military aspects of Soviet expansion both take for granted an unremitting pressure to extend the authority of the Kremlin,

*Dr. Raymond Garthoff, *Soviet Strategy in the Nuclear Age* (New York: Praeger, 1958).

either as the GHQ of the Communist world revolution or as the capital of the Soviet Union, or both. It is this aspect of Soviet over-all strategy that ties in with Soviet military doctrine, for a thoroughgoing *offensive* doctrine must differ from a basically *defensive* one in the kind of force structure it demands. If the Soviets were entirely defensive-minded, they could discard a good bit of their ground force and tactical air—and make good use of the saving in steel and manpower. If, however, the Soviets are primarily interested in preserving their territorial gains and in further gains in areas contiguous to the U.S.S.R. and its bloc, then the large ground force and tactical air elements of the force structure look logical, even in the event of an all-out war. If this concept were taken to its extreme, one could postulate a situation in which a large percentage of both the United States and the Soviet Union was destroyed in a holocaust but the Soviet Union ended up with firm control over a relatively undamaged Western Europe and Middle East by reason of its ground forces. Then even all-out war would not have been absolutely fatal to the Soviet Union as a world power.

Nuclear-war manpower. In 1956 Lieutenant General Krasil'nikov declared that nuclear warfare called not for a reduction in manpower but for an increase. There are two reasons for this: First, the danger that entire divisions may be wiped out had increased with the growth in the destructive power of offensive weapons, and large reserves would be needed for replacements; second, strategic fronts in modern war would have a tendency to encompass not one but several continents. Inasmuch as the Soviets would have great difficulty in getting army divisions into the Western Hemisphere, one must assume that Krasil'nikov was referring to the continents of Europe, Asia, and Africa. Soviet missiles and aircraft could destroy enemy bases in these areas, but if the objective was to incorporate these areas into the Soviet empire, then ground forces would be more useful.

Probably from the Soviet point of view this strategy for empire-building is the poorer of two alternatives. The other is that the Soviet long-range striking power can intimidate the Western world into immobility while the periphery of the Eurasian continent is nibbled away by the occupants of the Heartland—Russia and China. Under this alternative the large ground force with tactical air is the ideal instrument.

from defense to offense in military doctrine

Stalin's defensiveness. Except for the mopping up operations involved in incorporating Czechoslovakia into the satellite belt in 1948, Stalin's policies after 1945 were largely defensive—he wanted to hold on to his acquisitions and incorporate them into his system. The Greek and Korean incidents, both by proxy, and the tentative move into northern Iran would seem to confirm this thesis. Nowhere did he use Soviet armed forces on any scale. Even when all three of these attempts failed, there appears to have been no Kremlin enthusiasm for bailing out the proxies with direct use of Soviet troops. These were limited wars and Stalin was a stickler for the rules of limited war: when a gamble goes bad you do not bet more than the pot is worth to you. As a Marxist he was firmly convinced that history was with him in the long pull.

But things have changed in the Soviet empire since the early postwar days. The productive capacity of the Soviet Union has risen by leaps and bounds. The Soviets feel that they now have, or are nearing, parity with the West in nuclear weapons and the means of delivery. The satellites are now incorporated—they may rumble a bit now and then but they are relatively well subjugated. Soviet policy in the Middle East is making significant gains.

Post-1955 offensiveness. Probably the outstanding feature of Soviet military doctrine since 1955 is its *offensiveness.* It is hard to pin this down in chapter and verse but a bit here and there add up to a total that is impressive. A good example is the changed attitude toward the old bête noire, "capitalistic encirclement."

Back in the very early Twenties Lenin stated that the Soviet Union "was an oasis in the middle of a stormy sea [*sic*] of imperialistic rapaciousness." All through the 1930's Stalin beat the drum of capitalist encirclement as he flogged the population on in building ever stouter ramparts for the protection of "socialism in one country." In 1939 the rationale given for the Molotov-Ribbentrop Pact was the attempt of the Soviets to break up the unity of the capitalist encirclement. In the immediate postwar years the seizure of the so-called "platforms of invasion" was to thwart the capitalist encirclement.

But all is different now. The new attitude is stated by a Colonel Dzyuba in *Soviet Aviation* for 16 August 1958 in answer to the query of three comrade officers as to what capitalist encirclement meant and whether it still existed. He replied that since the formation of the new world system of socialism—the satellites and China, a system containing 26 per cent of the earth's dry surface, 35 per cent of its population, and 33 per cent of its industrial production—it is no longer correct to speak of capitalist encirclement. The Socialist world now exists alongside the imperialist camp, not encircled by it. He then quotes Khrushchev's interview with a correspondent of the French newspaper, *Figaro:*

> With the formation of the world system of socialism the world situation has changed radically. And the change, as you know, has not been in favor of capitalism. Now it is unknown who encircles whom: whether the capitalist countries surround the socialist states or vice versa. It is impossible to regard the socialist countries as islands in the midst of the rough capitalist ocean. In the socialist countries there live a billion of the earth's two and a half billion people. And so many people in the other countries stand in socialist positions!

deterrence

"Pre-emptive" doctrine. Soviet writing in the last few years and even more trustworthy evidence, their actions, indicate that they have studied all the nuances connected with deterrence. But the Soviets know that there is no such thing as an absolute deterrent. A deterrent is something that discourages an action, but it does not absolutely prevent it. Soviet theoreticians assume that to attain a break-even point under the present conditions would require a "pre-emptive" strike. The goal for the last few years has been the attainment of a level in nuclear weapons and delivery systems that would give them the capability of striking the "pre-emptive" blow. The fundamental question between Malenkov and Khrushchev was on this point. Malenkov felt that retaliatory capability would keep the U.S.S.R. safe; Khrushchev wanted more, namely, the ability to strike a crippling "pre-emptive" blow with a good chance of eventual victory.

Fundamentally there are two things wrong with the "pre-emptive" doctrine. First, it is basically a defensive doctrine, and no Marxist likes that. Second, is there any such thing as a viable "pre-emptive" doctrine? Such a doctrine assumes that one can ascertain when the enemy is going to strike and forestall him at the last minute. The history of the last war is not very encouraging on this point. The Soviets could not even detect a hundred or more German divisions poised on their own frontier in June 1941, and the United States could not even find a whole Japanese fleet off Hawaii in the same year. In the modern world both the United States and the Soviet Union have their attacking power in-being at all times. The job of intelligence is infinitely harder than in 1941. Just how can one tell when a strike is imminent and "pre-empt" it?

"Preventive war." This being the case, why not take the "pre-emptive" doctrine one step further to "preventive war"? Now one avoids the horrible intelligence problems involved with the "pre-emptive" doctrine. But one does need either the means of absolutely destroying the opponent's offensive power or of being retaliation-proof. If one has both, then that nation is really well off. That the Soviets have been working toward both is evident from their boasting, their doctrinal writings in the last few years, and their development of weapon systems.

limited war

If the Soviets find it very hard going to break through the nuclear stalemate while retaining any guarantee of security for the homeland, they do have another less drastic choice—limited wars. If the nuclear stalemate became a confirmed fact and all-out nuclear war truly equated with mutual suicide, then it would seem that the Soviets could indulge in brush-fire wars under this screen. There is every reason to believe that the Soviets might resort to the "little wars" if their present rather successful non-military policies were to bog down. This would seem to be borne out by a look at the present force establishment in the U.S.S.R., for in addition to their growing long-range capability in aircraft and missiles they continue to maintain large conventional forces.

The Soviet Army. The 175 or so Soviet Army divisions are becoming more and more mechanized, are getting more tanks per division and large amounts of self-propelled artillery and missile launchers. It is true that the divisions are rather small, but under the present conditions that should be an asset. At least ten of these are airborne divisions, and they boast that they have one hundred thousand parachutists. If rapid operations are necessary, the Soviet armed forces can draw upon Aeroflot* in addition to their own air transport. The latest generation of Aeroflot transports (the Tu-104, Tu-114, Il-18, and An-10) has the room and the range to serve as military transports.

The combat readiness of these forces seems beyond question.

*An important part of the Civil Air Fleet, which flies general passenger and freight routes.

One cannot open an issue of the Defense Ministry's daily paper, *Red Star,* without seeing pictures of companies of Soviet troops crawling around in the snow, bridging icy streams in combat maneuvers, or moving rapidly about on hot deserts such as the Kara Kum. Since 1954 there has been an enormous amount of emphasis in the military press on combat maneuvers under the conditions of a nuclear attack.

Evidence of limited war doctrine. In summary, these reasons among others seem to indicate that Soviet military doctrine includes "limited" military operations:

- In spite of the huge investments in long-range aircraft and missiles and nuclear weapons, the Soviets continue to maintain enormous ground forces and are devoting a great deal of time and effort to training these troops in the use of modern weapons and under the conditions of nuclear warfare.
- The Soviet naval program has put tremendous emphasis upon the supreme weapon of interdiction, the submarine. The naval force has been very fortunate in gaining an unearned increment when missiles and light nuclear warheads made submarines valuable as missile launchers.
- In spite of large expenditures on long-range aircraft and missiles, the Soviets have continued to maintain a large tactical air force. It is assigned to the ground commanders of the military districts for close support.
- The Soviets, well aware of how weak their own transportation system is, have developed a system of military districts that can operate autonomously—very handy for limited war on the periphery of the Soviet Union. Also the large number of vehicles assigned to the forces in the border areas would be able to operate more efficiently outside the Soviet Union because of the superiority of roads in other countries. What good roads are being built in the U.S.S.R. look more useful militarily than economically.
- The top echelon of the Ministry of Defense is very thin in Air Force marshals. The predominance of ground force officers is bound to color Soviet doctrine in favor of maintaining large ground forces.

In short, the Soviets are in an ideal position to move with conventional forces behind the screen of nuclear deterrence.

Soviet military doctrine in retrospect

1917-45. Soviet military doctrine first emerged when Marxism was superimposed upon the geographical, historical, and socio-political heritage from the Tsarist era. The military imprint of the Russian Civil War marked the Frunze military doctrine of the 1920's. It was taken over by Stalin, the new tsar, who continued to operate in the traditional Russian manner of combining the roles of chief of state and supreme military commander over an "armed camp" nation—an armed camp surrounded by enemies. But Stalin, like Peter the Great, saw that it was necessary to match the enemy's technology. Thus the entire economy, educational system, and foreign policy of the Soviet Union were unified and concentrated on one goal—the building up of the Soviet armed forces. The Communist fortress was defensive in nature, but following the successful conclusion of the great test of the Fatherland War it became the base of operations for further Soviet expansion.

The Soviets fought World War II with traditional weapons and in a traditional manner: immense firepower and huge masses of men—smother-the-enemy tactics. Armored divisions replaced the cavalry and tactical air support was new—but there was nothing new in the Soviet use of air power. In 1945 the Soviet Union found itself with enormous ground forces and a large tactical air force, but faced by the United States and Great Britain with a new strategy developed in World War II—the use of long-range aircraft to strike into the industrial heart of the enemy. Furthermore the West now had a weapon of a new magnitude to use with their strategic air force.

1945-55. From 1945 to his death in 1953 there was little Stalin could do to offset the air strike capability of the West. He secretly threw vast amounts of material and skilled manpower into catching up with the West in weapons, while publicly either ignoring or downgrading the nuclear threat. The official military doctrine emphasized only those things which the Soviets had: powerful ground forces, tactical air, and the euphoria of having just defeated the world's second-best army, the German. Maybe Stalin came to believe his own doctrine, at least to some extent.

1955—the future. By 1955 the Soviet Union had the new weapons and had lost the incubus of Stalin. The result was an acknowledgement of those factors which had been downgraded or ignored since 1945: surprise, timing, and the efficacy of nuclear weapons, especially in conjunction with supersonic aircraft and long-range missiles. But Soviet doctrine, unlike its Western counterparts, stuck to the desirability of maintaining large ground forces.

The Soviet objectives of protecting the homeland and of expanding Communism were assumed in this article to have remained constant factors. But the relatively backward Soviet Union of the late 1930's and the present bustling Soviet Union, center of a world system of socialist states, are two different things. If the Soviet Union is to expand in the future either it must convince the West that it would be suicidal to oppose its nibbling technique by other than limited means, or it must have the ability to smash the offensive capability of the West and keep itself relatively free from retaliatory destruction. The latter alternative would assume a reasonably efficient retaliation-proof capability. The only thing certain is that the Soviet leaders have been, are now, and probably will continue to be thinking offensively. Whether by economic and political penetration, limited wars, or all-out war, the attempts at expansion will continue. Which means will be used depends upon which is most suitable for the conditions at a given time. The closely integrated structure of the Soviet Union makes all or any of these tools immediately available to the Kremlin leaders.

Research Studies Institute

Experimental Studies on the Conditioning of Man for Space Flight

Dr. Bruno Balke

EVEN at this early point in the space age there is little doubt that in the not-too-distant future man will go into space. At first he may travel as a passenger in a vehicle controlled from the ground and obedient in its flight to the laws of celestial motion, but not long after that he will become the real pilot and crew of his spacecraft. As we progress in the many areas of research that must fit man into his spacecraft and enable him to do a useful job of work while he is there, one of the problems that we must examine very carefully is the choice and conditioning of the first space flyers. In this radically new venture little can be left to chance in their selection and training. The first space flyer must be capable of the most exacting human performance, must have the highest degree of tolerance to stress, and must have a demonstrated endurance to prolonged marginal conditions. Our research must identify the kinds and degrees of stress that he will undergo, must determine the human capabilities that will best withstand such stresses, and must discover means of conditioning and strengthening the necessary human defenses against the anticipated rigors of space flight.

Man's capacity for stress varies not only among individuals but also within the same individual, fluctuating with differences or changes in the proper adaptive responses. Generally, low or high tolerance for a given stress situation correlates with poor or good levels of "fitness."

The human organism, if properly conditioned, responds readily to acute and chronic changes of demands. A strictly sedentary life or forced inactivity can reduce functional reserves to a point at which metabolic requirements that exceed the basal metabolic rate by five to six times are well beyond adaptive capacities. On the other hand, properly conditioned and regularly active men might be safely stressed to 15 to 18 times the resting level of their energy metabolism. A cardiovascular and respiratory system which, through extensive physical training, has become adapted to such extraordinary requirements will stand up under almost any other stress situation. At the least such cardiorespiratory reserves will serve as a good background for further attempts to increase the tolerance for other stresses by additional special training.

It is all too true that human life exists in a very narrow zone compared to the diameter of our own planet earth and to the vastness of the space beyond the earth's atmosphere. From this point of view the 100 to 200 feet of water depths reached by divers and the 28,000 to 29,000 feet of altitude conquered by mountaineers delimit a ridiculously narrow belt of life. And even in this narrow zone what physiological adaptations are necessary! Of all the more highly organized living organisms, only man so far has demonstrated the ability to adapt to its extremes.

Our search is therefore for the qualities of the superman, and the subject of the following discussion will be the experimental work on man's tolerance limits to some of the anticipated singular stresses, with some emphasis upon cross-adaptability for complex stress situations.

general physical conditioning

Any normal healthy individual who fulfills the present standard requirements for Air Force pilot selection has the physical potentialities to become eligible for eventual space operations. Spacemen should be required to have a maximum of body reserves. The key to high body reserves is regular physical activity of a kind making high metabolic demands. This has been shown by experimental research in which running was employed as conditioning exercise. Aside from walking, running is the simplest and most natural form of physical activity. It is also one of the most disliked of exercises. Considering the great metabolic requirements involved, that dislike is easily understood.

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In work-capacity studies at the School of Aviation Medicine, USAF, it was found that 40% of more than 500 Air Force personnel were in "poor" physical condition. Their functional capacities were adequate for a maximal oxygen intake of only 35 milliliters (ml) per minute per kilogram (kg) of body weight. The physical condition of an additional 40% of test subjects was classified as "fair." Their maximal oxygen intake was 38 ml/min/kg. In the accompanying table the maximal oxygen intake, the classification of performance capacity, and the maximal performance in walking upgrade are correlated with running speeds. It can be seen that slow running, or "trotting," calls for maximal functional adaptations in the average man. No wonder that in even brief periods of running exercises he experiences pains, severely labored breathing (dyspnea), and general discomfort.

Maximal oxygen intake (ml/min/kg)	*Status of physical condition*	*Grade walking at 3.4 mph. Maximal grade in per cent*	*Running speeds*	
			Maximum in meters/min.	*1 mile in mins.*
35	poor	14%	140 m.	11′30″
38	fair	16%	160 m.	10′00″
43	good	19%	190 m.	8′30″
48	very good	22%	215 m.	7′30″
53	excellent	25%	245 m.	6′30″

The table illustrates sufficiently the great functional demands involved in running and the great value of this type of exercise for a physical-conditioning program. In such a program the emphasis has to be put on the so-called "interval training," a carefully balanced interchange of speedy running and recovery-walking periods.

Experimentally, such daily training of 30 to 45 minutes duration for a period of 10 to 12 weeks had these physiological effects:

1. It reduced the pulse frequency at any given work intensity. This means, since the oxygen intake for the same work intensity remained unaltered, that (a) the stroke volume of the heart, or (b) the oxygen utilization by the tissue, or (c) both these factors had been altered in the direction of a more economical circulatory function.

2. The maximal oxygen intake increased by about 25%, a reflection of a substantial increase of the maximal cardiac output.

3. The maximal breathing capacity during work increased about 40%. However, for comparable work intensities the effort of breathing was slightly reduced so that for equal oxygen intakes, or for equal work loads, less ventilation was required.

This means that the functional reserves were increased.

The training period also had a valuable effect on the metabolic reserves. Pretraining tests on the control group revealed that an average amount of 220 grams of carbohydrates was utilized before the subjects became extremely exhausted by a steady-state type of heavy work. Posttraining exhaustion occurred much later, after an average amount of 315 gm of carbohydrates had been mobilized. The extent to which carbohydrates from the glycogen stores in muscles and liver become available and the extent to which stored body fat is readily converted to fuel for muscular activity can be of great importance for the pilot of present-day aircraft and more so for the space pilot.

The increase of functional and metabolic reserves accompanying regular physical activity has more implications than those of work capacity alone. With more functional reserves physical fatigue is delayed or even prevented, or is such as not to be of too much concern from a performance standpoint. Regular physical exercise can help control body weight and prevent the functional disorders generally accepted as the natural deterioration of aging. Finally, the high body reserves achieved and maintained by regular activity can assist one's adaptation to other stresses, as, for instance, hypoxia or temperature extremes.

experiments to build up physical reserves

In an effort to build up functional and metabolic reserves still further and to improve the tolerance for various physiologically adverse conditions, the experiments were transferred from near sea level at Randolph Air Force Base, Texas, to the higher altitudes of the Peruvian Andes and the Rocky Mountains in Colorado. In Morococha, Peru, (14,800 feet) as well as on Mt. Evans, Colorado, (14,160 feet) various phases of acclimatization to high altitude were studied for their effects on

- Performance capacity
- Altitude tolerance
- Adaptability to hyperventilation
- Tolerance for pressure breathing without protective counterpressure

- Susceptibility to dysbarism at various stages of natural partial denitrogenation at low barometric pressure
- Tolerance for increased carbon dioxide levels in the inhaled air

Since all these experimental studies are pertinent to the physiological problems of space flight, the results will be briefly reported.

Performance capacity. At high altitude the work capacity is reduced. Even the native Indians who live at altitudes between 13,000 and 16,000 feet, and who work and play harder at those altitudes than most people in lower countrysides, do not attain the same maximal performance as do well-conditioned subjects at sea level. Their circulatory and respiratory adaptive response to work does show, however, signs of greater efficiency and economy than do the responses of individuals temporarily acclimatized to these high altitudes. There is some indication from experimental studies (Pugh) at altitudes up to 21,000 feet in the Himalayan Mountains that man, when temporarily acclimatized to more extreme altitudes, behaves more like a native Peruvian Indian after he returns to altitudes of 14,000 to 15,000 feet.

During the experimental period on Mt. Evans in 1958 physical training was regularly continued at altitude. The improvements in body reserves, although not determined experimentally, can be appreciated from the work performed in mountain climbing. In the initial phase of the 6-week period, climbs of 2-hour duration were very fatiguing. Toward the end of the mountain episode remarkable work in climbing steep slopes was accomplished for periods of 5 to 8 hours without the usually essential rest intervals or intake of food and liquids. The caloric requirements for such work amounted to approximately 3500 to 5000 calories and were furnished from the body stores without undue fatigue symptoms.

Altitude tolerance. In control tests of altitude tolerance in the low-pressure chamber which employed a gradual ascent to simulated altitude, the subjects reached on the average a critical level of 24,000 feet. After physical conditioning the subjects became unconscious at 27,000 feet. After five weeks at altitudes above 10,000 feet but only 10 days at 14,000 feet, the average critical altitude was 30,000 feet. At a level of 21,000 feet the average performance scores on a neuromuscular coordination test were higher than under all previous more normal conditions.

Utilizing a low-pressure chamber in Morococha, Peru, (14,800

Training runs and informal exercises for general conditioning were performed in the vicinity of Echo Lake (10,700 feet altitude) in the Mt. Evans Range in Colorado. Without any "formal exercises" the members of the experimental team were able to attain great capacities for all sorts of gruelling stress situations.

feet) and exactly the same procedure of gradual ascent as in the Mt. Evans experiments, a group of native residents reached an average critical altitude of 31,000 feet. The author, after living five weeks at Morococha and spending a few hours almost every day on hikes up to altitudes of 17,000 feet, was still conscious at 33,000 feet, at which time he took the precaution of turning on his oxygen supply.

The time of useful consciousness (TUC) at 30,000 feet, after discontinuing oxygen breathing, exceeded one hour in the permanently acclimatized natives as well as in the temporarily acclimatized subject. Velasquez has recently reported a TUC of one and one half minutes for natives exposed to a simulated altitude of 40,000 feet.

The TUC attained at simulated altitudes of 25,000 and 30,000 feet was also tested during the Mt. Evans experiments in 1958. All subjects stayed conscious far in excess of 30 minutes at a level of 25,000 feet where normally TUC lasts only four to five minutes.

At 30,000 feet the TUC exceeded the normal one- to two-minute period and went beyond the 30-minute mark in one experiment.

Adaptability to hyperventilation. Noticing the increasing tolerance for severe deficiency of carbon dioxide in the blood (hypocapnia) during frequently repeated hyperventilation experiments, a group of subjects volunteered to hyperventilate for 30- to 60-minute periods daily during three weeks. The hyperventilation was assisted by a respirator delivering alternately a positive and a very slight negative pressure at any rate desired.

The test results before and after the hyperventilation training confirmed the hypothesis that there is an adaptive response to chronic hyperventilation in healthy individuals. At high altitudes where hyperventilation becomes a necessity for proper oxygenation of the blood, the tolerance for hypocapnia reaches a maximum. There an excessive hyperventilation is limited by eventual breathing fatigue rather than by the deleterious effects of hypocapnia.

Tolerance for pressure breathing. Breathing against positive pressure is considered to interfere seriously with adequate blood circulation (hemodynamics). Experiments in our laboratory have shown that good physical condition, special training in pressure breathing, and proper breathing mechanics enable an individual to tolerate continuous mask or helmet pressures of 20 to 40 mm of mercury (Hg) for a considerable length of time without circulatory complications.

Breathing oxygen under pressure is the means utilized to increase man's altitude ceiling, at least for emergency situations. Pressure breathing without protective counterpressure is limited by fatigue of the hard-working respiratory muscles and by hypoxia. With increasing altitude both factors become greater handicaps. At an altitude of 50,000 feet the oxygen pressure delivered from the oxygen regulators presently in use is approximately 30 mm Hg. This is the equivalent of 18,000 feet altitude in ambient air. At 60,000 feet with a positive mask or helmet pressure of 40 mm Hg, which trained men can tolerate from several minutes up to one half hour, the equivalent altitude in ambient air is 26,000 feet.

So far seven subjects have been exposed to ceiling altitudes of 54,000 to 58,000 feet in pressure breathing without counterpressure after they had become partially acclimatized to an altitude of 14,000 feet. Neuromuscular coordination at these ceiling altitudes was only slightly impaired. The subjects did not represent a selected "tiger type" but rather a cross section of normal airmen. The average age was 33 years in a 20- to 52-year range. These experimental results reaffirm the usefulness of conditioning and special training as a keystone for greater reserves.

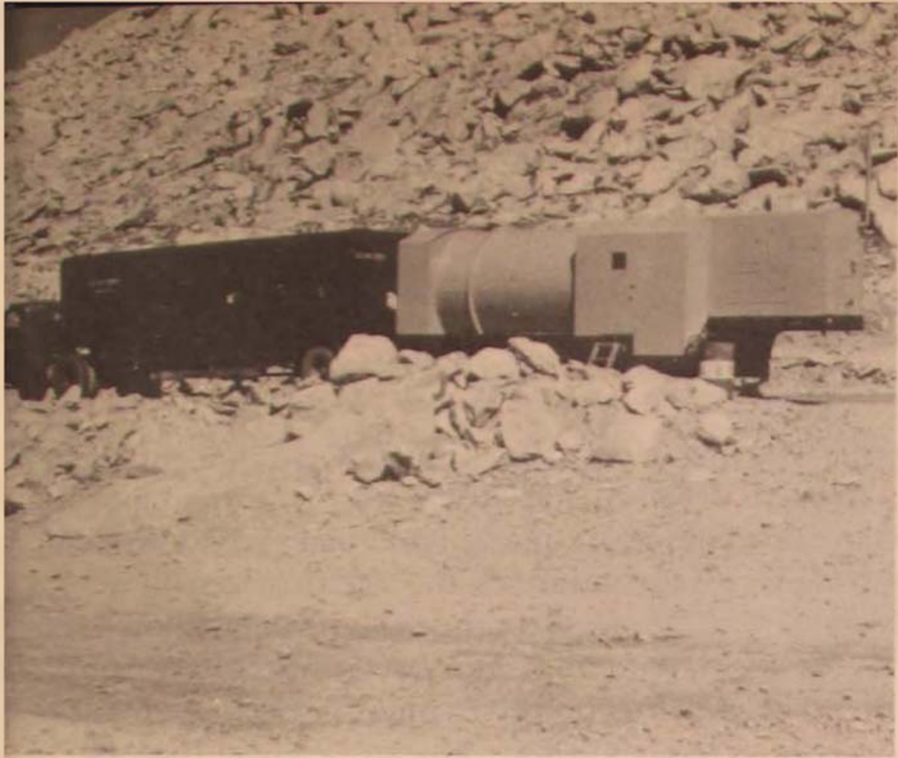
Susceptibility to dysbarism. Besides hypoxia the most urgent problem during acute exposure to altitudes above 35,000 feet is the development of severe pains—the so-called bends or chokes. The symptoms are caused by formation and growth of air bubbles in tissues of inadequate capillarization. The gas bubbles originate whenever there is a great difference between the partial pressures of the gaseous nitrogen dissolved in the body and of the nitrogen in the surrounding atmosphere.

Breathing of 100% oxygen for several hours before leaving for a high-altitude flight lowers the partial pressure of nitrogen in the lungs, blood, and body tissue in that sequence. In the subsequent ascent to high altitude the amount of nitrogen remaining in the tissue is minute, bubbles do not form, or at least do not grow to any considerable size, and decompression sickness is prevented.

For experimental research on the prevention of dysbarism the following assumption was made: since partial denitrogenation by breathing oxygen for a few hours results in bends protection, then living at higher altitudes with naturally diminished partial pressures of nitrogen should also provide sufficient protection after adequate time has been allowed for a complete equilibrium between the partial pressures of nitrogen in the body and in the atmosphere. The experimental work was done at Randolph AFB, Texas, in the Peruvian Andes, and in the Rocky Mountains in Colorado. A standard exercise test was employed in the low-pressure chamber at a simulated altitude of 38,000 feet. At Randolph AFB all subjects experienced third-degree pains after an average time of about 20 minutes. After living three to four days at an altitude of 10,000 feet, third-degree bends did not occur and second-degree pains occurred only after an average time of 50 minutes. After staying 48 hours at an altitude of 14,000 feet there were only two incidences of slight pains among seven subjects tested, and at Morococha (14,800 feet) all ten individuals tested remained symptom-free.

These findings, although mainly of basic research interest, may have some application in determining the desirable cabin environment in a space vehicle.

Tolerance for increased levels of carbon dioxide. Just as frequently repeated hyperventilation increases the tolerance for hypocapnia, so a more chronic subnormal decrease of air in the lungs (hypoventilation) favors adaptations to higher levels of carbon di-



The "laboratory on wheels" and the mobile low-pressure chamber (above) are shown "on location" beneath the summit of Mt. Evans (14,260 feet altitude) in Colorado in the summer of 1958. Attired in pressure suits (right), two members of the experimental team discuss steps to be taken in tests involving sudden decompression to atmospheric pressures equivalent to those at altitudes of 50,000 feet and above.

oxide. Divers who can hold their breath for two to three minutes, or top athletes trained for long-distance running who still breathe smoothly at a murderous pace, or patients who are inadvertently underventilated during treatment in an iron lung—all these conditioned people develop a lower sensitivity to the ventilatory driving force of carbon dioxide.

The two main causes of environmental emergency situations in the sealed crew compartment of vehicles flying at altitudes above 80,000 feet are likely to be the loss of oxygen pressure or an accumulation of carbon dioxide (CO_2). While altitude acclimatization provides considerable protection against severe hypoxia, it might not be compatible with sufficient tolerance for higher levels of CO_2 in the inhaled air.

To investigate this latter problem two types of experiments were carried out: (1) Rebreathing tests were performed, starting with a volume of 100 liters of a 30:70% O_2:N_2 gas mixture, and employing light work on the bicycle ergometer to raise the inhaled CO_2 concentration approximately 1% each minute. The control tests at sea level were compared with the tests made at an altitude of 14,160 feet on subjects having a few weeks' acclimatization. (2) During extended periods of confinement in a sealed chamber simulating effective altitudes between 12,000 and 20,000 feet, two groups of two subjects each were exposed to an accumulation of CO_2 at the beginning and again at the end of 8-day and 10-day experiments.

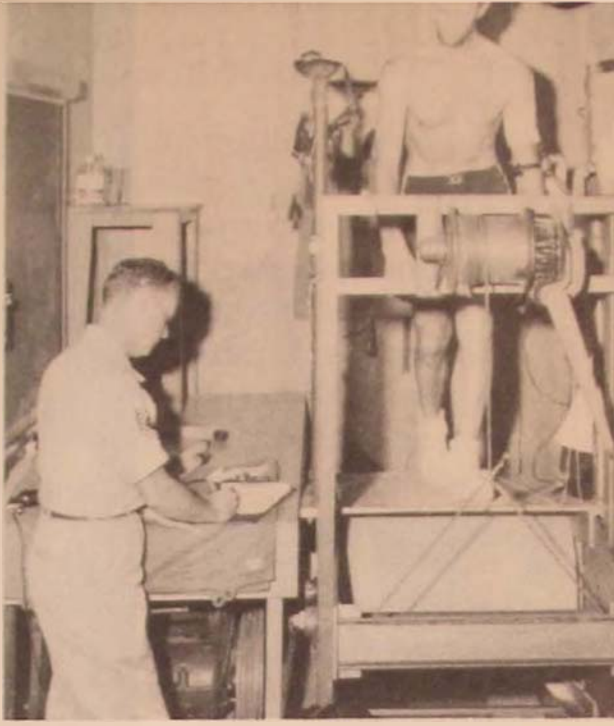
In both types of experiments the limiting CO_2 concentrations in the inhaled air were practically identical for the normal and the acclimatized man, although at comparable carbon dioxide concentrations the pulmonary ventilation of the acclimatized man was increased by 25 to 33%. Compared on the basis of inhaled or alveolar CO_2 tensions, however, the respiratory response to comparable tensions was almost three times and five times, respectively, that of the normal response. These findings indicate a great increase in the sensitivity of the respiratory center to carbon dioxide during the process of acclimatization to altitude. For all practical purposes, however, this increase in sensitivity to CO_2 did not lessen the CO_2 tolerance of the acclimatized man.

The reason for this apparently contradictory situation may be that during progressing acclimatization to altitude, assisted by regular physical activity, the maximal breathing capacity increases with the higher demands on the respiratory muscles. Maximal values of 180 to 200 liters of pulmonary ventilation per minute have been observed during work capacity tests in the mountains, compared to maximal values of 120 li/min at sea level. At any altitude the metabolic requirements for any given work are the same and the same volume of carbon dioxide is exhaled during a given time by the acclimatized or the unacclimatized subjects. Thus in a closed system without provision for the absorption of carbon dioxide the accumulation of CO_2 can be assumed to be of equal magnitude. Although the acclimatized man responds with greater ventilatory volumes, he does not become dyspneic sooner than the normal man because of the considerable increase of his maximal breathing capacity.

The measurements of pulse frequency and blood pressure during these experiments, averaging 130 pulse beats per minute and 200/110 mm Hg systolic/diastolic pressure, indicated a considerable cardiovascular stress when carbon dioxide concentrations exceeded 8 to 10%.

Cross adaptability for complex stress situations. The conditioning training of the experimental subjects at Randolph AFB

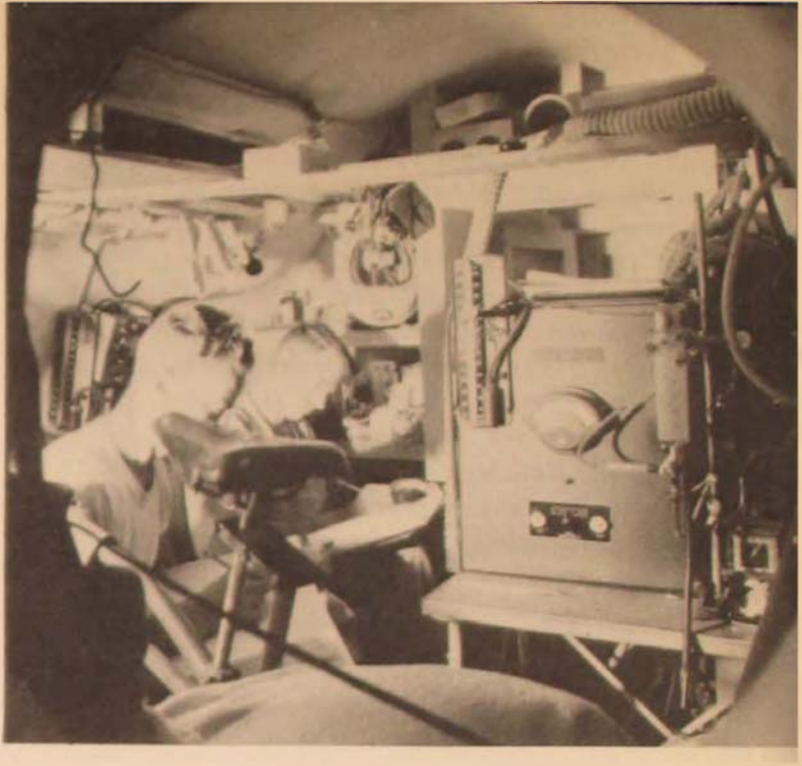
Standard work capacity tests were made on the treadmill before and after the subjects engaged in strenuous activity. Final performance on the treadmill was then compared with earlier (or normal) performance to demonstrate the loss of "physical fitness" resulting from the intervening exertion. Dr. Balke is shown in a final work capacity test on the treadmill, walking at a speed of 3.4 mph steeper and steeper "uphill" toward his exhaustion or breaking point.



before leaving on the mountain expedition in Colorado affected not only their work capacity but also their heat tolerance. The workouts were usually held during the noon hours when the temperatures were between 32° and 36° C. On some training days the relative humidity reached 80 to 90%. The subjects ran distances varying from three to five miles. When each subject's work capacity was tested on the treadmill, once at room temperatures of 22° to 24° C and again at temperatures of 33° to 34° C, no essential difference was found. Under the additional heat load the critical pulse rate of 180 per minute occurred, on the average, one minute earlier during the gradual increase of work intensity.

In the mountains the experimental group adapted not only to altitude but also to a rather cool environment with temperatures around the freezing point. Immediately after the return to Texas in mid-August the daily workouts were continued. The subjects ran four to six miles in temperatures ranging from 34° to 38° C. Subjectively and objectively there was no deterioration in performance.

Ten-day sealed chamber experiment. A crucial experiment was carried out by two individuals four weeks after they had returned from Mt. Evans, Colorado. They spent 10 days in the mobile low-pressure chamber that had been used during the experiments in the mountains. The purpose of this experiment was to study various physiological, mental, and possibly psychological reactions of thoroughly conditioned and cross-trained men to an excess of combined stress situations.



At a simulated altitude of 16,000 feet in the crowded low-pressure chamber (above), the two subjects perform a simple calculation test during their 10-day experiment. After completing the experiment (left), one of the subjects walks on the treadmill while measurements are taken of his blood pressure and pulmonary system functions.

The chamber environment was kept at barometric pressures equivalent to 14,000 or 18,000 feet, and the oxygen content was regulated so that the effective simulated altitude was controlled at levels between 14,000 and 20,000 feet. The chamber temperature varied from 26° to 36° C with average temperatures of about 29° C at night and 31° C during the day. Carbon dioxide and water vapor were absorbed by lithium hydroxide. The capacity of lithium hydroxide for water vapor absorption is far less than that for carbon dioxide. Thus the relative humidity varied between 70 and 92%, while the level of carbon dioxide was kept below 1% most of the time.

The most severe environmental conditions were encountered when at an effective altitude of 16,000 feet the levels of carbon dioxide, humidity, and temperature were allowed to rise. When the chamber temperature reached 36° C, the humidity 92%, and the inhaled CO_2 concentration 4.5%, the enormous sweating rate was most uncomfortable but the circulatory and respiratory reserves were only slightly affected. A cold spell, unusual for that time of the year in Texas, terminated the heating part of the experiment.

Attempts to counteract the effect of the drop in outside temperature by more rigorous exercise on the bicycle ergometer failed. Despite a high energy expenditure for a period of 30 minutes the inside temperature dropped to 34° C. The relative humidity, on the other hand, rose to almost 100% and the carbon dioxide content to 5.5%. Five hours later when the carbon dioxide level reached 8% the temperature had fallen to 31° C, and the subjects were in good physical and mental condition. When at this point the subjects attempted to clean up the chamber, the increase in physical activity caused an unexpected respiratory and cardiovascular response. Within 30 minutes the pulmonary ventilation increased to maximum, and the rise in pulse rate and blood pressure also indicated impending limitations in the CO_2 tolerance. Intense efforts were required to make the last physiological and environmental measurements before putting on the oxygen mask.

Immediately after this experiment was terminated, the chamber pressure was lowered to a simulated altitude of 40,000 feet for a bends test. During a period of two hours at that altitude the subjects experienced no symptoms of dysbarism, confirming the earlier findings that natural denitrogenation at altitude levels of 14,000 feet and above provides satisfactory protection from decompression sickness.

Under the severe environmental conditions of the experiment the energy, fluid, and electrolyte balance was disturbed. Meals and beverages were not cooked but consumed lukewarm at the prevailing chamber temperature. The highly chlorinated water was very distasteful and the canned baby food—as canned food in general—was unappetizing. Occasionally one or the other subject became slightly nauseated, probably as a result of hypoxia or of heat and dehydration. The daily energy intake did not exceed 1600 calories on the average, while the expenditure was estimated as approximately 2600 calories. The total loss of body weight during the 10-day experiment averaged 10 lb per person. Undoubtedly the great metabolic reserves achieved during the period of extensive physical work high in the mountains had been adequate to cope with any of the acute or temporary energy requirements of the experimental situation.

Both subjects demonstrated satisfactory mental alertness at all times and never failed under any of the severest experimental conditions. Although the hourly checks of all the environmental factors became routine, the instrument manipulations and the necessary calculations required accuracy, good coordination, and a clear mind. A simple adding test of one-hour duration and a neuromuscular coordination test were performed daily. Sufficient physical activity was provided by changing the CO_2 absorber, cleaning the chamber, riding the bicycle ergometer, and practicing putting on the pressure suit as fast as possible. Under the prevailing environmental conditions all that work caused a great degree of physical fatigue, which was not relieved by compensating rest and sleep. Restlessness, headaches, nausea, the narrow bunk bed, odors, and the feeling of air stagnation, high temperatures, etc., cut the time of sleep to three to four hours in each 24-hour period.

No definite psychological observations were made. Both subjects expressed the subjective opinion that confinement to the very primitive and odd chamber interior had no effect on their spirit. Boredom was unknown. Any free minute was used either for relaxation or for technical or entertaining reading, especially during the night shifts. The matter of how two people would get along together for 10 days in such a tiny compartment proved to be no problem at all: the mutual respect and regard and the readiness to serve and help each other at any moment were accentuated under the more severe stress situations. Anxiety and fear, of course, did not enter into this type of earth-bound experiment. It is felt, however, that most specific situations in space causing anxiety and fear can be anticipated and can be obviated by training. Any experienced pilot or deep sea diver or mountaineer might agree with this hypothesis.

Experimental evidence exists that the human organism has a great capacity to adapt to superhuman requirements of a biological nature. With proper conditioning and training each man can achieve his own physical, mental, and psychological maximum of adaptive capacity. Since the limitations of these capacities are not known before considerable efforts have been made to increase the psychosomatic reserves, the selection of an eventual spacecrew becomes possible only after such special efforts have been made. Certainly there are numerous ways open for proper conditioning and training. In the experimental research described simple methods were successfully used. These methods might also be effective to increase g tolerance. For a preadaptation to the state of weightlessness, exercises requiring highly developed neuromuscular coordination might be helpful.

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Glossary of Terms

capillarization. The degree to which the body tissues are supplied with the tiny, microscopic blood vessels (capillaries) that are vital for the exchange of biological gases, nutrients, and metabolites between the blood and tissue cells.

carbohydrates. A group of complex biochemical compounds, such as the sugars and starches produced by plants, that constitute a major class of food material for both plants and animals. Carbohydrates are basically composed of carbon, hydrogen, and oxygen in the ratio of 1:2:1.

denitrogenation. The removal of nitrogen dissolved in the blood and body tissues. In aviation, usually the breathing of pure oxygen for an extended period of time in order to prevent decompression sickness (aero-embolism) at high altitudes.

dyspnea. Difficult or labored breathing.

electrolyte. Any chemical substances that, when ionized in solution, conduct electricity. The proper proportion and balance between certain electrolytes (sodium, potassium, chloride, etc.) in body fluids and tissues are vital for normal body function.

ergometer. An instrument for measuring muscular work.

functional reserves. The ability of the body to accomplish additional muscular activity and useful work beyond the normal level of activity of an individual.

glycogen. A starchlike, complex type of carbohydrate, formed from simple sugar (glucose) in the liver of man and animals. Glycogen is the principal form in which carbohydrate is stored in the body, mainly in the liver and muscles. Commonly called "animal starch." See **carbohydrates.**

hemodynamics. A branch of physiology concerned with the movement of blood through the heart and blood vessels, particularly with the pressure, volume, flow, and resistance relationships within the cardiovascular system.

hyperventilation. Overbreathing. A respiratory-minute volume, or pulmonary ventilation, greater than normal. Hyperventilation often results in an abnormal loss of carbon dioxide from the lungs and blood, which may lead to dizziness, confusion, and muscular cramps.

hypocapnia. Deficiency of carbon dioxide in the blood and body tissues, which may result in dizziness, confusion, and muscular cramps.

hypoventilation. Underbreathing. A respiratory-minute volume, or pulmonary ventilation, that is less than normal.

metabolic reserves. The energy source stored in chemical form, such as carbohydrates, that can be efficiently mobilized and utilized by the body, particularly for muscular activity and work beyond the normal level of activity of an individual.

systolic/diastolic pressure. The highest (systolic) and the lowest (diastolic) blood pressure within the heart and great blood vessels produced by each full cycle of the contraction and relaxation phases of the beating heart.

ventilation. Biologically the aeration of the lungs and blood by breathing. The inhalation and exhalation of air in the process of respiration.

Surprise in the Missile Era

LIEUTENANT COLONEL ROBERT O. BROOKS

DOES the ICBM threat mean that the attacker is supreme? Can he destroy our retaliatory forces before they are launched, figuratively shooting the gun out of our hand? Will we have only fifteen minutes in which to try to make the destruction mutual?

Assume that at some future date we face the most difficult Soviet threat which we can now foresee: the U.S.S.R. has large numbers of accurate intercontinental ballistic missiles with nuclear warheads; these missiles are in place at dispersed sites and are constantly ready for instant launching at the press of a button. Assume too that our super radars can detect missiles about fifteen minutes before they strike their targets; we have IRBMs in place at overseas bases; but we have no ICBMs operational and our anti-missile defenses are of very limited effectiveness. Would we in this situation be totally dependent upon these uncertain and last-minute warnings, or are there other factors that, if carefully watched and assessed, can give us a longer and more fruitful notice of impending attack?

surprise and warning today

Ever since the United States first created effective nuclear deterrent or retaliatory forces, it has appeared obvious that in an all-out war only by a surprise blow at these forces could an enemy prevent his own destruction. Surprise in the initial attack has become most dangerous to us and most advantageous to the enemy, for our national policy and tradition leave to the enemy the choice of time and manner of initiating hostilities.

Our nuclear delivery forces have maintained their deterrent effect through their capability to launch massive retaliation during the interval between detection of the enemy strike and arrival of the enemy weapons on their targets. As the Soviet delivery capability had progressed from Tu-4's to jet bombers, we had been forced to improve both our detection capability and the readiness of our defensive and retaliatory forces. Now that we are entering the missile era, we must determine whether impossible demands are placed on our detection and reaction capabilities by ICBMs which take only thirty minutes from launching to target. Do missiles give an aggressor a reasonably sure means of achieving surprise?

Our continuous efforts to prepare for the worst surprise blow the enemy can launch revolve in great measure around the degree of warning we can expect. The warning time greatly influences the deployment and state of readiness of our forces. The shorter the expected warning time, the greater must be the continuing state of readiness of our defensive and retaliatory forces. Military forces increase their continuing readiness only at great cost in personnel, equipment, communications, and facilities—all of which translate too easily into huge dollar costs. As warning time decreases, reserve forces and civil defense measures lose their importance in plans for the initial battle, and the effectiveness of forces in-being can be little better than the level of immediate readiness which they can maintain around the clock, 365 days a year.

The need for warning time has placed a great premium on the capabilities of intelligence to provide "strategic warning" in advance of the "tactical warning" that could be expected from radar and similar means. (A rough dividing point between strategic and tactical warning is the launching of the enemy strike force: prelaunch warning is strategic; postlaunch warning is tactical.) The value of strategic warning is twofold. To a greater degree than tactical warning, it provides time in which to bring our forces to the highest possible state of effectiveness. Additionally there is the possibility that strategic warning may permit us to frustrate the enemy attack before it is launched.

Despite the element of predicting enemy intentions always

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inherent in strategic warning, U.S. intelligence has continued to emphasize enemy capabilities rather than intentions. Strategic warning has been regarded in terms of the detection of the enemy's final preparations to attack, these preparations being indications of the imminence of hostilities. This presumes that the enemy is not now ready to launch his attack, that there are one or more additional things he must do before he can strike. Intelligence seeks to detect the enemy's final increases in capability: the progress from "capable of attacking with X days' preparation" to "capable of attacking with one day's preparation" to "hours" to "now." The threat of large numbers of accurate missiles standing continuously at instant readiness appears to nullify the concept of indications intelligence. If there are no additional preparations to be detected, there is no prospect of strategic warning based on such indications.

surprise and the ICBM

Before writing off intelligence indications as a fairly reliable source of strategic warning, let us re-examine the threat of surprise attack by ICBMs. The assumptions of future Soviet ICBM capability should be questioned. Even if they are accepted, there remains a most important question: Does the probable degree of warning depend solely on the delivery system used initially?

The ICBM threat carries us into the future and into a new type of weapon system. There is little or no factual basis for criticizing assumptions on the nature of the threat, but in the past there has been a consistent tendency to overestimate the physical capabilities of the enemy's weapons and his ability to produce, deploy, and use them. We should guard against simila, errors in considering the ICBM threat. While we can conceive now of the threat stated at the beginning of this discussion, we should not translate our conception into an enemy capability without considerable evidence. (On the other hand we cannot wait to prepare ourselves until the threat is full grown—there are few easy answers!)

It would be pleasant to dismiss the ICBM threat as technically unlikely, or at least as too far in the future to influence present thinking and planning. Still we cannot rule out such a threat, despite technical problems that loom large now. If we assume, for purposes of discussion, that the Soviet overcomes the problems and develops the threat of large numbers of ICBMs at instant readiness, we must examine the effect of such a weapon system on our capability to provide warning.

surprise and the decisive nuclear attack

Is the probable degree of warning determined solely by the delivery system employed in the initial attack? That is, must our warning be limited to our ability to detect the attack itself after it has been launched? Here we are concerned not only with warning that the missiles are coming but also with warning of the imminence of hostilities. If the missiles are at instant readiness, there might seem to be no distinction between warning of the actual strike and warning of the imminence of hostilities. The two types of warning might merge into one—and that one worth only fifteen minutes at best—if the missile attack is the only action which the enemy will carry out at H-hour.

The idea of a single, decisive, surprise attack might seem to be the most dangerous threat we may face. For possibly valid reasons, our concern with surprise has been limited largely to the timing of an attack through the air with nuclear weapons.* Since this attack would probably be decisive (or at least would intend to be), it seems obvious that the attacker should avoid activities of lesser importance that might provide warning of the imminence of hostilities and thus degrade or nullify the surprise sought with the decisive force. For example: the Soviet should not send its submarine force into the open oceans prior to D-day because we might detect the move and regard it as a strong warning of impending hostilities. This line of reasoning has been carried to the point where, in our idea of the worst threat, all other forces and activities must continue their normal, everyday functions until after the decisive initial strike force has been detected. In this reasoning, the achieving of surprise with the decisive force is worth so much that it justifies some losses and is worth the sacrifice of the advantages of maximum readiness and local surprise by the secondary forces. For any who think that the U.S.S.R. might lack the resolution to accept such losses to achieve its principal objective, there is the awesome chapter in Soviet history of mass starvation as grain was exported to pay for machinery.

factors that vitiate surprise

The idea of the single, decisive blow is appealingly ruthless and may seem overwhelmingly logical, but it is not realistic.

*Perhaps this reasoning is not entirely valid. An ideal surprise attack achieves surprise with respect to the geographical source of the attack, the route of approach, the weapons and delivery systems used, places attacked, speed, and time. Surprise is limited by what the victim expects and prepares for. Historically, military surprise attack has been most effective when there existed an obvious and logical course of action which was not followed, the attacker choosing a more indirect means or method that was usually more difficult and risky than the obvious course. Our emphasis on only the timing and speed of one type of attack may be hazardous.

There are two overlapping factors that tend to expand the single, decisive blow into a simultaneous attack by all forces. The first is the basic necessity for the Soviet to survive; this requires preventing us from carrying out retaliatory nuclear strikes. The second factor is human nature as it governs a variety of actions and emotions.

Survival is a powerful factor. If the U.S.S.R. attacks, it must try to prevent nuclear retaliation. Destruction of our retaliatory force is in fact the objective of the "single, decisive blow." We must not limit our thinking to the continental United States, for much of the retaliatory force is at our overseas SAC bases, in our carrier forces, in our tactical air and missile units, in British forces, and in the near future will be in our missile-launching submarines. These must all be hit by the first strike. Not only must all these targets be hit on the first strike but there are the problems of malfunctions of missiles and warheads, losses to defensive action, and missed targets. Either the enemy must launch more than one missile per target or he must provide for immediate poststrike reconnaissance to determine which targets must be reattacked.

The Soviet must assume that part of our retaliatory force (airborne alert plus normal training) will be airborne before the surprise strike is detected. It must assume further that some additional aircraft and missiles, especially those on normal short-term alert, may get into the air in the brief interval between detection of the Soviet strike and arrival of warheads on targets. In short the enemy must expect to meet a retaliatory attack within hours after his strike is detected. However small our retaliatory attack may be, the power of nuclear weapons demands that the enemy maximize his defensive readiness. To ensure maximum effectiveness of his defenses, they must be alerted prior to launching the initial strike.

Air defense forces of the Soviet Union are tremendous. They include detection and interception systems spread over the entire Communist bloc. Detection systems normally operate at a high percentage of their maximum capability, so perhaps no special preparations need be made to improve detection. Interceptor forces, whether missiles or manned aircraft, can be brought to a considerably higher degree of effectiveness through several days' advance notice. This period permits completion of routine maintenance, maximizing personnel strength, and setting up a degree of alert during the critical hours that could not be maintained normally. In addition to forces whose primary mission is air defense, the large air defense capability of other forces would become distinctly more effective with advance notice. This capability is found in tactical air units and in the antiaircraft and antimissile weapons of all surface combat forces.

Recognizing the need to alert the air defense forces, the Soviet must then face a series of questions as to which forces should be alerted. Is it sufficient to alert only the interceptor forces? Should this alert include Soviet interceptor forces located in the satellites? Should satellite air defense forces be alerted? If army and navy air defenses are to be alerted, there are the same types of decisions to be made.

In answering these questions the Soviet must consider that each step which increases the effectiveness of its air defense may save it a vital center. Making its decisions easier is the hope—perhaps even confidence, stemming from long practice of security measures—that it can maintain the secrecy of the surprise attack, even though very sizable forces are alerted, and take some preparatory actions to achieve a state of maximum readiness.

Air defense against a limited retaliatory blow is not the end of the problems that Soviet planners must face in developing their surprise attack. There is a series of temptations to avoid unnecessary heavy losses and to seek additional advantages. What of Russia's tremendous submarine fleet and her massive ground forces? It will be inevitable that the leaders of these forces will want to use them in the initial assault and to protect them from unnecessary losses.

If naval vessels are not alerted, especially the submarines, most of them will be in port or in the narrow seas when war begins. Under these conditions the Soviet navy would be unable to contribute its very real strength to the initial blow and would be vulnerable to heavy losses from retaliatory strikes. Even if the U.S.S.R. were to survive the initial phase of hostilities with much less damage than the U.S., the naval forces would have to fight their way out of the narrow seas, taking losses and forfeiting all chance for surprise. As with the problem of alerting air defense forces, the Soviet must determine how far to go. It seems reasonable that it would not deploy its entire navy prior to D-day but would deploy into the open seas as many ships as it thought it could on a surreptitious basis. In determining this number it must face strong inducements to overestimate the effectiveness of its security and deception measures.

Soviet army leaders can be expected to exert similar pressures.

If their strong peripheral forces are not alerted, they must face the prospect of being caught in their garrisons by our tactical atomic weapons. Without alert they must forfeit all the benefits of tactical surprise and must fight forward, slowed down by demolitions as well as by active defenses. Especially in Europe these factors must loom large. There is no need to move up heavy reinforcements, which would obviously spoil the surprise. Soviet ground forces already in the satellite areas are adequate for the initial assault (though what commander ever said he had enough?). All that is needed to achieve surprise and avoid unnecessary loss is to have them ready to move out of their garrisons to the attack the instant the decisive strike is launched. Again there is the temptation to hope and believe that these valuable steps can be taken in complete secrecy.

Lower down in the scale are other temptations to avoid losses: to evacuate key diplomatic personnel from target areas in the West, to bring merchant shipping into friendly ports, to evacuate key government personnel from the more obvious retaliatory targets in Russia, to complete many movements and projects that "would be nice" to complete before D-day. As comparatively trivial as such things may seem, they are likely to have strong advocates within the government, each with his urgent pleas and a plausible plan for maintaining the secrecy of his own project.

summing up

For reasons ranging from the essential needs for self-preservation to ordinary bureaucratic pressures, an initial surprise attack would be accompanied and preceded by the actions of many other forces. From this it is clear that the amount of warning we may obtain is not determined solely by the Soviet missile forces.

The realistic worst military threat that we face now or in the foreseeable future may include a sudden, devastating attack with nuclear weapons. Whether the main attack is delivered by high-performance aircraft or by missiles, the enemy cannot limit his preparations to a relatively small force striking the continental United States. The enemy must simultaneously attack our nuclear delivery forces at sea and at overseas bases, and he must prepare to defend against retaliatory blows from such of our forces as survive his initial attack. He must accept seemingly needless losses in his surface forces or else he must try to protect them and use them to advantage at the outset.

The worst military threat that we face is not a single sneak attack but a coordinated massive attack, probably employing all types of forces. Grim as such a massive assault may seem, it offers both hope and constructive guidance. It promises that intelligence can maintain a capability to provide strategic warning through detection of several or many of the extensive preparations the enemy must make. The prospect of this warning enhances the probable effectiveness of both our defense and our retaliation. Perhaps even more important, even in the missile era, we may have time to deter the attack before it is launched by announcing our knowledge, our readiness, and our determination.

6928th Security Flight

A Preface to Organizational Patternmaking

Colonel Robert A. Shane

With the increasingly complicated weapon systems since World War II, considerable attention has been given to both hardware and human engineering problems in military and industrial research and development programs. In a high percentage of cases these problems are apparent—though not always solvable—to the researching engineer and psychologist. Less apparent is the problem of organizational engineering—the functioning of individuals and their related equipment when combined first in teams (e.g., metal shop) and secondly in over-all organizations (squadrons, wings, etc.), which are then pyramided into a total force of like and differing elements (integrated fighter, bombardment, and missile units).

seeing the trees or the forest

A research program that accents equipment reliability, general performance, and the individual qualitative personnel requirements to operate this equipment is to a great extent monitored by technical personnel. Naturally they focus on performance as planned for individual items of equipment rather than on the grouping and interrelationship of equipment. Measurements of effectiveness thus may concern how far it will fly, how fast, how high, how accurately, how heavy it is, and how long. The "it" most often appears to refer to an individual weapon rather than the performance of a group of weapons in an organizational environment. Engineers are quite prone to assume that the patterns of resource clusters will in any event produce like results regardless of how the resources are combined. This assumption has not inevitably been justified by the results, but in general it is the basic philosophy of most research engineers. On the other hand mathematical models to predict the organizational pattern against firm measures of effectiveness are few and far between. The operations researchers are just entering this subject area. This is true not only of the military but also of industry. The high cost of research and development, as well as the almost automatic identification of aeronautical, electronic, *et al.* engineers with research and development, finds the economist, methods engineer, organizational planner, and logistical planner excluded from or at best granted minor participation in the early period when a new weapon concept is being formulated. This exclusion is perhaps a reason for what may prove to be a failure to give proper emphasis to organizational patternmaking studies.

The writer has no ambitious intention of solving universal organizational problems or suggesting intricate models for their solution in this article. Rather it may be considered a preface to the task of resolving pattern problems and is more truly written to stimulate further investigation and deep thinking.

A Mathematical Model for Fighter X

Let us begin our discussion with the outline of a problem, several assumptions, and a review of some past history. All this will be related to a hypothetical weapon system called Fighter X, an interceptor which in supposition is a part of the fighter family planned for some six or seven years in the future. Fighter X will be used to illustrate some of the factors we are so prone to gloss over amidst the glitter of attractive individual weapon characteristics and potential performance criteria.

problems and objectives

Turning to our problems, or perhaps more to the objectives of a mathematical program in this area, we find two major purposes at hand. The first appeals more to Operations, the "doers," while the second interests the long-range planner and research types, the "crystal-ballers." The first objective in each weapon system (Fighter X is but one in a number of similar cases) is to align resources to wartime objectives, so as to provide maximum task accomplishment through best use of limited resources (concept A). The second objective, which can be mathematically computed from the first, is to align resources to wartime objectives, so as to provide a stated task accomplishment through use of a minimum combination of resources that could theoretically be considered to be potentially available (concept B). Throughout this article concept B is assumed possible but conditional upon success with concept A. The problem is to produce sound mathematical models suitable for an electronic computer and to establish the framework of Unit Equipment (UE), the number of weapons per squadron, for new aircraft and missile weapon systems. The computer and model are to diminish the weaknesses of tradition and intuition, those two inherent ingredients of the past, and to integrate several thousand factors now either not considered on a mutual basis or beyond the capability of individual human minds to digest and process in a logical fashion to an efficient, conclusive figure.

An additional objective is to provide research and development—Air Proving Ground Center—with an experimental model especially adapted to smoothing out numbers originally computed in suitability testing in the field. Current practice does not place major emphasis on studying alternative UEs during field testing. Quite on the contrary, emphasis is more likely to be found on varied explanations of how a preselected UE can be made to work even though not on the most efficient or effective basis possible when compared to other UEs.

From a budgetary aspect, UE optimization would provide a mathematical basing point geared to effectiveness versus cost (in terms of economic resources). This would facilitate executive-level decision-making in adjustment of budgets through optimum adjustments in force and at the same time reduce man-hours and time spans now required for manual computations. In essence the objective would be to apply scientifically an increase or decrease of, let us say, a billion dollars in funds or similar changes in personnel resources so as to arrive at the most advantageous residue of forces.

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Numerous by-products would also be obtained as a part of the field test flying involved in model development, such as tests of the structural capability to support war plan sortie rates.

prerequisites to UE optimization

Before any successful UE optimization program can be established, certain things must be accomplished in at least five quasi problem areas. These are not the only ones but represent the most troublesome areas, especially from the aspect of resistance to change.

First, unfreeze UE authorizations, allowing for differences between individual weapon systems or groups of systems. U.S. fighter squadrons have used an authorization of 25 UE for over 40 years!

Second, utilize past history of UEs as a basing point only. Make use of benefits from prior study, both U.S. and foreign. Then test a new weapon system or group of like systems on its own merits.

Third, determine and back up all conclusions and principles by practical, down-to-earth field tests accomplished by a using combat command and properly observed by competent operations analysts. There is no research center primarily equipped at present for field tests needed in development of such a model. A current, stable performance weapon in the hands of units operating under a war plan is required as a vehicle for initial modelmaking. This leaves the entire program at the mercy of the red tape inherent in using combat command forces to accomplish a research project in addition to their normal assigned mission.

Fourth, maximize the potentially productive research efforts of manufacturers, research agencies, and the like that are presently contributing little to this vital subject.

Fifth, avoid the pitfalls of suboptimization in researching this area. This means avoiding restrictions or compartmentation of individual staff activities, e.g., Materiel, Personnel. Compartmentation is conducive to overaccenting a specialized interest to the exclusion of some other area. Quite often this results in an over-all loss of efficiency and effectiveness. By effectiveness is meant merely getting the job done; by efficiency is meant how well the job is done.

assumptions

To keep our eye on the subject, we must establish certain assumptions or the tremendous number of variables will rapidly discourage our efforts. Perhaps this has been the case in the past, since concrete models are remarkably few.

The general preliminary assumption is made in this program that established force structures are correct as portrayed in programing and planning documents. This assumes that these forces are the optimum from the standpoint of being the best over-all force it is possible to compute against a given enemy and within some limits of available national wealth. If this is not true, then total force-structure modelmaking is in order on a scale that exceeds the area considered here, for our take-off point is knowing the required numbers of sorties and missiles on target and the general framework of forces behind these numbers.

In the stage preparatory to actual modelmaking, the work would be restricted to an aircraft well represented in the inventory or, in the case of missiles, to one of the simpler varieties on which *unit* performance data are available. In this particular type of work the British science group strongly believes that actual modelmaking efforts should be applied to manned aircraft before moving to missiles. Some scattered results and estimates do seem to point to more fruitful efforts in the missile area. This is not to imply that aircraft units cannot be predicted but rather that, in computing prelaunch reliability versus resource combinations, a higher accuracy of prediction appears likely for missiles than for manned aircraft.

Many factors affect the optimization of weapon numbers in a unit. Under concept A—maximum effectiveness with limited resources—I have assumed five resource limitations and five common considerations. Although there are other factors affecting optimization, in my opinion those enumerated have the greatest weight in deciding the issue. Field testing, which will be discussed later, could prove other factors more vital.

First come the five resource limitations:

- number of Air Force wings by type (no limits on squadrons per wing)
- troop spaces, civilian spaces
- maintenance and operations appropriation
- military construction funds
- critical career fields (quantitative, qualitative)

The five examples of common considerations are related to where the particular system is to be located, whether anything is known of the next system or anticipated follow-on systems, and what techniques of combat operations are planned:

- weather
- mobility
- dispersal—vulnerability
- conversion
- tactics, techniques of combat operations

In most cases the actual model will lack information as to some of these factors. Continual refinement will be necessary as the system progresses from research and development to proving ground to first combat unit to full utilization. As an example, the first product of the model, having been computed perhaps seven years prior to placement in inventory, would in all probability lack the location-of-unit data needed to differentiate unit UE by the weather factor. The same might be true of the conversion factor where the successor system was still too nebulous to be included in the UE of the system being computed.

This means that the early research and development model would be quite approximate. The first Air Force model using a current, stable weapon system will probably appear as antiquated as a Model-T Ford to experienced mathematical statisticians.

history of UE retention

What has been the past history of this situation? In our particular case, where we now propose to develop a model from current fighter data which we can improve upon to satisfy our problem of UE for Fighter X, the research is most interesting. The National Archives reveals a UE of 25 aircraft during World War I. This figure continues into the late 1920's where a typical squadron had 25 aircraft UE and 96 personnel. And even now we find a UE of 25 aircraft in existence per modern supersonic fighter unit. At long last, however, both unit commanders and staff members are intermittently but strongly questioning the advisability of building our unit UE on numbers developed in past history and continued perhaps by mere tradition. To carry this to hypothetical extremes, would we automatically accept the 25 UE figure for a long-range interceptor, more complex and larger than the B-47, requiring over 700 personnel in the basic squadron, if one were scheduled for our inventory? Past history seems to point to an affirmative answer.

Perhaps a vital factor in our retention of historical UEs has been our success in combat with whatever UE figures we have chosen to support. If one has the resources, it is indeed possible to build a lovely home in a swamp at a location determined by mere map inspection. What the expounder of "it works this way so it must be right" always fails to state (since he is perhaps in no position to make the statement) is that "it works this way in a more effective and efficient manner than any other way," or at the least, "than most other possible ways."

In past wars and their related organizational patterns the cost impact of materiel has in general been of secondary importance. Time has been available to build up vast stockpiles of comparatively low-cost-per-item hardware and consumables. Thus a 20-per-cent error on the high side in estimating .50-cal ammunition per squadron would not seriously affect the over-all ability to produce other items of support or to find the money to do so. In the era of supersonic aircraft and guided missiles, individual weapons are the equivalent of large numbers of obsolescent weapons. They are many times more costly and more difficult to support with personnel and materiel resources. Errors of the same 20-per-cent magnitude in computing the number of air-to-air missiles per interceptor squadron could have serious repercussions both within the system and as regards the drain-off of potential resources from other systems.

Even when the total capital weapons equipment is the same, the grouping of weapons in differing size combinations will, the writer believes, result in unlike total revenues of effective sorties in the case of aircraft, and in unlike total revenues of missiles on target in timely sequence in the case of missiles. If this does not prove valid in field tests, which will be covered later in this article, then random numbers of weapons per unit within a total number in the entire inventory will work equally well and prove my theories invalid. Even this result would be worth knowing in organizing future units. As of this date, however, there is no evidence that such broad field test data are available on any weapon system.

Comparative Model Development

A project of this type is operations research with medium- and long-range implications. It is not primarily a fire-fighting project to change current structures, although it does utilize current, stable weapons and units as experimental vehicles for model development. Throughout each and every phase of the project, operational factors should be the prime consideration as against any other single category of factors.

UE selection and project control

The flow of control in selection of weapons per unit in the Royal Air Force, German Air Force, and U.S. Army, and my proposed USAF flow are shown in Chart 1.

The Royal Air Force in its science group has teams equipped to analyze in operations research terms logistics, organization, operations, management engineering, and human resources. This group is directly under the Chief of Air Staff, RAF. No other similar organization appears at such a high command level. The U.S. Army's Combat Operations Research Group (CORG) is organized on a lower level of command. The Air Force's operations analysis group has no logistics, organization, or personnel teams as such, and in most cases is directly under the DC/S Operations.

organizational philosophy

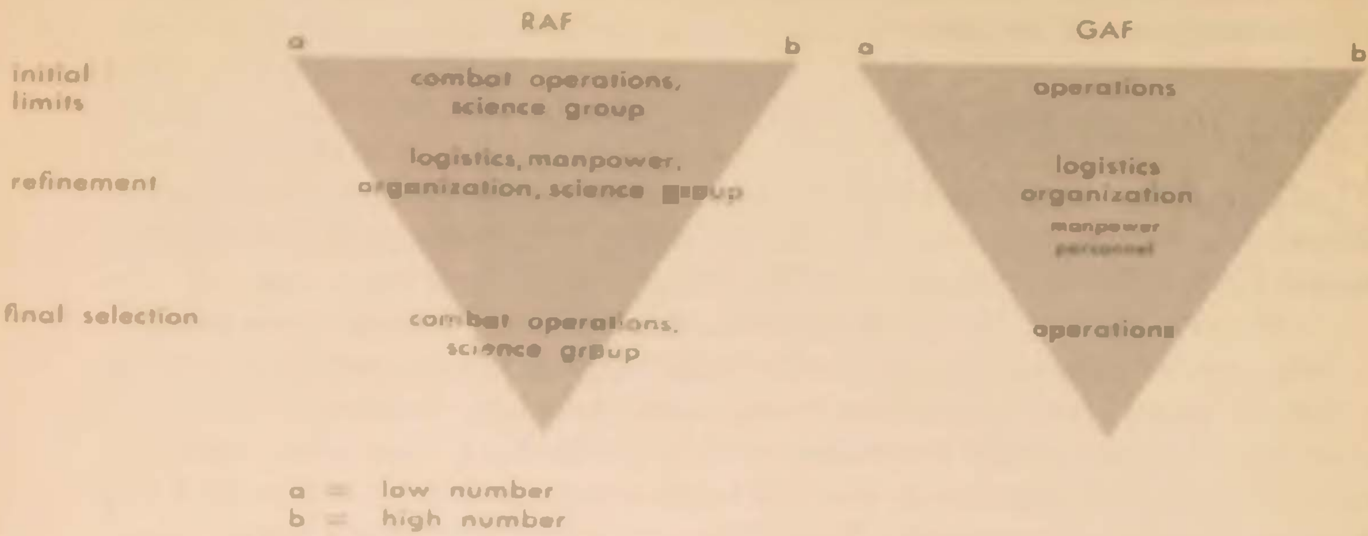
The European philosophy is generally to organize against a total block of required sorties as opposed to computing sorties against a preset organizational pattern, all within fund limitations. The U.S. Army CORG is experimenting in somewhat the same manner on the size and composition of the rifle squad, and at Ft. Knox Project SpanCon has entered the area of diminishing-returns computations in armored force structures. The inverse pyramid is the same in all cases. Operations picks a high-low number beyond the limits of which unit operations are not feasible. This is referred to and refined by the Logistics and other staffs. The final number is again adjusted by Operations to fit operational requirements.

The RCAF, upon studying RAF data (which have been accumulating over the past half-dozen years), has instituted a similar test program on all-weather fighters at Uplands Base. The French and Belgians are beginning to reason in the same direction to some extent through their plans organization.

control of variables

Some claim the variables are beyond control. This is a normal

Chart 1 Flow of Control in Selection

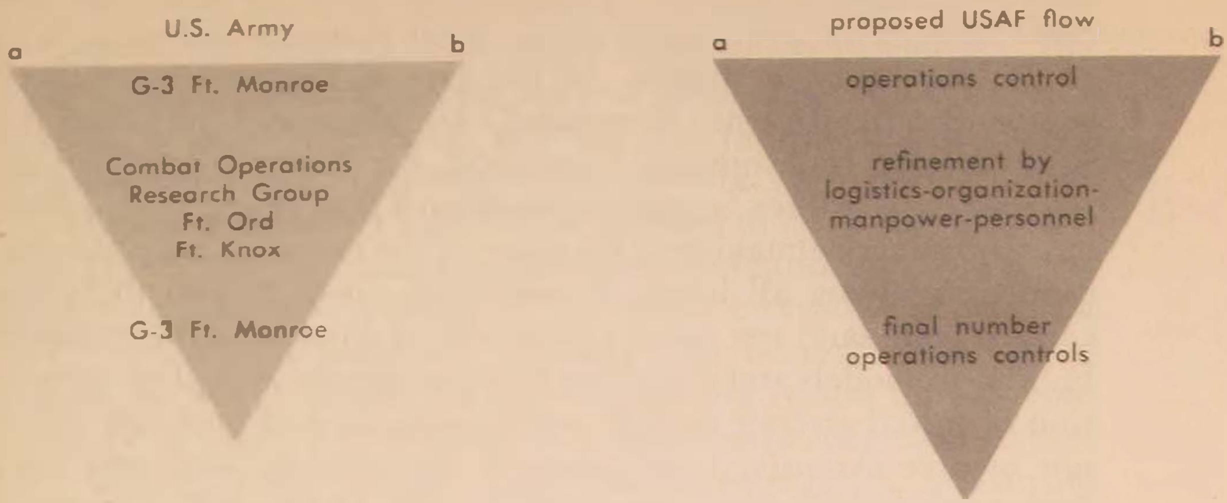


reaction to any difficult scientific problem. Fortunately many so-called "mad" inventors have not agreed with such a premise, and apparently impossible things have been accomplished and will continue to be accomplished despite these die-hards of conservatism.

The correlation data compiled several years ago by the writer, as War Gaming Weapons Controller, and Richard Blythe, Jr., Operations Analyst at Air Defense Command, tend to show that a highly developed war-gaming model can produce computed results closely allied to real-life facts. In this case variables presented an even more difficult problem than in the case of establishing sound organizational UE patterns. Success is certainly not assured in this type of project but neither does failure have an assured probability of 1.0!

who is involved in modelmaking?

Organizational patternmaking work of the type being considered in this article cannot efficiently be the product of any one segmented staff activity. Staff participation must be contributed by Operations, Training, Organization, Personnel, Logistics, Facilities, Plans, and Cost activities. The enormity of the task involved in establishing the initial model seems to point toward of Number of Weapons per Unit



parceling out the work on a subcommittee basis. Thus five work blocks are suggested: Operations and Training; Logistics (including Facilities); Organization, Manpower, and Personnel; Cost and Funding; Mathematics, Statistics, and Data Analysis.

The over-all control of such a project should remain with Operations and, considering the extensive mathematics and statistics involved, be under the direction of operations analysts. Lest we forget the importance of operations as we discuss the suggested field test, may I remind the reader of the inverse pyramid structure shown in Chart 1. Operations is the playmaker of this team. Operations selects original limits and has the final say in adjusting the mathematically computed, refined number. If the original high-low number ranged from 30 to 10 and was mathematically refined to 17, operational requirements could override "mathematics" in deciding that the number had to be adjusted to 16 or 18 to properly fight the weapon, even though Logistics, *et al.*, might cause the model to arrive at an answer of 17. So the judgment factor has by no means been eliminated in this procedure. Rather an attempt has been made to harness the judgment factor and to reap the rewards of past operational experience as well as those of the more inflexible though objective techniques of the mathematician.

Not only must various high-level staff activities participate in the establishment of a model, but at least one objective, nonservice research agency should participate as technical adviser, looking in from the outside. Further, participation must involve organizations close to the problem as users and as planners and supporters of any new weapon system. In the case of Fighter X, an interceptor, the Air Defense Command, Air Materiel Command, Air Research and Development Command, Air Proving Ground Center, and the Weather Service, to mention a few, would be involved.

Initial modelmaking is therefore quite complex, with the procedure involving all levels of command down to and including combat command test units armed with a current, stable weapon. Follow-on models and adjusting into the missile area after completion of initial aircraft models may be simpler and probably would not involve extensive field testing at the combat command level. Such testing could be accomplished in the ARDC–APGC phase of a new weapon system with minor adjustment made after the first few units had been in operation within the combat command. To gain from the model, computations must be valid early in the life of the weapon system to guide procurement quantities, allocation of supporting resources, and how they will be grouped. The ARDC–APGC complex takes on an added importance in weapon system planning and implementation when more specifically given this additional responsibility. AMC also enters the organizing play at an early stage.

A Sequence of Model Events

There are numerous ways of establishing a model, and this article will not delve into the details of modelmaking. If the reader is convinced that a model would be useful and worth investigating, the purpose of this preface has to a great extent been accomplished.

One sequence of model events which would seem quite satisfactory is suggested:

a. A Gallup-type questionnaire would be devised by psychologists and operations analysts. It would have leading questions on various resource aspects of squadron operations and would be filled out by all squadron commanders involved with the current, stable fighter which is to be used as a basis for the initial model. Such a questionnaire has in fact been developed, although not implemented as of this date. It has been successfully tested at a few of the combat squadrons on a trial-run basis. The value of the questionnaire is in trend analysis rather than strict study of mathematical facts.

b. The field test with its interrelated command and staff would be next on the program. The more units which participate, the more accurate the data will be, up to a point. Before this point is reached, however, the testers will face the inevitable problem of releasing units from their regular mission for testing.

Objective measures must be established as goals for optimization. There must be no suboptimization of organizing for peace as opposed to war or vice versa. If this is not carefully examined, a unit organized for peacetime training will be rather poorly organized for war. Perhaps this may be one big reason for any continued poor exercise performance as opposed to successful day-to-day training. There appear to be two categories for measuring effectiveness—one for peace and one for war. The key staffs involved in these packages are Operations and Training for the peacetime, and War Plans for the wartime. Together they weave the two packages or similar packages into one pattern of desired effectiveness.

c. Model development, testing, implementation, control, and continuous refinement would then take place under the auspices of operations researchers (both military and civilians in the military) and nondefense agencies as may be selected to assist.

d. Model application would be utilized in predicting UE of all new weapon systems as an accepted practice.

Field Testing

initial field testing (phase I of concept A)

Before testing a series of equipment-manning combinations, we must analyze the accuracy of our factors. Therefore the initial field test will involve the number of units and a statistically developed experimental test design similar to the follow-on tests. Initially the resources other than aircraft would be held constant, varying only the number of aircraft per squadron. An alternative would be to hold all resources except aircraft constant, with personnel placed on a "representative" basis by AFSC rather than as authorized (see last column in Chart 2). A simple design is shown in Chart 2 ranging from 12 to 25 aircraft per squadron with four squadrons being formed per current three squadrons (reflected in line 3 of the chart). Trainer aircraft will also have to be considered as a part of the package.

Chart 2 Maximum Effectiveness with Limited Resources

phase I: determine UE best supported by current manning and equipment tables and related current authorizations and resources

test current resources

aircraft		or	
a = 25 aircraft b = 18 aircraft c = 12* aircraft	all resources held constant as authorized, other than aircraft		all resources held constant as authorized, other than aircraft; personnel will be on a "representative" basis

*4-squadron per present 3-squadron basis

A typical but not exclusive experimental design covering a squadron at each of three bases for a series of 20-day cycles of tests is shown in Charts 3 and 4.

These tests would be thoroughly observed and periodically reported, allowing for analysis of variance to be computed. Tentative observer's check lists for all activities have already been developed to an extent. Frequency of observations varies both with function and with whether a peacetime or wartime block of events is being studied, e.g., effective war sorties, peacetime training hours.

The results of the initial test may prove that our currently organized resources actually best support some number of aircraft other than 25 per unit. They will at least provide a frame of reference for organizing the vital testing that follows.

follow-on field testing (phase II of concept A)

The over-all spectrum of categories in the case of a fighter squadron might run from category A with 10 aircraft per squadron, B with 15, C with 20, and D with 25 to category F at the upper size limit with 35 aircraft per squadron. Number of squadrons per wing, or in air defense per theoretical wing, could run from two in the case of large squadrons to four in the case of small squadrons. Differences between types of fighters can also be allowed for by developing models or adjusting a master fighter model for necessary categories of day fighter, reconnaissance, etc., depending upon workload, data availability, and accuracy desired.

In the initial field test conducted within limited resources and further restricted by actual authorizations (e.g., 309 spaces per

Chart 3 Two-Cycle Latin Square*

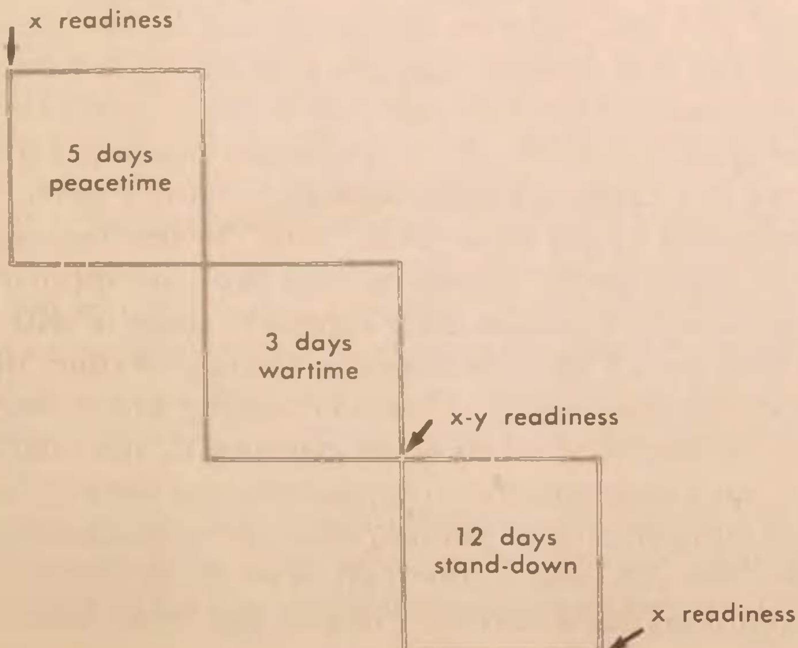
air base	20 days	60 days			60 days		
#1		a	b	c	c	b	a
#2	pretrial: a	b	c	a	a	c	b
#3		c	a	b	b	a	c

*A Latin square is a square array of n letters each repeated n times and disposed so that each letter occurs just once in every row and column. Latin squares form the basis for an important type of experimental design.

a = 25 aircraft
b = 18 aircraft
c = 12 aircraft-
4-squadron per
present 3-squadron basis

Chart 4 Each 20-Day Subcycle

(each subcycle of the same letter varies number of aircraft)



squadron of specific AFSCs and grades) and specific equipment types and amounts, we are merely studying one of five or six possible organizational make-ups within category D mentioned above. We are generously assuming that the other four or five possibilities in D have been studied in deciding on current make-up. We have no proof, however, and cannot reasonably assume that other categories A, B, C, E, and F have been considered in a scientific fashion before D was chosen.

In the follow-on field tests we are only restricted by grand totals of resources available and not by current authorizations for individual units as we were in the initial test. In essence the spectrum from category A through F must be analyzed following the initial test. A segment of such an analysis is shown in Charts 5-8. Chart 5, for example, makes use of the factors learned in the initial tests to show a portion of the spectrum which will be the basis for operating the follow-on tests. Categories C and D only are shown as illustrative of 20 and 25 UE, respectively. The same analysis would have to be performed for the other categories A, B, etc. For the combat objective and limiting resources factor, a simple situation has been used. The entire fighter force of our current, stable weapon system with which we are experimenting is to produce 2400 sorties for the first day of war. Twelve thousand or less spaces of varying grades and AFSCs are available to the system. It must operate within a 12-wing ceiling but is free to choose the number of squadrons contained therein. The standard cost index is one million dollars per sortie produced. This cost figure is obtained for each category and subcategory (D1, D2, etc.) by dividing the initial capital cost and one-year operating cost by the number of sorties produced. It is realized that the cost covers more than the first day of war and that the one-year cost does not reflect the useful life of the weapon. But since all categories are computed similarly, this will serve as a crude measure of dollar-resource performance.

The judgment factor as to what "mix" to test for categories A, B, C, D, E, and F in the follow-on tests must be applied to the five or six possibilities within each category, since it will be impossible to field test all the subcategories because of time, tie-up of force, and expense limitations. Thus in choosing which single subcategory will be tested of all those in category C, the analyst will note that C1 has a large number of squadrons and aircraft, an over-utilization of equipment and people, a low per-aircraft sortie capability for the first day, and a low total revenue in sorties, in fact below that required (see Chart 6). The cost per sortie is also rather high. C3 and C4 both reach the goal and even exceed it. C5 is closest to the goal, has the lowest cost, meets the 12-wing requirement, and has resource utilization with most "greens"—a "green" being an efficiently utilized piece of equipment or human resource. The analyst also notes that production of aircraft could be critical within time and plant availability at 800 aircraft. He finds that C5 requires a force of only 720 aircraft to produce a revenue of 2448 sorties. C5 would be selected as the candidate for the C category in the follow-on field tests.

The same analytical procedure, here greatly oversimplified, would be carried through for D and the other categories. Note in Chart 7 as well as in the force capability column of Chart 5 that no subcategory in D reaches the goal of 2400 sorties and that cost in every case exceeds or equals one million dollars per sortie. One can now begin to see the danger of restricting UE to a single category consideration, such as D, without examining other categories within the high-low limits per unit established by Operations. Returning to Chart 5, should the analyst fall into the trap of trying to patch up his best D subcategory, D4, by planning 11 wings or 33 squadrons in hopes of reaching 2400 sorties, he will in most instances be the victim of diminishing returns if he operates within the original resource limitations. His per-aircraft sortie capability will drop below the 2.9 which applies to 30 squadrons and he will remain below the 2400 sortie total. To reach 2400 and maintain the 2.9-sortie-per-aircraft capability he must add resources. As mentioned previously it is possible to build a nice home on a swamp if we are wealthy enough. This is all rather simply shown on two economic curves in Chart 8 where, within resource limitations, diminishing returns show in the elasticity of the curves. Thus in moving from D3 to D2 we add 75 aircraft. The per-aircraft sortie capability, however, drops .5. This causes a loss of 450 sorties in the D3 force and gains only 150 sorties (75 aircraft $\times$ 2.0 rate per aircraft) from the added aircraft. Since D3 produces 2250 sorties and D2 produces 1950 sorties, the net loss in moving from D3 to D2 is 300 sorties in total revenue. The situation is in many ways related to establishing a selling price in a market research problem. Too high a price sells few items, resulting is low total revenue. Too low a price sells many items, but also results in low total revenue.

An experimental design pattern must also be carried through the follow-on tests. The same principles are used as shown in Charts 3 and 4 for the initial tests of two 60-day periods, each comprised of three 20-day differing cycles. Now we are testing new organization tables and equipment representative of one subcategory within each category as selected by analysis. One base may be tested for 10, 20, 30 aircraft UE, another for 15, 25, 35 aircraft UE, etc., to cover the range of categories within a reasonable test period and with sufficient statistical data provided to lay the framework for model establishment.

Chart 5 Hypothetical Analysis of Categories C and D

(a segment of the A to F categories in the follow-on tests)

objective—2400 sorties first day of war

sample of limiting conditions

a. 12,000 spaces or less

b. 12 wings (24 to 48 squadrons)

c. cost index under 1 million dollars per sortie

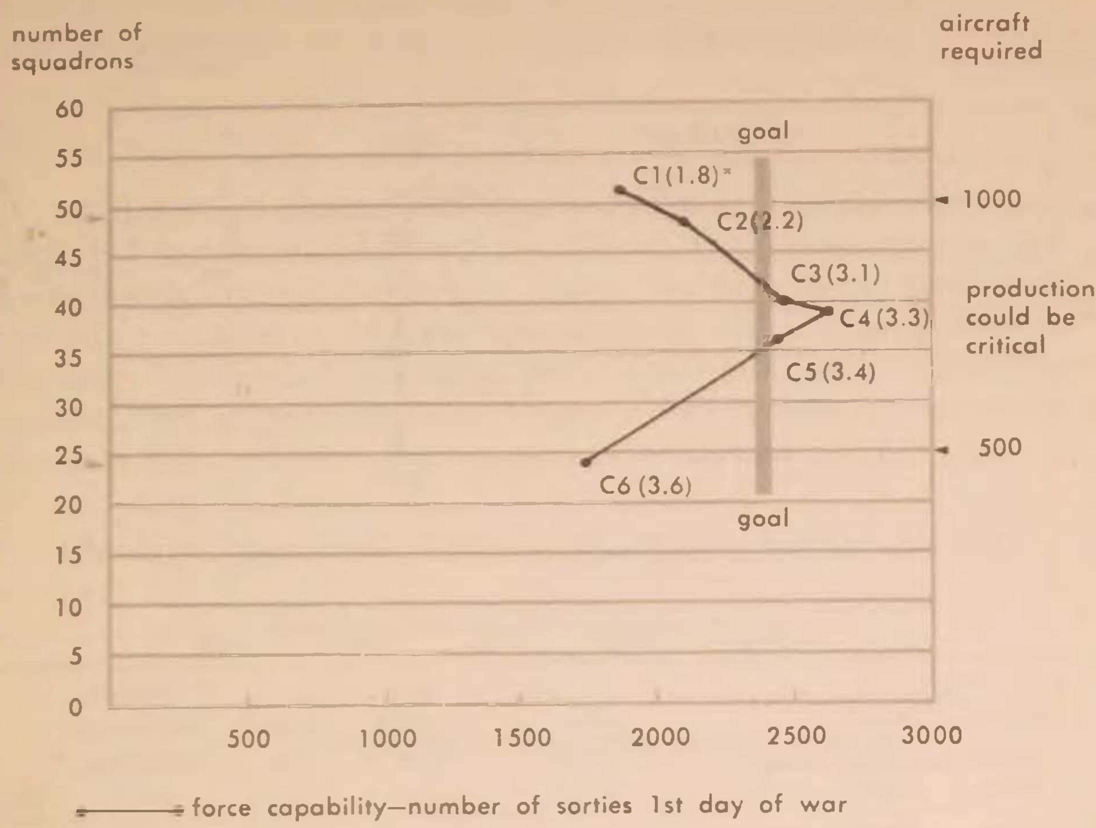
UE	organization and equipment tables	number of wings/ squadrons	number of aircraft	predominant utilization coding*—people-teams-equipment	per-aircraft capability—1st day sorties	force capability—1st day sorties	cost index per sortie
20	C1	13/52	1040	red O	1.8	1872	1.4M
20	C2	12/48	960	red O	2.2	2112	1.1M
20	C3	10/40	800	green	3.1	2480	1.0M
20	C4	13/39	780	green	3.3	2574	.9M
20	C5	12/36	720	green (most)	3.4	2448	.8M
20	C6	8/24	480	red U	3.6	1728	1.0M
25	D1	15/45	1125	red O	1.0	1125	2.0M
25	D2	13/39	975	red O	2.0	1950	1.4M
25	D3	12/36	900	green	2.5	2250	1.1M
25	D4	10/30	750	green (most)	2.9	2175	1.1M
25	D5	8/24	600	red U	3.1	1860	1.0M

With no assurance of greatest return per unit of economic resources, we can force 2400 sorties with an input of extra resources. Thus—

UE	organization and equipment tables	required sorties 1st day of war	probable number of sorties per squadron	required number of wings/ squadrons	number of aircraft	total sorties produced	cost index per sortie
25	D4	2400	(2.9)(25) = 72.5	11/33	825	2400	1.1M

*On field-testing data-collection splash sheets, efficiently utilized factors are posted in green and others in red, giving a splash effect of red or green for each category. The coloring is superficial but would show trends from red to green predominance and vice versa. The terms "red O" and "red U" mean "red (Overutilized)" and "red (Underutilized)."

Chart 6 Hypothetical Plotting of a 20-Aircraft UE for Category C



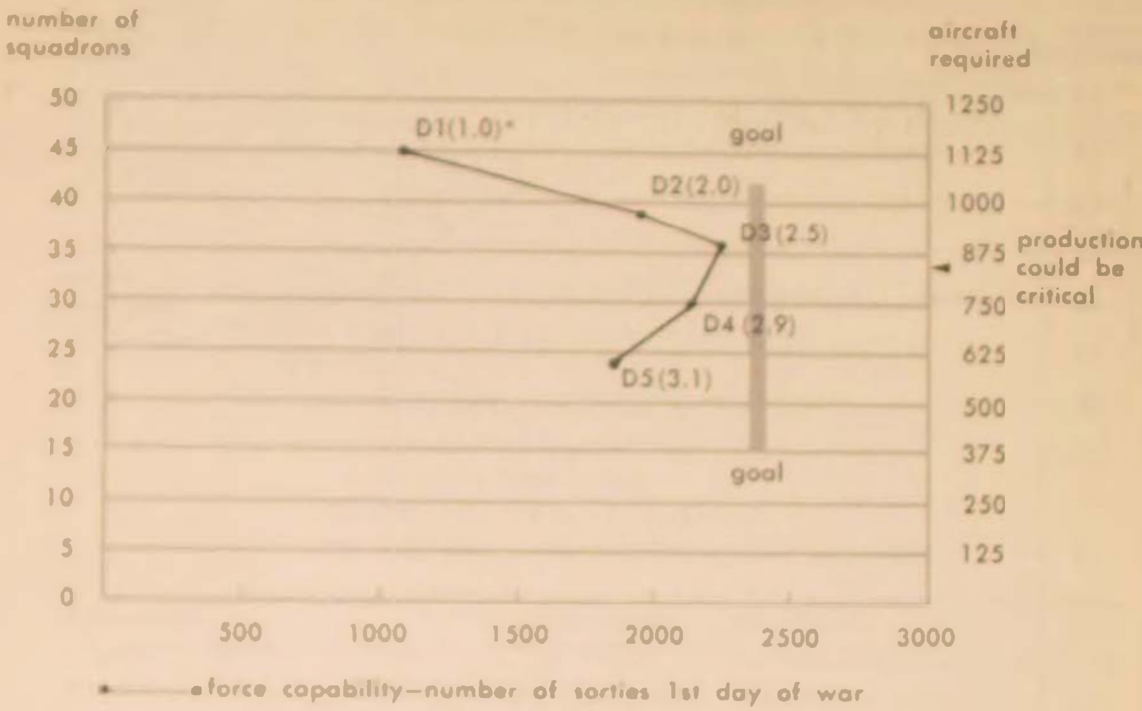
*Number in parentheses beside each plot indicates 1st day sorties per aircraft.

excess capacity

Discussions with design engineers reveal some interesting features of excess capacity that could well be considered in establishing UE quantities. The engineer is usually given the basic UE rather than asked to analyze it from characteristics of support equipment design and multiples. When such an analysis is not made (not that it would be *the* single governing factor), the designer forces the design, thus encouraging design inefficiency. In addition the meeting points of the 1-per-12-aircraft and 1-per-6-aircraft types of equipment are not always in the same multiple of that UE which is selected without considering support equipment design and high-dollar meeting points. "Meeting point" refers to the point where critical and high-dollar support equipment have a common divisor. Thus three required equipments, one on a per-4-aircraft basis, one on a per-6-aircraft basis, and one on a per-12-aircraft basis, would have a 12-aircraft (or multiple thereof) meeting point.

If the meeting point and the UE do not coincide, we have

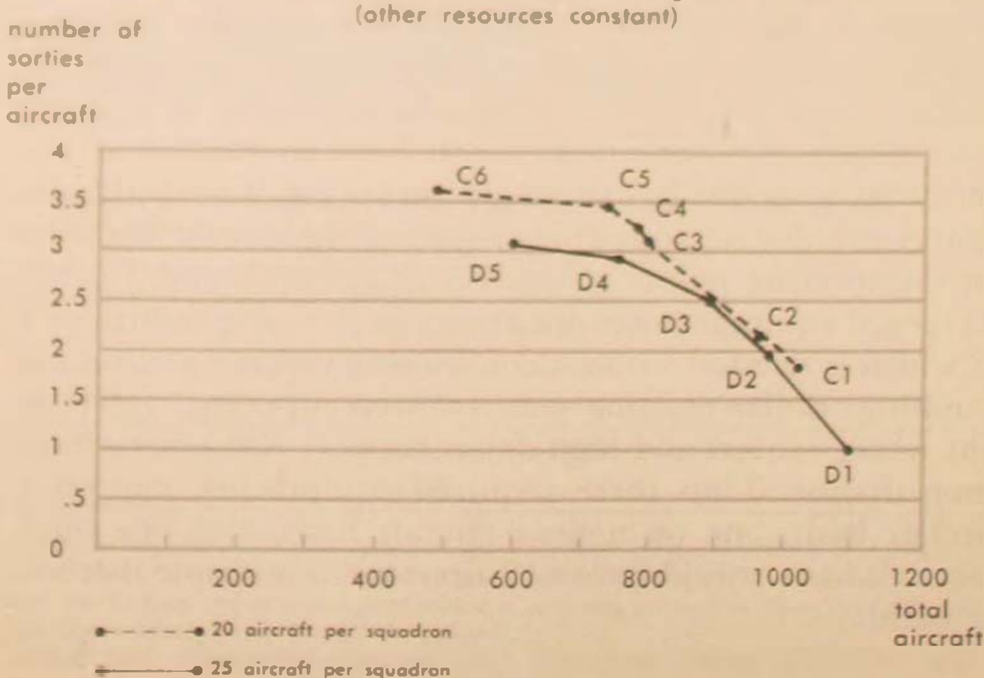
Chart 7 Hypothetical Plotting of a 25-Aircraft UE for Category D



*Number in parentheses beside each plot indicates 1st day sorties per aircraft.

Chart 8 Hypothetical Potential Sorties per Aircraft 1st Day of War

Versus Total Aircraft Involved for Categories C and D (other resources constant)



the same situation as exists in a mess hall where enough extra people are eating to require an additional cook but not quite enough to keep him really busy. In equipment this causes higher cost per sortie and is a form of economic excess capacity.

the missile UE

Apart from the basic hardware design of a missile there is a group of factors which exerts considerable influence on the prelaunch reliability of the missile. Again we refer to the method of grouping missiles and related resources in units. If with limited resources we desired to obtain 1000 missiles on target (within a certain circular probable error) fired within a certain time limit, the operation analysis might appear as presented in Chart 9.

Chart 9 Hypothetical Missile Illustration (Oversimplified)

objective: 1000 missiles on target in *n* hours

UE	number of squadrons/ command posts	number of missiles	probability firing in *n* hours		reliability factor		success factor	missiles on target	cost index per missile on target
40	28/9	1120	.95	×	.9	=	.855	958	.85 M
60	24/8	1440	.9	×	.8	=	.72	1037	.72 M
120	21/7	2520	.6	×	.5	=	.30	756	.97 M

If we are already at 120 UE per squadron in our hypothetical case, the normal procedure would be to add more units and accordingly more missiles to bring up the 756 missiles on target to the 1000 required. This can be done by adding resources. If resources are limited or at the least are to be used in the most efficient manner, a better solution is to cut the UE to 60, thus obtaining 1037 on target at a cheaper cost per missile on target. In other cases the UE might be too low originally—for example, an initial selection of 40 per squadron produced 958 on target. There is no simple solution to choice of resource combination. A poor choice will lead to continued poor combat-readiness, failure to meet alert requirements and firing rates, and target misses galore.

Since missiles have no heavy precedent in the organization area, there is a golden opportunity to make the right choice while such a commitment remains open. British operations researchers seem emphatically to propound this viewpoint.

My final remarks are brief and rather pointed. Completed weapon system work cannot end with mere hardware engineering. Let us at least think of organization and the best way of putting together the remarkably fine resources our engineers develop. Let us unceasingly question whether we have indeed established the best possible unit format as we analyze each new weapon system. And finally let us ask ourselves whether the science of mathematics is not, in circumstances such as I have discussed in this article, the equal or at least a copartner of the accepted factors of intuition and tradition.

Headquarters Fifth Air Force

In My Opinion...

WHAT MAKES A LEADER?

Lieutenant Colonel B. J. Smith

During the last fifteen years a great deal has been said and written about push-button warfare. Implicit in much of this discussion has been the elimination of man as other than the ultimate button-pushing decision-maker. But as the space age has moved in, the place of intelligent, thinking men has become more rather than less important. One of the great national worries after the sputnik was and is the failure of this nation to produce scientific and technical people as rapidly as does the Soviet Union. It is recognized that the people of a nation are its most important national resource. It is also recognized, though perhaps not so generally nor so well, that the quality of a nation's leadership is a highly important element of the quality of its people. Nor is it generally recognized that leadership is a complex subject, not to be solved merely by having more young men attend college and become expert technicians and scientists.

Real understanding of leadership, even among otherwise enlightened, sophisticated, successful leaders, has an antiquated quality completely out of line with modern technology. That this is so has a sound historical basis. Many successful leaders down through history have expressed their views on why they were successful. These views were almost always subjective and were generally in terms of "I am a leader, and successful; thus to be a successful leader, one should emulate me." Only recently have social scientists begun to make an objective study of leadership. As these studies progress it has become clear that the "emulate me" formula is not a sound basis for understanding leadership.

The traditional approach to leadership, the "emulate me," has been labeled the "traits approach." It is characterized by a listing of certain traits that an individual must possess if he is to be a leader. Perhaps the best known of these lists is that of Ordway Tead. Tead said that a leader must have:

1. Physical and nervous energy
2. A sense of purpose and direction

3. Enthusiasm
4. Friendliness and affection
5. Integrity
6. Technical mastery
7. Decisiveness
8. Intelligence
9. Teaching skill
10. Faith

Most lists of traits, including that taught in the Squadron Officer School, use some or all of Tead's traits.

Major General Roscoe C. Wilson reported in the *Air University Quarterly Review* in 1953 on some studies he had made of the traits approach. He compared the traits listed as desirable by ten United States and foreign leaders and institutions and found very low correlation. He concluded that no composite leader could be found and that, as long as there is balance, one man's list is as good as another. A study by Professor Ralph M. Stogdill made a statistical analysis of 124 papers and reports on leadership. He failed to find even one trait that was considered essential by all, though there was quite high correlation on some of them.

Failure to identify a common listing of traits that will identify leaders has led later students of leadership to adopt a somewhat different approach. They have come to the conclusion that certain minimal abilities may be required of all leaders but that these abilities may be widely distributed among nonleaders. Thus, rather than searching for a group of invariant traits that enable an individual to lead a group to the accomplishment of its goals, they have looked for those actions which the group must take if it is to achieve its goals. Since the search for a common listing of traits has been unsuccessful, they have begun to look upon the study of the

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dynamics of group action as the area in which an understanding of leadership might be found. This has been called the situational approach to the study of leadership.

Perhaps the best example of the situational approach is one cited by Dr. S. B. Sells of the School of Aviation Medicine, USAF, in a lecture to the Squadron Officer School in 1955. In World War II bombing crews, the airplane commander was often an effiective leader in the normal activities of flying bombardment missions. But if the crew were shot down and faced a completely new situation, such as escape and evasion in hostile territory, a new leader often emerged. The new situation demanded a new set of leader qualities. If those qualities existed in the group, the individual possessing them became the new leader.

A considerable amount of research in leadership has been done in recent years. This research has been from the situational point of view, stressing the characteristics of the group and the situation in which it exists. It does not attempt to find invariant traits of leaders. Instead it seeks to discover what actions are required by groups under various conditions if they are to achieve their objectives and how different group members take part in these group actions. Leadership itself is seen as the performance of those acts which help the group to achieve its objectives. Professors Cartwright and Zander of the University of Michigan have expressed this view in a survey of recent leadership research. They contend that leadership consists of those actions by group members which aid in setting group goals, moving the group toward its goals, improving the quality of the interactions among members, building the cohesiveness of the group, or making resources available to the group. Further they say that leadership may be performed by one or many members of the group.

The research continues and it is likely that many years will pass before the social scientists produce a complete analysis of leadership. But the tentative conclusions that have been reached have application now. It is clear that the view of leadership which sees the leader as a knight in shining armor, the embodiment of all the noble traits, is a delusion. If there is such an individual, he might be the leader in some situations but not necessarily in all. It is more likely that even he would find it necessary to share his leadership role with other members of his group. And less liberally endowed individuals, which includes most of us, rarely find a situation that allows them to lead without large contributions by other members of the group. Then a reasonable working view of leadership must see it much as do the scientists—as a group endeavor, not an individual one.

Does the view of leadership as essentially a group manifestation mean that the Air Force Academy, the Military Academy, and the Naval Academy can be closed down? Are we wasting our time training young men to make the noble virtues their rule of life? No, of course not. But we are misleading these young men if we allow them to go on believing that the possession of a group of desirable traits will automatically make them leaders. This is the impression that much of what is now taught about leadership will leave. The individual who is devoted to duty, who has integrity of character, and who knows his work is an absolute essential to the accomplishment of any important endeavor. But if that individual also understands the real nature of leadership and is not misled by the idealized version taught by the traits approach, he will more easily and efficiently accomplish his goals.

Science and technology have provided the hardware with which man can destroy himself. To the United States they provide the means to defend itself from domination by an alien ideology. Only through the efforts of devoted, intelligent, knowledgeable people can the complex technical and management problems involved in the employment of that hardware be solved. An adequate understanding of leadership can aid greatly in making the most efficient use of those efforts. The situational approach to leadership offers such an understanding.

Headquarters Air Materiel Command

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OPERATION SWIFTLIFT

Peacetime Utilization of Air Reserve Forces

Lieutenant Colonel Jaffus M. Rodgers

THE peacetime utilization of Reserve forces is a problem of long standing in the planning chambers at the Pentagon. Organized and trained for D-day readiness, these forces also strive to attain an operational status in which they augment the everyday requirements of the Regular services. A realistic approach to the problem of applying this capability to routine Air Force requirements is evidenced in Operation Swiftlift, the Continental Air Command's Reserve airlift program.

This operation is essentially the commitment of a sizable portion of Reserve transport aircraft and crews to supplement the airlift resources of the Tactical Air Command. Though manned in full by inactive personnel and tailored to the special aspects of the Reserve program, Swiftlift is providing a very tangible contribution to TAC's everyday operational needs.

Swiftlift was conceived in April 1957. In search for a means of giving realistic training to its growing numbers of C-119 Reserve crews, the Continental Air Command proposed that these crews and aircraft be used by the Tactical Air Command. In the face of growing demands for more and more airlift beyond its own resources, TAC accepted ConAC's proposal with restrained optimism and an eager "let's see" attitude. Since then the Swiftlift program has grown to a man-sized fulfillment of the tactical and training features of its conception. Its value to the defense system is accepted and its capability continues to grow as more Reserve wings participate in daily activities that are incorporated in TAC's peacetime operations.

production

The production figures of this Reserve-supported operation are especially impressive since they are realized at no additional expense to the Air Force budget. Each Swiftlift flight is a Reserve training exercise. Each commitment is accepted and met as if a regular aircrew were participating, though the program is restricted to Reserve aircrew personnel.

During the period from 17 April 1957 to 31 October 1958, ConAC Reserve crews and aircraft accumulated a total of 29,000 aircraft hours under this project.

Cargo has included aircraft parts, conventional reciprocating engines, high-value outsized jet engines, and unit equipment. Unit equipment carried was associated with deployment of Air National Guard and regular units to and from training exercises. Some Regular unit deployments were tactical mobilization exercises related to current war plans. In the past Air Materiel Command has moved high-value outsized jet engines by rail and van. Commercial air carriers cannot handle this large-size cargo. The C-119 aircraft used on the Swiftlift project is well adapted to movement of these engines and substantially reduces the en route and ground-handling delay.

Personnel flown on missions have included troops on combat missions as well as regular members of tactical air force organizations involved in the operation. Over 7000 such personnel have been safely flown on training exercises.

operations

The mechanics of the Swiftlift program are effected by coordination between TAC's Ninth Air Force and ConAC's Fourth, Tenth, and Fourteenth Air Forces. The ConAC units provide Ninth Air Force with a quarterly estimate of airlift capability in terms of numbers of aircraft and hours. Ninth Air Force analyzes its over-all airlift commitments and assigns specific missions to the ConAC units for accomplishment. A combination of TAC and ConAC Reserve aircraft and crews may be utilized to support an airlift mission. In this setup Ninth Air Force exercises control over allocation of the airlift capability generated by Air Force Reserve troop-carrier units.

The airlift flights performed by the Reserve units are on an "on call" basis rather than according to a set schedule. Reserve aircrews are called to active duty in support of Operation Swiftlift and accomplish other flight training whenever Swiftlift missions are not available. Depending upon the Reservist's ability to leave his civilian occupation, these tours have averaged eight days in length since this operation began.

As of December 1958 ConAC had 31 Swiftlift C-119 aircraft committed to TAC on an around-the-clock standby basis. Each Reserve squadron that has reached an airlift capability within its flying training program provides one aircraft and aircrew to this operation. As more squadrons attain airlift capability this number will eventually reach a total of 45 under the present Reserve program—one each from all 45 Reserve transport squadrons.

To ensure that this program does not interfere with the normal training

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missions of the Reserve units and detract from D-day state of readiness, ConAC has limited Swiftlift crews and aircraft to one each from each Reserve squadron. As emphasis shifts from the present crew training to unit operational activity, the Swiftlift commitment could be increased. More crews could then be obligated to TAC's airlift requirements. With a total of 757 C-119's programed into the Reserve organizations, the airlift potential of such a fleet is tremendous. With a 10,000-pound payload in each aircraft, over 7½ million pounds of cargo could be lifted in a maximum one-time effort.

Under TAC direction Swiftlift has served the Air Materiel Command, the Air Training Command, and the AFROTC and CAP programs. Other commands, including MATS, have made inquiries on the availability of this service. Flights are limited in general to the zone of interior, but missions to Panama, Bermuda, Canada, and Newfoundland have been authorized and are being accomplished.

flying safety

Under ConAC supervision the Reserve personnel connected with this airlift program have established an enviable flying safety record. In over 29,000 hours of flying time devoted to Swiftlift missions not a single accident, major or minor, has occurred. This attests the high qualifications of the crews, most of whom are veterans of Korean and World War II operations.

ConAC was awarded the Daedalian Trophy for achieving the USAF's best flying safety record during 1957. The ConAC rate was 6.2 per 100,000 flying hours. This safe record of Swiftlift, other similar projects, and the normal tactical troop-carrier training within this command establish the fact that the Reserve is not a "Sunday afternoon" flying club. The experience level is high and projects such as Swiftlift are accomplished in all types of weather at any hour.

TAC benefits

The Tactical Air Command benefits from this program in several ways. One is the added source of airlift with which to conduct the support function of the troop-carrier mission. There are 35 different locations of Reserve troop-carrier squadrons. These widely dispersed locations provide TAC with a source of airlift at strategic points near all the major population centers of the country. This is a saving in time and money over the use of regular Air Force units to perform urgent missions requiring one or two aircraft.

These live missions provide another benefit: TAC is able to evaluate the actual performance of the Reserve units and to incorporate them into realistic D-day slots. In this aspect the Reserve is fully integrated into the Air Force war plan.

ConAC benefits

Units of the Continental Air Command receive flying training from the live airlift missions performed in the Swiftlift program. With this comes the experience in maintenance and ground- and air-handling of cargo and passengers. Administrative experience is gained from the continuing contact with the active units of TAC and other commands, and a closer coordination between the Reserve and active units is effected.

The participation by the Reservist in this program of live operational flights has increased his enthusiasm for the Reserve program. This gives him a sense of fulfillment in his role as "professional" Reservist.

the future

Swiftlift is the first of several formal methods whereby the capability generated by the Reserve forces can be integrated into peacetime requirements. As stated before, ConAC could enlarge this program when the training situation permits. Large-scale support of Army airborne training exercises and special-mission support to SAC and other commands are further uses of this growing capability.

With the stabilization of the Air Reserve into an all troop-carrier structure, this airlift potential is great. In today's world of constant urgency, Operation Swiftlift is one logical answer to the role of a trained Reserve during peacetime.

Headquarters Continental Air Command

Books and Ideas...

Notes on Air Force Bibliography

with a List of Basic Reference Guides

Dr. Raymond Estep

FOR anyone interested in writing something—from a paragraph to a book—on United States air power, there is a vast amount of material to support his efforts. Usually it takes a librarian or an archivist to keep tab on the location, content, and availability of the widespread sources. Some of the major collections and bibliographies useful to a study of air power are described in this article. The many public and private organizations having research materials on air power may be grouped into two broad categories: general and governmental.

general

Of first importance in this category are the nation's municipal, college, university, and endowed libraries, most of which are open to the user with few if any restrictions. These range in size and extent from the small municipal library, with its limited number of books, periodicals, and newspapers, to such giants as the New York Public Library with its millions of items, and the Library of Congress, which is in a class by itself among U.S. libraries. Its aeronautical holdings include the papers of the Wright brothers, General Henry H. Arnold, and General Carl Spaatz. In a special category are the relatively small libraries of the Air Force, Army, and Navy service academies at Colorado Springs, West Point, and Annapolis.

Another type of holdings, widely dispersed and generally not open to the public, is the personal collections of letters, diaries, journals, memoirs, and records of leaders in the aviation industry and military aviation. A few of the notable collections have been placed in public archives and some have been opened to the general user. A rich source is the as yet almost untapped volume of records of the aircraft manufacturing and air transport companies. Although some firms have opened their files to writers of company histories and biographies of company executives, most probably require the prospective user to satisfy company or family requirements before granting him unrestricted access to corporate records.

A third group of materials, virtually unknown as a source because of the lack of an adequate bibliography, is encompassed in the articles on various aspects of aviation published in the quarterlies, journals, and reviews of the nation's learned societies—national, regional, and state. A number of excellent studies have appeared in these publications, especially in those issued by historical societies. The student with time and the opportunity to search the publication files of these organizations may be richly rewarded.

Another source, equally rewarding and certainly more extensive in nature, will be found in the masters' and doctors' theses of students at the nation's colleges and universities. Of particular interest will be the theses produced by Air Force students of the Air Force Institute of Technology, both by students on the AFIT campus and by those monitored by that organization in their study at civilian institutions of higher learning.

governmental

In this category are found the archives of agencies of the General Services Administration and those of the different military services. In using the records held in these agencies, the researcher will find in many cases that he must satisfy security classification requirements and often establish a "need to know" to gain access to certain archives or to examine desired collections. Numerous categories of materials have been listed for declassification in recent months and many documents heretofore unavailable can now be studied. The potential user of the archives discussed below should, before visiting them, ascertain what actions are necessary for securing clearance to use classified materials and what the possibilities are of securing the declassification of desired data.

Pre-eminent among the institutions preserving governmental records is the National Archives, Washington, D.C., the official depository of the records of various agencies of the federal government. Among its holdings are millions of records dating from the beginning of the nation's history to the present. These include a large number of items pertaining to military and civil aviation. Specific references to volumes indicating the nature and size of some of these holdings are given in three of the publications described below.

Noncurrent records of the Office of the Secretary of the Air Force and of Headquarters USAF are preserved in the Federal Records Center, Alexandria, Virginia. This center also has the records of joint and combined activities in which the USAF participates, war crimes trial records, and other special collections of historical significance.

At the Air Force Records Center, St. Louis, Missouri, will be found permanent noncurrent records, daily strength reports, and Air Force field organization records whose retention is required by statute or Air Force regulation. Similar U.S. Army and U.S. Navy records establishments are main-

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tained at the same site as part of the over-all Department of Defense Records Center.

Of especial interest to students and historians of U.S. military air power are the holdings of the Air University Library and the USAF Historical Archives at Air University, Maxwell Air Force Base, Alabama. In supporting the educational mission of Air University, the library has accumulated 200,000 books, 521,000 documents, 250,000 maps and charts, 29,000 bound volumes of periodicals, and more than 10,000 photographic items, and currently subscribes to some 1500 periodicals and newspapers. The library is not restricted exclusively to student use, and many researchers and writers have used its facilities.

The forerunner of the USAF Historical Archives was established early in World War II as the depository of the official narrative histories prepared by all Air Force units. Among its 1,500,000 documents are histories of all air forces, commands, and subordinate organizations written since 1942. These histories, varying in length from a few to hundreds of pages, describe the organizational structure and mission, and discuss the activities, personnel, morale, housing, equipment or materiel, and combat employment (in time of war) of the respective reporting units. In addition to the histories, the archives has acquired much material pertaining to the Air Force in its various designations as the air arm of the U.S. Army. Significant among the latter are the typed drafts of lectures, course outlines, and other pertinent records related to the pre-World War II operations of the Air Corps Tactical School. Much of this is of great value to a study of the development of Air Force doctrine in the period between World Wars I and II. Among the special collections of the archives the following are significant and indicate some of the types of material, other than unit histories, available to the researcher: the papers of General Muir S. Fairchild and Lieutenant General Millard F. Harmon, and the Lieutenant Colonel Ernest L. Jones Collection (consisting of the books, newspaper clippings, and a 50-volume typed "Chronology of Aviation from the Earliest Records through 1948," assembled by this member of the Early Birds).

Supplementing the records held in the official centers described above are the current records of every Air Force echelon from Headquarters USAF to the lowest level of unit administration. These staff section records and reports preserved at every command and air force headquarters, and especially those at research and development centers, are invaluable to the study of a given organization.

The writer contemplating the study of an air power topic will find a number of bibliographical tools to assist his search for specific information. Among these are the following works usually found in the larger libraries: *Readers' Guide to Periodical Literature, Applied Science & Technology Index, Biography Index, Book Review Digest, Business Periodicals Index, The Education Index, The Engineering Index, Index Aeronauticus, Index to Current Technical Publications, Industrial Arts Index, International Index,* and *Public Affairs Information Service*. In the newspaper field he will find *The New*

York Times Index of great value for its specific references to information appearing in that publication and also for its clues to the dates similar items appeared in other U.S. newspapers. The writer may also find it worthwhile to consult *The Official Index to the* [London] *Times.*

In addition to the above general works that are more or less standard items, there exists in the field of air power a large number of special bibliographical tools that will aid the researcher in his quest for specific types of information on civil and military aviation. These tools, prepared in response to different requirements and needs, vary considerably in format and in content. Some were compiled for the purpose of indicating the holdings of an organization in a given area, others in response to requests for information on a specific subject or in a given field.

The list presented below includes some of the more significant of these bibliographies and reference lists. Entries give title, author, place and date of publication, security classification (if any), and a brief description of contents. Air University Library or USAF Historical Archives call numbers are shown for items cataloged at Air University. Items not bearing a call number can be secured from the producing organization.

Basic Reference Guides

An Air Force Reading Guide, 1957-1958. Department of the Air Force. Air Force Pamphlet 34-11-1. Washington: Government Printing Office, 1958. 42 pp., printed.

The 11th edition of the publication formerly published under the title of *A Professional Reading Guide for Air Force Officers.* It contains annotated entries to approximately 350 books arranged alphabetically by author in 14 subject matter categories. The list is not confined to air power topics; items included were chosen on the basis of their special interest to Air Force personnel. Many of them will add to the reader's general knowledge and furnish a background for the understanding of various current problems.

An Air Power Bibliography. Raymond Estep. Maxwell Air Force Base, 1956. 200 pp., printed. AUL No. M-37097-1-NC/No. 252-54.

A collection of 3151 titles of books, periodical articles, and research studies primarily covering the period 1950-54, but with some materials from earlier years. Arranged alphabetically by title within 58 main subject matter categories also alphabetically arranged. Subject and author indexes, glossary, lists of periodicals, and publishers' full titles. Annotations give brief descriptions of contents of items and some cross-reference material. All items listed were at Air University at the time this volume was prepared. References to books and USAF Historical Division Studies show AUL or Historical Archives call numbers. For references to numerous printed bibliographies on air power topics, see Items 1090-1115 of this volume, and Items 1529-1571 in the volume cited next below.

An Air Power Bibliography, 1955-1956. Raymond Estep. Maxwell Air Force Base, 1957. 273 pp., printed. AUL No. M-37097-1-NC/No. 252-57.

A continuation of above volume, listing 3216 entries. The annotations contain a large number of cross references to items related to the main entry. Material is arranged alphabetically by title within 57 alphabetically arranged main subject matter categories and subcategories. All items listed were at Air University at the time this volume was prepared. References to books and USAF Historical Division Studies show AUL or Historical Archives call numbers.

Air University Annotated List of Student Research Reports. Air University Library. Maxwell Air Force Base, 1957. 91 pp., multilith. AUL No. M-40259.

Volume I of this proposed annual publication lists and briefly summarizes all of the 153 theses prepared by Air War College students in the class of 1957 and the following papers from students in other Air University schools in the school year 1956-57: Command and Staff School, 34 staff reports; Squadron Officer School, one staff study and one special study committee report; School of Aviation Medicine, 10 theses; Air Force Institute of Technology, 5 theses. Listing shows author, title, length of study, and Air University Library call number. Author and subject indexes.

Air University Library Miscellaneous Bibliographies. Maxwell Air Force Base, 17 November 1958. 6 pp., multilith.

A list of 113 bibliographies on various topics (many related to air power), 95 of which were prepared by Air University Library personnel. Bibliographies cited vary in length from 1 to 135 pages. Those prepared by Air University Library personnel are limited in scope and application, and are usually the by-products of a request of a single individual for information on a specific topic.

Air University Library Special Bibliographies. Maxwell Air Force Base, 1953-_____. Multilith.

Begun in 1953, these now number 162 (December 1958). These are prepared by Air University Library bibliographic assistants and reference librarians on request of staff and faculty members of different Air University schools. Compiled for use in seminar and research problems, they cover a wide range of topics. Most are directly related to the subject of air power. Materials listed are taken from books, periodicals, newspapers, and documents (classified and unclassified). Bibliographies vary in size from 2 to 99 pages, and in number of entries from 20 to several hundred.

Air University Periodical Index. Maxwell Air Force Base, 1949-_____ (9 volumes to date). Printed.

This outstanding contribution to the field of periodical indexing covers a wide range of aviation and military publications not indexed in the commercially prepared H. W. Wilson *Readers' Guide to Periodical Literature* mentioned above. Prepared quarterly and consolidated annually and triennially, this Index currently contains references to items appearing in more than 70 U.S. and foreign aviation and military publications in the holdings of Air University Library. Entries are arranged alphabetically by title within different subject matter categories.

Air War College Thesis Summaries. Maxwell Air Force Base, 1947-57. (One volume per year.) Mimeographed. AUL No. M-32983-2-NC.

These annually issued volumes, prepared by or for the students of each Air War College class, are arranged alphabetically by author. Each unclassified summary shows thesis title, name of author, definition and scope of problem, conclusions, and recommendations. Classified summaries are published separately. Beginning with the class of 1958 a shortened version of these summaries appears as a section of *Air University Annotated List of Student Research Reports* described above.

Federal Records of World War II. Vol. I: *Civilian Agencies* (1950). 1073 pp. Vol. II: *Military Agencies* (1951). 1061 pp. General Services Administration, National Archives and Records Service, The National Archives. Washington: Government Printing Office. Printed. AUL No. R/940. 5373/U581f.

Volume I describes the records of the Civil Aeronautics Authority, Civil Aeronautics Administration, Civil Aeronautics Board, and other Federal civil aviation agencies. Location of the records of each is indicated. Volume II, pages 151-234, contains a detailed description of the holdings of the different Air Force records collections for the period ending in 1951. Subject index.

Guide to Air War College Theses, 1947-1956. Maxwell Air Force Base, 1956. 156 pp., mimeographed. AUL No. M-32983-O-NC.

A list of the titles of 1210 Air War College theses arranged alphabetically according to student author. Entries give date of thesis, security classification, number of pages, and file number. Subject and author indexes.

Guide to the Records in the National Archives. Philip M. Hamer (ed.). Washington: Government Printing Office, 1948. 684 pp., printed. AUL No. R/353/U58g/1948.

Lists records of various military and civilian organizations and agencies, for the period 1909 to World War II, among the holdings of the numerous collections of the National Archives. Briefly outlines history of organization in period covered by records held, and indicates linear footage of records. Included are the records of several civilian and military aviation organizations. Materials are arranged by Record Group numerical file number from 1 to 224. Subject index.

Handbook of Federal World War Agencies and Their Records, 1917-1921. Washington: Government Printing Office, 1943. 666 pp., printed. AUL No. 353/U58ha.

Lists records of civilian and military agencies and organizations for the above period filed in the National Archives. Briefly describes contents of collections and indicates linear footage of holdings. Arranged alphabetically by name of organization or agency. A number of collections contain records pertaining to aviation, especially military aviation in World War I. Subject index.

Index to Evaluation Staff Project Files. Evaluation Staff, Air War College, Air University. Maxwell Air Force Base, 17 November 1958. 19 pp., mimeographed.

A list of 233 titles of studies begun or completed by the Evaluation Staff of the Air War College between 1946 and 1958. Entries show project number, title, and date completed, canceled, suspended, or otherwise disposed of. Many are classified; most pertain directly to some phase of air power.

List of Studies Prepared by the Documentary Research Division, Research Studies Institute. Maxwell Air Force Base, 1 February 1958. 4 pp., mimeographed.

Titles of 64 studies produced by the Documentary Research Division in the period 1947-58. Studies cover a wide range of topics. Some are on air power; some are classified. List shows title, classification, publication date, and author.

National Air Power and International Politics: A Select Bibliography. Eugene M. Emme. Maxwell Air Force Base, 1950. 191 pp., mimeographed. AUL No. 016.62374/U58n.

A selection of 1484 titles of books and periodical articles covering period through 1949; some annotated; most in AUL holdings. Entries are arranged alphabetically by author within eight subject matter categories. Subject and author indexes.

Publications of the Arctic, Desert, Tropic Information Center, Research Studies Institute. Maxwell Air Force Base, August 1957. 2 pp., mimeographed.

A list of 25 studies, prepared by ADTIC in the period 1949-57, generally dealing with survival in nontemperate regions. Some studies are classified.

The Rand Publications Index. Santa Monica: The Rand Corporation, 1958. Loose leaf; printed, various places. AUL No. M-30352-8.

This annually issued volume includes titles of all Rand studies and abstracts of unclassified reports, research memoranda, papers, and translations. Most are on air power subjects. Each annual issue is a cumulative edition and supersedes previous issue. Entries list title, author, date of issue, security classification, and Rand call number. Author and subject indexes. Volume is classified.

Studies and Histories Prepared by the USAF Historical Division, Research Studies Institute. Air University. Maxwell Air Force Base, 1957. 12 pp., mimeographed.

A list of 138 studies on U.S. military aviation that have been written, are in process of being written, or on which work has been suspended or canceled as of 1 September 1957. List also includes titles of 12 policy studies, 2 special studies, 6 volumes of the *USAF Wings at War Series,* 6 volumes of *The Army Air Forces in World War II, The Official Pictorial History of the AAF,* and the *History of the Army Air Arm, 1907-1941.* Publications listed were prepared or supervised by the USAF Historical Division or its predecessor organizations.

Unit Histories of World War II: United States Army, Air Force, Marines, Navy. C. E. Dornbusch. Washington: Office of the Chief of Military History, Department of the Army, 1950. 141 pp., mimeographed. Supplement, 1951. 49 pp., mimeographed. AUL No. R/016.94054/U58u.

Prepared by a member of the staff of the New York Public Library, the

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