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" . . . between a rock and a hard place"

The Information Job

MAJOR GENERAL ARNO H. LUEHMAN

MILITARY public relations has long been a stepchild in the official structure, a career field often misunderstood both within and without the service. The amorphous basic nature of this profession is partly to blame, but in larger measure I believe the misunderstanding stems from the wide variety of interpretations as to what public relations means, what it encompasses.

In a 1954 reorganization of the Air Force Public Relations Office, the name was changed to Office of Information Services. Two years ago the word "Services" fell victim to progress, and today the name is Office of Information. In looking back I feel it is unfortunate that the term "Public Relations" was dropped, because to me it is much more meaningful than "Information." Even the words "Public Relations" do not reflect the full scope of the function or the responsibility of the job at hand.

Throughout our political and social structure today new movements and forces are changing the classic responsibilities of military leadership. They are forcing all of us, whether we like it or not, to re-examine our relations with the public, with industry, the Congress, our schools, churches, and other public groups and activities.

The problem is complex and elusive, hard to hold in focus long enough for a rational or studious appraisal. Problems in human relationships are always like this. Public relations, in particular, is a field of abstractions, judgment, and intuition rather than of cold logic and precise rules. Let us examine briefly the way business and industry are coming to regard public information and public relations.

Recently *Business Week* magazine wrote about a new management concept, "corporate public relations," which it described as "a continuing effort on the part of management to win respect of the public by acting in a way that wins respect." In other words, big business is convinced that responsibility for public relations goes straight across the board. Management itself, by its own actions, must justify public confidence. The job cannot be turned over to the public relations man and then forgotten. He merely advises, recommends, and informs. It is management's performance that must win and hold the respect of the public.

But it is not enough for management to do its best job and assume that all else will follow automatically. Management must take one more step—and that is to inform the people so that they are aware that the job is superior. Here we find the essential link between management and the public—the press and other news media of various types. And lodged squarely between management and the media is the public information (or relations) officer. He indeed sits "between a rock and a hard place

Business Week continued about corporate public relations in these words: "Corporate public relations means keeping management informed of changes in the opinions of its various publics—stockholders, employees, customers, suppliers and government. It also means counselling management as to the impact its action or lack of action will have on the opinions of these publics. Once a corporate decision has been taken, public relations' job is to communicate this information in the best and most accurate manner to the company's publics."

Note that reference is made not to "public" in the singular but to "various publics." Just as responsibility for corporate public relations goes beyond any one segment of management, so does "the public" include far more than the mythical man in the street. Responsibility begins within the corporation and spreads out through employees and stockholders to all external groups.

Let me point out, too, that big business is not pursuing corporate public relations merely because it is a nice thing to do. Big business has not changed its objective, which is to make profits. Big business has learned its lessons the hard way. Sometimes I wonder if the military services, the biggest business of all, whose objective is the defense of this country, have really learned theirs.

Let us consider the concept of corporate public relations in terms of the national defense establishment. Specifically, why do we have information officers in uniform? They do not exist to "sell" a particular branch of service or to make it easy for reporters to get news about a service. As an information officer I do care how many friends I have, how many reporters, commentators, journalists, and publishers I know on a first-name basis. But if promoting the Air Force or handling press inquiries were the sole measure of my activities or those of my office, I would consider myself a failure. I believe there is a far more important job to do than just to parrot an official line or cushion the activities that have public impact or interest.

Starting with the premise that the American people have a right to full and complete information—good or bad—about the Air Force, subject only to limitations of real security, my job is to get the whole Air Force—officers and men, military and civilian—to *work* on that premise. Let me emphasize, this is not an attack on necessary secrecy. I simply want to acknowledge the fact that in the American scheme of things, a government of, by, and for a people governed by their own consent, the right to know is with the public. The government is granted the authority to withhold some information, which means the burden of proof of need to withhold is on the government.

This necessity in no way alters our duty, obligation, and authority to safeguard, to the best of our ability, information involving military security. In practice, recognition of this principle will strengthen our security system. It will also increase public respect for the military service. Our government—any government of free men—has the obligation and authority, which free men insist it exercise, to maintain constructive security of information of various kinds. This is a very precious grant, and its abuse can erode the very foundations of our government. The uniformed information officer is an "in-house" guardian of this principle. He is also the public's advocate for the rights of a free press. It is his duty to advise his superiors of the hazards of unnecessary withholding of information and of the obligation of every military officer to respond to proper inquiry by representatives of the news media.

A leading American industrialist, chairman of the board of one of the Nation's great business enterprises, once said that the public relations man must be the conscience of industry. I believe that we in uniform have a similar responsibility for the military service in our dealings with the public. We must have a conscience, both for ourselves and for the public as a whole. In the services and in the press, integrity must be the watchword. When anything threatens the integrity of either the uniformed ranks or the press ranks, we face serious trouble as a nation.

All of us should be aware of a rather strange paradox confronting this country. At a time of new world danger and new reliance on our military strength, when the integrity and moral discipline of the men in uniform are more important than ever, there is a growing fear of what former President Eisenhower called "the military industrial complex." Fear and suspicion of "the military" mount even as a nation in peril comes to rely more and more heavily on its armed forces to combat a grim international threat. Much of this feeling is sincere and deeply felt. Writing in influential publications, a number of well-known analysts have critically discussed the role of the armed forces in the United States today. Most of the argument seems to focus on these major points: that the military is too deeply involved in cold-war activities and that the military is undertaking political indoctrination of the civilian populace. Dirty words appear, like "military brass" and the "military mentality" and lately, "military public relations."

One writer put it this way: "The path to these heights of power and influence is cleared for the military and its industrial allies by a public relations establishment that has no equal in American public or private life. The establishment *uses* the press, television, movies, comic strips, civic organizations, veterans groups, schools and troops to *sell* the military point of view to the American people. No other point of view, save that of the President alone, can reach the people from so many sides at once." Later in the same piece he says, "The channels of communications are manipulated each day with taxpayers' money to implant the general military view of life on the American people."

I think it will come as a surprise to the press to learn that it is being "used," "sold," and "manipulated" by that powerful and sinister group which the information officer is alleged to represent. It is not a very flattering remark about a fundamental, American institution.

Through years of experience in working with its members, I am convinced that the press is the least likely of any group to be "used."

In the first place I think that writer made, consciously or unconsciously, one basic incorrect assumption, and that is that the military services are free agents in the field of public information. They are not. They have not been since 1949.

We do not quarrel with the fact that they are not. The Army, Navy, and Air Force are all subordinate elements of the Department of Defense, which is headed by a civilian Secretary, presently Mr. Robert McNamara. Rules, regulations, and guidance pertaining to all the public affairs of the three services are laid down in his name by a civilian Assistant Secretary for Public Affairs. The incumbent is Mr. Arthur Sylvester, formerly Washington Bureau Chief, *Newark News.*

These rules, guidance, directives, etc., are not always hard and fast as to what one can and cannot say. The majority of them are broad guidelines governing what might be called ethics or precepts for a normal, prudent man to measure his actions against. Certainly we do not agree with all of them all of the time. But let me make the obvious point—the military and its public relations people are not in revolt. We have tough, competent civilian leadership. Even though we may have occasional disagreements, we know who's boss, and we respect and abide

". . . the right to know is with the public"

by the boss's judgments. This is not to say that we are being "gagged." We are not. We would not stay in this business very long if we were.

Primarily, we in the Air Force do not think we have a God-given right and duty to straighten out and educate the American public on every ideological, political, or controversial issue of the day. Nor should we usurp the duties of the home, school, or church. In the field of national policy, for example, we are the instruments not the formulators of policy.

We do have, however, a full-time, man-sized job and duty to prepare our men in uniform for the role they are playing in the battle against Communism—by arming them with knowledge of the strength and value of our democracy, as well as the nature of the threat we face. To this end we are prosecuting a vigorous program, and we intend to step it up, under our civilian superior's leadership and direction.

Abe Lincoln expressed himself very clearly when he said that with public opinion nothing can fail, against public opinion nothing can succeed. This is important, for it is clear that the competition for men's minds keeps on increasing. And, though people sometimes act as though this were not so, an opinion can be as strong as a fact, even if the opinion is wrong.

The average military information officer deals in facts rather than opinions. To the extent that he is a reliable, knowledgeable, and truthful source of factual information, he is necessary and useful to the commander and his staff, to the media, the public, and the total national defense establishment.

The information officer in the field serves as an extension and ally of the media representatives with whom he works. Without his services the press, the essential link between military management and the publics to whom we are accountable, would be handicapped in playing its essential role in our society, notwithstanding its current skill and excellence.

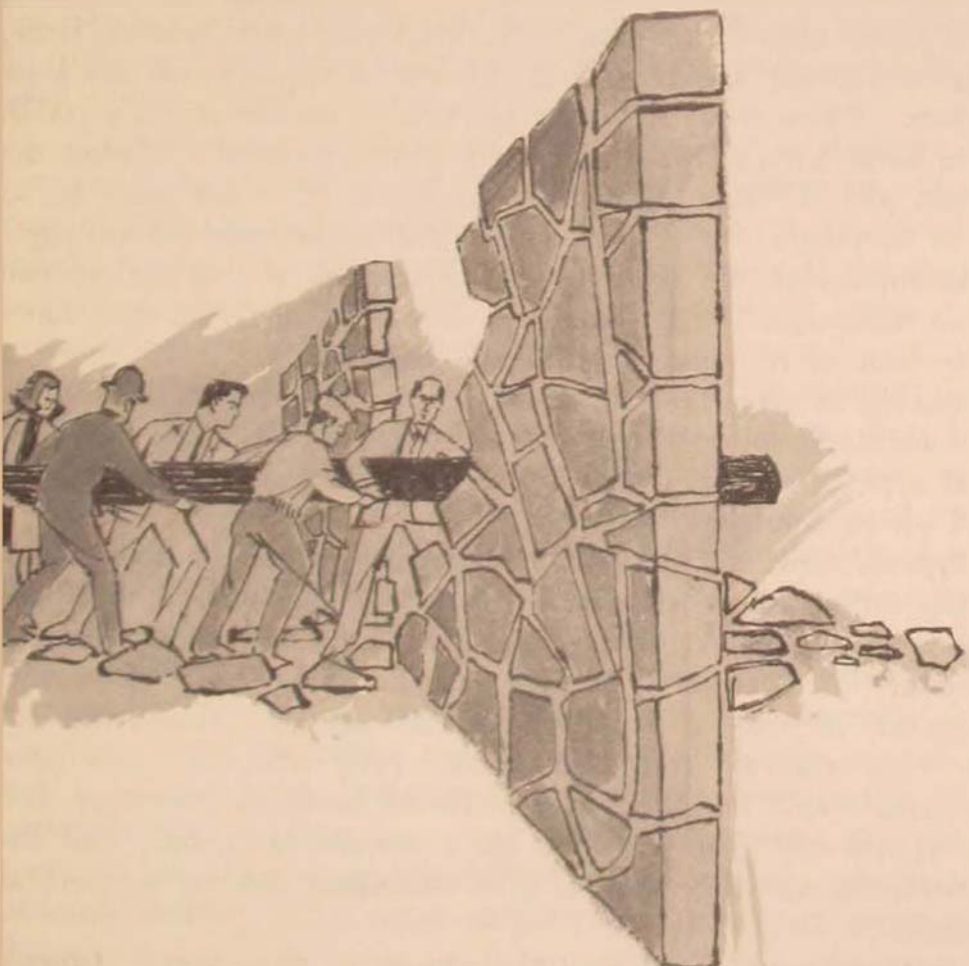
While it is true that the information officer performs a staff function of the highest importance, it is also true that he often receives little credit or support in times of stress and little recognition even for generally high performance of his craft. Seldom is it acknowledged by commanders, or for that matter by the media, that their work has been aided and improved by the information officer's input. Although it is not written into his job description, the information officer frequently serves as the bird in a badminton game in which the opposing sides are the media executives and their representatives on the one hand and his civilian and military superiors on the other.

There is one final observation I would like to make. What is essential today is not that civilians and the military stop carping at each other, but rather that they understand and respect each other.

The future of the United States will be decided by the strength and determination which we all as citizens bring to the task of preserving our liberties. Involved is the resiliency of democratic society. This challenge has absolutely nothing to do with military versus civilian. It has everything to do with the survival of freedom, in the building of which freedom of the press and adequate national defense were both carved into the capstone.

It is in this perspective that the function of information officers must be viewed and against this background that they must perform their tasks.

Office of the Secretary of the Air Force



". . . against public opinion nothing can succeed"

Economics of Logistic Support

A Paradox of Cost and Policy

Lieutenant Douglas N. Jones

IT IS generally accepted that the most immediate aspect of the threat the United States faces today is military in character. In response, national policy calls for assuming a military posture inferior to none, of the highest combat readiness, and capable of deployment any time and anywhere. When these demands are placed on the military establishment, to be realized out of a defense budget tempered by "what the economy can afford," it is apparent that military monies must be so managed as to return the greatest increment of defense per taxpayer dollar. Accompanying the present state of the art in defense are two forces which make such dollar management more difficult yet even more imperative—time of response and cost of complexity.

This discussion undertakes to relate these two forces to the specific problem of logistical support in the nuclear–missile age. It is based on two central hypotheses: the first bears on the nature of logistic support, the second on its implications.

It is hypothesized that premium transport of military cargoes, which is principally air transport, now makes the critical contribution to cost and preparedness in total logistic response. Since technological advances and complexity of equipment have made the price of preparedness (cost) so great, high-speed transport logistics must be substituted for stockpiles. This is to say that obsolescence rates and unit costs have developed which call for a savings trade-off between inventory and transport. If delivery time is halved on a stocked item, only half the usual inventory need be bought to give the same flow of support at the using end.

It is further hypothesized that the nature of the logistic response to the military threat poses unique and substantial issues for public policy in military–industry relations in both transport and manufacture. Since logistics provides the vehicle for the interplay of forces between the military and the economy, it is not surprising that the fulcrum of these forces might be found to shift from time to time. It has in fact, by circumstance and design, become a one-directional shift. Military preparedness support is being integrated with industry to an extent heretofore not experienced in peacetime. President Eisenhower spoke to this latter point in his farewell message:

> This conjunction of an immense military establishment and a large arms industry is new in American experience. . . . We recognize the imperative need for this development. Yet we must not fail to comprehend its grave implications. Our toil, resources and livelihood are all involved; so is the very structure of our society.

time and logistic support

The economic and policy implications of the type of war to be faced have direct bearing on logistics, for the logistic response is necessarily bound up with the nature of the force response itself. It is not merely patterned after it but must be the direct image of that response. Weapons capable of thousand-mile-per-hour speeds cannot effectively operate when tied to a logistic system month long in supply and oxcart in delivery speed. Nor are these multimillion-dollar weapons maintainable with few and low-cost parts and gear.

Transportation is a means toward an end and hence a derived demand from the nature of the transactions it supports. Surely in the case of military requirements the only effective combat items are those which, through transport, are placed in the hands of the combat forces when and where needed. All other items—however large the stockpile—are irrelevant to the combat issue.

This causal connection can also be stated in reverse; that is, the nature of the transportation services available dictates the character of transactions carried on. Thus the existence of a global air transport net has a very real effect on the kind, quantity, and value of the resupply transactions of military operations. Here the dimensions of weight and distance do not provide an accurate measure of transport service, for transportation takes place through time as well as space. While availability, reliability, and cost factors are clearly elements of transport, speed is in fact the critical one which has real economic significance. To the military the critical significance of the element of speed in transport is focused in the "pipeline." Logistic pipeline describes the *flow* of materials from a source to a user and is tied to *time* through measurement of the lapse from the initiation of an item requirement to its ultimate delivery. Our main concern here is the transport segment of the pipeline.

Pipeline time, or time in transit, must be considered a period of suspended satisfactions in terms of defense—a lag in the connection of production with consumption, whether the movement is of materiel or men. Failure of transport to keep pace with either production or consumption creates substantial problems. For the pipeline flow of supplies does not respond as water through a faucet; rather there is operative a logistic momentum. This is to say that both the amount and the rate of support must be appropriate to the using end of the line. The flow must be geared to a level of support adequate for constant readiness in peacetime and at the same time capable of rapid expansion, lest the surge to wartime demands find the system technically or organizationally deficient. In economic terms this flow concept is analogous to the familiar relationship between time and commodity movements to market in terms of (1) the quality of perishability, i.e., facing of a new market for a limited time is comparable to the advent and subsequent demands of a force emergency, and (2) the size of the market, comparable to the magnitude of the emergency and dictating the amount and rate of flow to it.

Continuing the market analogy in a military context, these gains are allowed by increased speed in transport. The first benefit is the reduction of inventories and prepositioned stocks. The practice of hand-to-mouth buying is based on the ability to replenish stocks rapidly and as needed through the availability of high-speed transport service. The Air Force has thus committed itself to support its two most important arms, the Strategic Air Command world-wide and the Air Defense Command domestically, through an air pipeline. Direct air supply to overseas units is now accomplished under a time standard of seven days, and daily scheduled airlift into zone-of-interior SAC and ADC bases looks to instant readiness by a two-day pipeline time. By permitting direct support of our principal weapons, this air logistics net is enabling the gradual consolidation and phasing down of costly oversea and domestic depots.

A second gain is the reduction of capital frozen in transit. A paring of pipeline time itself reduces the quantity of support items that are out of service at any one time—that is, in the stream en route. Similarly the away-from-station time of personnel is reduced by moving military personnel (and dependents) by air.

Widening of the sources of supply can be cited as a third area of gain. Here the concepts of "point to point" and "source to user" airlift apply. The former describes the bulk of present air cargo military traffic and may be defined as airlift from point A to point C which involves reworking and transfer of cargoes at point B en route. This kind of airlift is typified by the movement of cargo by air to the aerial ports of embarkation on both coasts, there to be rehandled and airlifted overseas to final destination. Source to user airlift, on the other hand, comprises a single air movement from point of origin (production) to the using installation (consumer). Secret cargo, cargo of high sensitivity, and high-priority cargo, for example, are increasingly moved direct by air from the point of manufacture to the military consumer site. Rather than a deepening of sources, the flexibility of air transport here permits a geographic broadening of suppliers.

Fourth, and at the other end, high-speed transport improves the mobility of the consumer. In short the mobility of combat units has been increased through a logistic ability to tie a resupply line rapidly into a distant site and a minimum-facility airfield.

Here the economist's problem of treating quantitatively the differing characteristics of goods and services comes into focus. For while ton-miles or passenger-miles may constitute the "product" of the transport agencies, it is not accurate to say that different speeds merely represent different rates of production. Rather they represent different products in that there is a qualitative difference between high-speed and low-speed transport—a difference in kind which is distinct from the effect on volume. The difference turns on a distinction in use, which allows the satisfaction of demands that are new in character and not solely matters of degree.

Still, as with conventional transportation economics, the demand for speed is not absolute. Even in defense terms, the demand becomes more elastic at the higher speeds as support requirements are met; increases in speed of delivery at high levels give readiness returns that diminish as additional speeds are reached. As Chart 1 shows, a small increase in speed *AB* results in a large increase in readiness returns *BC*, but at the upper ranges of delivery speeds a large increase in speed *DE* provides only a small return in readiness *EF*.

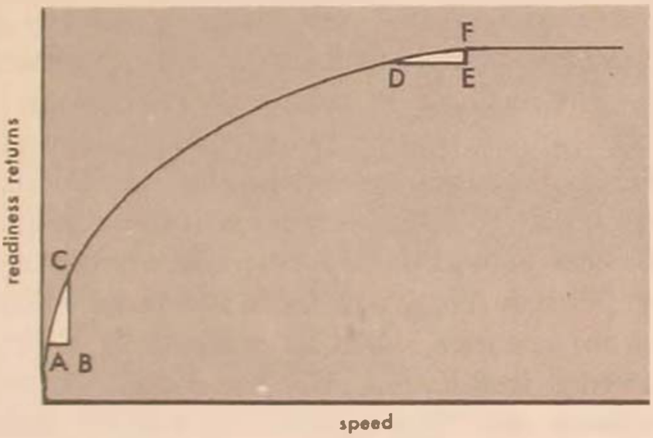


Chart 1.

Within considerable bounds, then, the value of speed in transport increases directly with the value of time, but there is a ceiling to time-saving relative to the importance of that additional saving. This principle may take on particular significance as ballistic missiles rapidly become a major part of the military arsenal. Missiles require a support system tailored to the peculiar problems posed by their technical characteristics and planned employment, for optimum mission performance must be "built into" them and constantly maintained at reliable levels. The logistic responsibility continues to the countdown when the missile is fired on its one-time flight. But it is this last which may make missile-support demands (after the phasing-in period) elastic to speed at the higher levels. Since these vehicles are not practice-launched, there may not be the same kind of wear-out rate and repair problem that manned aircraft experience. What is called for is a one-shot reliable firing, and it seems unlikely that transport support, having once enabled this, makes a further comparable contribution at a still higher speed level. There is little to be gained by being able to launch the missile "twice over."

cost and logistic support

The cost pressures of logistic support are steadily upward. Not only are military procurements subject to the same inflationary price changes as consumer buying, but more importantly they must suffer the effects of increasing complexity and developing technology. The causes of these growing pressures are several. The required weapon performance at fantastically increased speeds has called for intricate electronic armament systems and elaborate navigational equipment accurate within minute tolerances. Both requirements push unit costs up. Such equipment tends to fail more frequently and more erratically than the less failure-prone, predominantly mechanical equipment of older aircraft. Moreover as the degree of commonality of parts among weapons approaches zero, the benefits from common use of costly spares largely disappear.

Rapid technological change makes for high obsolescence costs and hence shorter weapon life, especially at the time of phasing-in of new weapons. Frequent modifications and design instability in the early stages induce procurement complications and enlarge demands for maintenance skill in support. These factors may increasingly become cost concerns with successive and varied generations of missiles. Normally they mean less-efficient operation, more failures, and increased support.

Finally, changing war plans and altered strategic requirements substantially affect the cost of logistic support. Clearly the average cost of maintenance and support is less where there is a large volume of activity at a single location, for instance, when large numbers of similar weapons are concentrated at each installation. But the dictate of modern warfare is dispersal of weapons, and thus support equipment and stocks must be dispersed with the maintenance operation, again tending toward higher cost.

Economic analysis provides some alternative concepts of the problem of cost and logistic support. Given a level of indifference in terms of equal combat effectiveness, there are trade-offs to be made between buying many weapons and supporting them (maintenance, repair, transport resupply) at a low level and buying few items and supporting them at a high level. The decision of the Department of the Air Force is in favor of the latter, and the other services are following suit.

What, then, of policy and practice during this period when the mix of weapons has become more expensive to support in terms of unit cost? In the Air Force instance—the major procuring component of the Department of Defense—the total cost of support has not in fact increased. As presented in the chart drawn from accompanying table, the trend in dollars provided for aircraft initial and replenishment spare parts has been steadily downward from $1.45 billion in FY 1956 to $1.02

billion in FY 1961. It now may be expected to level off. Within these figures is reflected the change in procurement philosophy. One notes that (1) expenditures on initial spares (those originally bought with the item) have dropped from $1.15 billion in FY 1956 to $0.12 billion in FY 1961, and (2) expenditures on replenishment spares (those bought subsequently) have increased from $0.30 billion to $0.90 billion over the same period.

Aircraft Initial and Replenishment Spare Parts, USAF

Fiscal Years 1956-1961 (in billions of dollars) *

Fiscal Year	Initial Spares	Replenishment Spares	Total
1956	1.146	0.304	1.450
1957	0.880	0.500	1.380
1958	0.600	0.680	1.280
1959	0.450	0.750	1.200
1960	0.229	0.855	1.084
1961	0.116	0.900	1.016

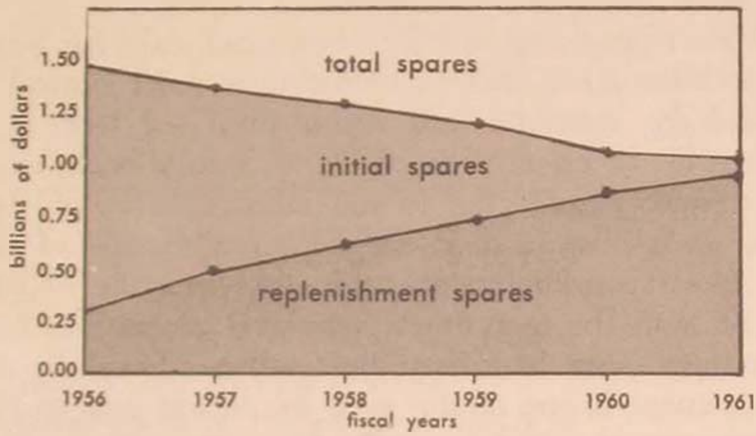


Chart 2. Aircraft initial and replenishment spare parts, USAF, fiscal years 1956-1961.

The key instruments for controlling the cost of logistic support are the selective management of materiel, procurement innovations, and the substitution of high-speed transportation for stockpiling. The first involves a program for tailoring the degree of management effort applied to materiel to the value of the actual stock items. The second involves deferred procurement of resupply stocks until subsequent design changes and wear-out rates can be experienced. The third involves paring the transportation segment of the total pipeline time to permit the first and second programs.

Since 1952 the Department of Defense has been turning more and more toward applying scientific supply management techniques to its logistic system. The Air Force has instituted the most advanced of supply systems with a program labeled Hi-Valu. Within its more than 1½ million separate items of inventory (400–500 items are added to the

* Source: *Selective Management of Materiel*, USAF Spares Study Group, Wright-Patterson AFB, Ohio, Report No. 10, 1960, p. 6.

catalog daily), the Air Force has established two main categories for management purposes: "diamonds" and "popcorn."

The "diamonds" are items of significant value from the standpoint of cost ($500 or more) or mission importance which justify extra management care and attention. The tremendous importance of this classification is seen when we note that while less than 1½ per cent of the inventory items are in this group, those items represent in value approximately one half of the dollar inventory on Air Force shelves. These are the "Hi-Valu" items. Principal types of commodities involved are aircraft spare parts, aircraft accessories, aircraft instruments, aircraft engines and parts, electronic components and parts, photographic equipment and parts, guided aircraft rocket and missile parts, and ground communication components and parts. The "popcorn" embraces some 900,000 items of $10 or less unit cost, and the problem is more one of time and management effort than dollar value in inventory. The philosophy here is to buy liberally but economically and to simplify management controls. Our interest is primarily with the "diamonds."

The Hi-Valu program, now nine years old, calls for buying a minimum of high-value items, then monitoring a strict control over transportation, stockage, issuance, and repair until the item is obsolete or ready for discard. In essence the objective is to allocate expenditure of efforts and resources according to the relative value of the results to be achieved. It is obvious that the "diamonds" side of the program requires the closest working relationships between the military and the contractor, for both the quantity bought and the rate of buying determine the savings to be had from the system. Thus the approach of phased procurement is one of the most significant aids to the program. Deferred procurement has not meant no procurement but rather has meant later procurement phased according to need. During this waiting period item requirements are carefully watched and controlled, making for more accurate later procurement.

Postponed procurement action does, of course, run the risk of items being out of stock as unexpected demands on the system occur. The answer to this is now found through the policy of increasing the manufacturer's responsiveness to military needs. This is accomplished by providing "buffer" stocks of raw materials or semifabricated parts at the contractor's plant through a token buy. Then as unpredicted demands for spares arise, response is quickly made from either the contractor's production line or his bins of semifabricated stocks. In one case it was found that a token investment of 8 per cent in raw materials was sufficient to defer the cost balance of 92 per cent approximately half the normal lead time, allowing for optimum use of experience data.

It is timely that these management developments are available for application to ballistic missiles from the start. Substantial returns can be expected, for in FY 1962 Air Force procurement funds devoted to missile systems are up to two thirds of the manned aircraft investment.

Though selective management programs and "short buy" procurement policies have made major contributions toward controlling the cost of supply support, they have placed correspondingly high demands on the delivery portion of the logistic cycle—a premium on speed in transport. Thus reduction of transportation time has been of critical importance. By utilizing high-speed transportation, principally air, for those items whose mission and monetary worth warrant it, costs have been reduced and reaction time improved.

A hypothetical example illustrates that high-speed transportation makes sense in terms of reduced quantities of inactive equipment tied up in the pipeline. The Air Force has estimated the value of Hi-Valu shipments per day to be $3.69 million for the zone of interior (ZI) and $0.41 million for overseas (OS). Using the standard of 30 days conventional-speed and 8 days Hi-Speed pipeline time for the ZI and 124 days and 32 days respectively for overseas, a significant comparison can be made:

			conventional speed			**Hi-Speed**	
			pipeline days	*value of pipeline stock*		*pipeline days*	*value of pipeline stock*
ZI daily Hi-Valu shipment rate:	$3.69 m	×	30 =	$110.7 m	×	8 =	$29.5 m
OS daily Hi-Valu shipment rate:	$0.41 m	×	124 =	50.8 m	×	32 =	13.1 m
Comparative value of total Hi-Valu pipeline stock, conventional speed vs. Hi-Speed:				$161.5 m			$42.6 m

The difference in cost, then, between filling a conventional-speed pipeline with Hi-Valu items and filling a Hi-Speed pipeline with Hi-Valu items amounts to about $119 million.

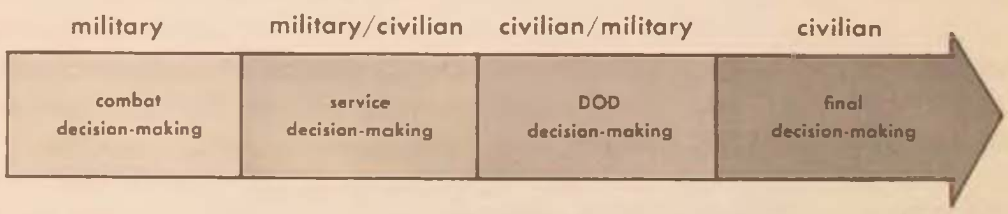
implications in modern logistic patterns

It is clear from the above example that the trend of the military, especially the Air Force, is increasingly toward the concept of direct support—of tying the contractor ever closer to the user. The Air Force is well committed to a program which links individual aircraft and missile firms into a world-wide communication system, from combat installation to industrial plant, in the interest of close logistical support and procurement economies. Prime contractors of the major weapon systems and manufacturers of the vital components are joined together both in hardware and in information. In sum there has taken place an integration of industry into the military's logistic complex on a scale and to a degree never before experienced in peacetime. It is likely that the missile era will intensify this integration.

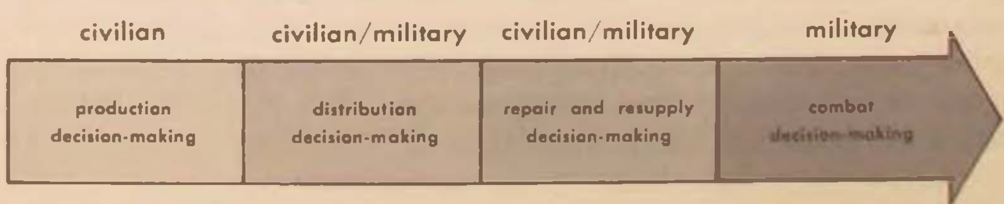
Presently the Air Force buys the Thor missile, for example, delivered and erected on site—that is to say, takes ownership of the weapon in a "package procurement." In terms of control this is a significant departure from buying a machine gun and accepting it at the manufacturer's plant. The significance lies in the fact that, in the case of the missile, integration with the private contractor involves delegation of responsibility for logistic support in anticipation of greater efficiency. Such a policy may give the best results in terms of efficiency, or it may be adopted as the line of least resistance.

But involved in this alignment are very formidable "costs," no less real for their elusiveness to ready recognition or orderly quantification. These costs proceed from the diseconomies of integration and are properly assignable as social costs. They are (1) an erosion of public (military) responsibility through the gradual abdication of defense support authority to private contractors without commensurate assessment of defense support accountability; and (2) by way of current military procurement programs, the fostering of industrial concentration patterns in conflict with other Government policies.

In the consideration of civilian versus military decision-making it is common to view the combat aspects as more properly the province of the military and the support activities as more normally the province of the civilian side. The streams of influence, military and civilian, are not fixed, however, and have come to vary in force from time to time. Decision-making on the fighting aspect might fairly be presented in the following conceptual spectrum with civilian influences flowing from right to left and probably not dominating military influences beyond the Department of Defense.



A similar spectrum on the support side might well appear quite differently in the balance of civilian and military decision-making. Here civilian influence—in fact private industry—"enters early and stays late" in the process. If the spectrum has validity, civilian influence is increasingly pressing in on the tactical commander under present defense logistical policy. It may not be too farfetched to contemplate a situation where Eli Lilly or Merck & Company representatives, for example, may



be called upon to support—even to employ—unconventional chemical weapons in an operation for which responsibility is charged traditionally and constitutionally to the military.* The wag's remark of "contracting out a war" is partially approaching actuality.

It is common to find a national preoccupation with what the economy can afford. And this is generally thought of on the receipts side. The case can be made that attention might better be directed toward the expenditure side of national security, for here the issue is what we can afford by way of defense policies which generate concentration in firms, industries, and regions. Further the magnitude, rate, and direction of defense expenditure rarely have neutral effects on the economy—rather they make either for disturbance or for stability.

Of the $47-billion Department of Defense budget for FY 1962 about $14 billion is for aircraft, missiles, ships, electronics, and other hard goods. Note too that of this latter figure approximately two thirds ($10 billion) is destined for aircraft and missiles—which in fact tend to be supplied by the same firms. From FY 1950 through FY 1959 procurement of supplies, materials, and weapons amounted to $228 billion. Of this amount 37 per cent went to the 10 largest suppliers and 74 per cent to the 100 largest.

Greatly contributing to this concentration, of course, is the decline of the competitive bid system of military procurement and substitution of the negotiated bid. Negotiated procurement has become the overwhelming rule, as evidenced by the fact that 87 per cent (by dollar value) of all military buying is now done by this method. Moreover during the 1950's the volume of riskless, cost-reimbursed contracts increased from 13 per cent to 41 per cent, while the fixed-price contracts dropped from 87 per cent to 59 per cent.

The result of dealing with the few, and this on contract terms very favorable to the recipients, is the selective creation of great industrial firms substantially dependent on Department of Defense purchases. Looking to the five leading aircraft companies, one finds that upwards of 78 per cent of total company sales is to the Department of Defense. In the case of the eight leading electronic firms the figure is upwards of 20 per cent. Such defense expenditures which take a substantial part of the product of whole industries carry with them vast powers to shape the pattern of the economy. Procurement agencies, wittingly or not, in large measure come to control the destinies of many unseen firms and people.

The use of the "weapon system manager" concept itself is a further instrument of concentration and hence is assignable to the social cost side in terms of general public policy. This system involves the selection of a prime contractor whose task is to manage the production of a

*The military historian Walter Millis in *Arms and Men* (New York: G. P. Putnam's Sons, 1956), p. 337, strikes a similar note in writing of the 1950's, "The great private operations, like General Motors, du Pont, the leading airplane manufacturers, which the government had evoked to assist it, had assumed positions of monopoly power which, however unavoidable, at least seemed to raise new questions as to the legal and constitutional organization of the state."

total weapon—end item, components, spare parts, associated skills—through the use of subcontractors. This means that independent firms interested in such orders look not to the Department of Defense but to the dominant firms in their own or kindred industries. Thus a single company can extend its influence far beyond the bounds of its own facilities. A prime contractor, for example, can wield a dual economic power in deciding which firms it will join as part of the "ins" and which it will exclude to become or remain the "outs." In the former case there is very real question whether such integration of facilities and information on the part of participating companies for the instant case is compatible with competition of undiminished vigor in their concurrent and subsequent relationships. In the latter case public policy has normally refused to be party in opportunities for one firm to "discipline" or otherwise exercise preferential or prejudicial treatment in its relations with another.

Finally, it is probably fair to say that the use of these great defense expenditures as an economic tool has not been fully exploited. The dilemma confronting the top policy maker is, of course, the likelihood that the dictates of military necessity may not coincide with fiscal and countercyclical considerations. While some current efforts are in evidence in the latter connection, it is a fact that as recently as 1959—despite the existence of chronically depressed areas—California got one fourth of all procurement dollars, or as much as the next four largest recipient states and as much as the 37 smallest. This is only to suggest that an economy which in peacetime is geared to hostile attack carries with it significant social cost implications in the sense of conflicts in policy. The need is that these be identified, assessed, and minimized, lest motives of expediency or inertia assume the guise of national defense interests.

In this discussion the transportation segment of the logistic cycle was selected for critical examination in terms of the economies of the supply support it allows and the diseconomies it generates. High-speed transport was seen to mean principally airlift with preparedness equated to reaction capability—in turn a derivation of time. It was held that the logistic system must be the reflection of the military response it supports. In accomplishing this the system is striving to react in the shortest possible time to the demands of military forces and to do so from the smallest stockpile of materiel.

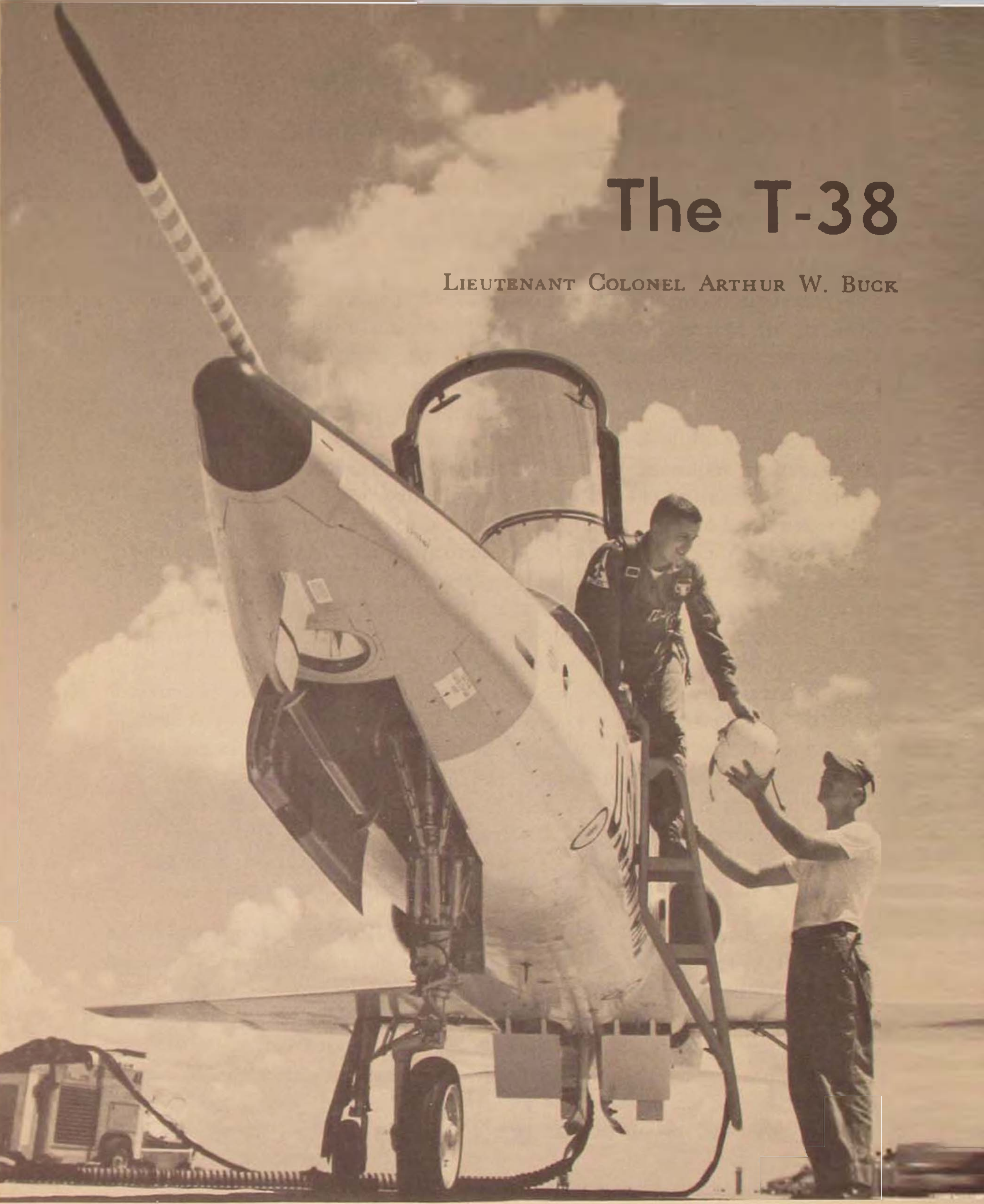
There is actively under way in the Department of Defense a fundamental change in logistic philosophy. This results from the impact of technology, with its compression of time for response and aggravation of cost in complexity. Substantial relief to both problems is presently found in the refinement of procurement techniques and the tailoring of high-speed transport as the normal means of logistic support. These involve the trade-off of high-speed reaction for inventory, enabling substantial reductions in procurements.

The necessity for such measures designed to hold the line in the cost trend was treated as a conglomerate of unit cost pressures upward. The helpfulness of economic conceptualizations—particularly indifference analysis and opportunity costs—was cited in the posing of alternative solutions between weapon numbers (and parts) and levels of support under a given combat effectiveness.

While these increasing movements toward direct support, contractor-to-user, in the interest of logistic responsiveness are advantageous, they are not without undesirable aspects. The merits of the integration of force support with industry are admitted to; in fact they give validity to the first hypothesis. The negative ramifications—the diseconomies of the relationship—while less readily recognizable, were viewed as being of a magnitude requiring general public policy consideration.

The alignment of the military and industry is, of course, not new, but its extent and apparent fixity are. Annual expenditures of $46 billion into the economy clearly cannot have neutral effects. As a result of the direction of this procurement, one negative aspect is the creation and hardening of industrial and regional concentration patterns contrary to general public policy and calling for review. A second is the passage of defense authority to private industry without attendant public accountability. Interestingly, this trend is analogous to the earlier governmental practice of hiring mercenaries to defend the country. The famous remark attributed to Clemenceau regarding the matter of war not being left to generals might now appropriately be altered to admonish, "War is much too serious a thing to be left to contractors." The cost conflict can be generalized: less perfect integration may sacrifice efficiencies in money costs of defense support, but more perfect integration may generate social costs which public policy should be slow to endorse.

United States Air Force Academy



The T-38

Lieutenant Colonel Arthur W. Buck

TRAINING for war takes time. Unfortunately we no longer have either a cushion of time or a cushion of space. Both have been drastically reduced by high-speed aircraft and missiles capable of carrying nuclear weapons of tremendous destructiveness. D-day will likely be not a day of mobilization but rather a day of decision. That is why the Air Force is geared for immediate combat readiness. Tactical units must focus their attention on preparedness and can spare little time for fundamental training of aircrew input. More than ever before the Air Training Command is responsible for producing highly trained, capable pilots who are skilled in the basic fundamentals—pilots who can reach a state of combat readiness within the tactical units in a short time. This does not mean that the Training Command will specialize. It will continue to produce a well-rounded pilot, but a pilot capable of transitioning to advanced Air Force aircraft with a minimum of additional training.

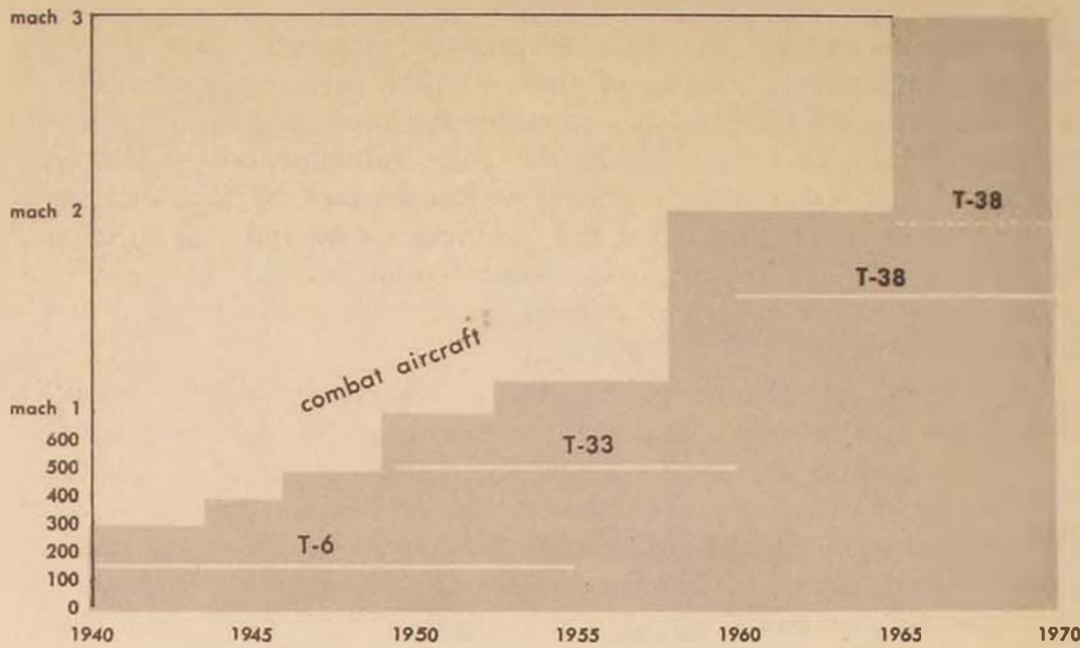
Air Training Command policy has always striven for parallel development of trainers along with combat aircraft. As the capability of our fighters and bombers increased, the speed and performance of the training aircraft were improved accordingly. Whenever the performance gap between trainer and first-line aircraft becomes too large, the training load of the combat unit is increased. For example, in 1948 it was realized that the new jet aircraft coming into being—the F-84, F-86, B-47, etc.—required training that could not be adequately supplied by the available trainers, the T-6, T-28, and B-25. The T-33 was introduced as a basic trainer.

The T-33 has done well as a basic trainer in past years, but now the performance gap has opened up again. The supersonic, high-altitude flight performance of the fighters and bombers now in the USAF inventory has again advanced the problem in flying training. Since the T-33 is unable to prepare the student pilot adequately for flight in the century-series aircraft, the training load has been slipping back on the combat crew training program and on the first-line units themselves. It has caused an increased requirement for two-seat, trainer-fighter versions of tactical aircraft. These fighters are costly to operate, and inevitably some combat capability is sacrificed with the addition of the extra cockpit.

In anticipation of this problem Air Training Command set a requirement in 1953 for a new aircraft to succeed the subsonic T-33 as the basic trainer. The general operations requirement for the replacement was completed in 1956, calling for a "lightweight economic basic trainer" capable of preparing pilots for operation of "high-speed jet aircraft of the present and the future."

Now the T-38 Talon is a reality and will soon replace the T-33 "T-Bird" as the Air Training Command's basic trainer. Questions naturally arise: "What effect will this high-performance training aircraft have on the training program?" "What will the impact be on the first-line units?" The answers to these questions will not be fully known, of course, until the completion of the present Category III Test Program and until the first T-38-trained graduates are combat-ready in operational units. Our present experience does enable us to make certain assumptions and draw conclusions from them.

Speed Comparison
Trainer vs. Combat Aircraft



impact of the T-38 on ATC

First, let us consider the physical impact of the aircraft within Air Training Command. The free utilization of airspace is becoming increasingly restricted and the high-performance characteristics of the T-38 will only add to this problem. If the student is to receive realistic and effective training, maximum-power climb corridors and supersonic flight areas must be established. Supersonic flying must be closely regulated to avoid unnecessary hazards and community relations problems. On the positive side, the high cruise altitudes of the T-38 should alleviate some congestion at the lower altitudes.

Basic Trainer and F-100F Capability

	Capability		
1960 Requirements	T-33	T-38	F-100F
1. Transition			
Solo flight	•	•	•
High sink rates		•	•
Subsonic flight	•	•	•
Supersonic flight		•	•
High-altitude indoctrination		•	•
Acrobatics	•	•	•
2. Instruments	•	•	•
Extreme attitudes		•	•
3. Formation	•	•	•
High altitude		•	•
4. Navigation	•	•	•
High altitude		•	•
Supersonic dash		•	•

Little physical modification of ATC bases will be required to accept the T-38, which can operate from any adequate T-33 runway. The Talon's twin afterburners produce a much shorter take-off roll, and the T-38 landing roll is nearly equivalent to that of the T-33 despite a 25-knot increase in touchdown speed.

The maintenance impact of the new trainer is not as great as might be expected, although an extensive training course is required for ground crewmen and specialists. The amount of ground equipment required to maintain the T-38 is not greatly increased over that for the T-33, but it must be procured with the aircraft. Gas-turbine units are required for starting, and liquid-oxygen equipment is needed to service the Talon's ten-liter system.

The quick turnaround characteristics of the T-38 are reminiscent of the old T-6 days. The black-box concept, used extensively in the T-38, allows replacement of an entire component rather than requiring on-the-spot maintenance. Single-point, high-pressure refueling and the capacious liquid-oxygen system, which requires only one filling per day, make the sleek trainer ready to go within minutes after landing.

Performance Comparison

Performance	T-33	T-38	Typical 1965 weapon system
Cruise	0.70 M	0.90 M	0.95 M
Maximum speed	0.80 M	1.60 M	3.0 M
Service ceiling (take-off weight)	45,000 ft	55,000 ft	75,000 ft
Landing-pattern speed	160 K	180 K	200 K
Approach speed	120 K	140 K	170 K
Landing attitude	normal	nose high	nose high
Engines	1	2, with afterburners	2 plus, with afterburners
G stresses	7.33	7.33	7.0

The man-hours of maintenance required for each hour of flying time will not increase greatly over those presently spent on the T-33. Although the aircraft is still in test status, it is already operating at approximately 30 maintenance man-hours per flying hour. By the time the T-38 reaches the training bases, it is programed to be operating at 14 hours per flying hour. This compares favorably with the 10 hours the T-33 now boasts after more than 10 years of operation. Maintenance and operating costs will be slightly higher for the Talon than for the T-33, but still quite nominal in view of the added performance.

How will the new trainer affect the instructor personnel already in ATC? Thus far, we have experienced no difficulties in checking out qualified T-33 instructors in the T-38. Present plans call for T-33 instructors to receive a 37-hour academic course and a 35-hour flying program to qualify them as T-38 instructor pilots.

Next, let us consider the effect of the Talon on the pilot training program and on the student pilot. The present T-33 program has recently been increased to 130 hours to make its graduate more proficient and to introduce low-level navigation into the training syllabus. The T-38 program will be another 10 hours longer, for a total of 140 hours. This increase is being used to strengthen navigation and formation flying, the areas where first-line units felt additional emphasis was needed.

Comparison of total flying hours does not give the entire picture. The T-38 is not restricted by its fuel load from any maneuver, including landings, and it spends very little time in reaching its working altitude. Thus a greater variety of training can be accomplished on a shorter training mission. The T-38 syllabus of 140 hours represents approximately 100 training sorties as compared with 80 missions in the 130-hour T-33 program.

From a student standpoint the step from the T-37 primary jet trainer to the T-38 should not be a difficult one. He will already be experienced in normal jet operating procedures and in multijet operation. The student will of course have some initial difficulties in coping with the high performance of the Talon. The increased stall speed of the T-38 requires a higher final-approach and touchdown speed. The quicker acceleration and the tremendous increase in rate of climb (30,000 ft/min at sea level) will require a longer pre-solo period for the student to become acclimated. But from a purely mechanical point of view, the T-38 is much simpler in many ways than the T-33. Instruments and switches are more logically and conveniently located and many procedures have been greatly simplified. Examples of this are the normal airstart procedure which requires only two steps, and the emergency or "tiger" airstart which is accomplished in one step.

With the team of the T-37 primary trainer and the T-38 basic trainer, the student need conquer only one major problem at a time. In the T-37 he will master the rudiments of flying and the basic jet techniques and procedures. Since T-38 procedures are simple, the student can concentrate on adjusting to the high-performance characteristics of supersonic aircraft. This mental conditioning will produce the product that ATC is striving for, a pilot that is "high-performance oriented." For example, what happens when the awesome sound "barrier" is broken? Actually nothing happens in the T-38. The student pilot will not even know he is supersonic unless he looks at the mach indicator. This, then, is one of the problems which will not concern him when he checks out in a first-line aircraft.

There are other lessons to be learned in the supersonic range. The student will see how rapidly high g-forces, required for maximum performance turns, cause airspeed to bleed off into subsonic flight. In the formation training phase he will learn the necessity of precise control

T-33 vs. T-38 Basic Training Flying Hours

Present T-33	Flying phase	Proposed T-38
40:30	Contact flying	37:30
33:00	Instruments	33:30
19:00	Navigation	26:45
31:00	Formation	38:30
6:30	Optional time	3:45
130:00	total	140:00

movements while supersonic, since the controls are very sensitive. If he ventures too far forward from his normal wing position in formation, his aircraft will be shaken by the invisible shock wave being pushed ahead of the leader's plane. The supersonic dash to target, a combat technique developed for the latest bombers and fighter-bombers, will require careful pilotage navigation. No radio aids will be available, ground is covered rapidly, and the pilot cannot afford to miss a single check point.

One of the most important gains realized from T-38 training will be in high-altitude indoctrination. Although the aircraft is flying at a high true airspeed and high mach number, the indicated airspeed is quite low and is usually in the aircraft's marginal performance range. The pilot must avoid abrupt control movements or rapid attitude changes, either of which can cause a drop in airspeed. Any airspeed loss must be corrected immediately, since the aircraft is operating near stall speed. In addition to these problems, the pilot must pay special attention to his oxygen equipment and cockpit pressurization. Any malfunction must be corrected immediately because a pilot's "time of useful consciousness" without oxygen is very short at these high altitudes.

Initial indoctrination in high-altitude flying will be given in the transition phase, but in each phase of flying training certain missions will be devoted to showing the student the effects of high altitude on that particular type of flying. In the instrument phase the major problem is attitude control in the marginal airspeed range. This problem continues into formation flying and is compounded by slow aircraft response to power changes. High-altitude navigation is complicated by the very strong high-altitude winds and the continuous problem of attitude control. The importance of this high-altitude indoctrination cannot be overemphasized. Both fighters and bombers are attaining very high cruising altitudes, and future manned vehicles will probe even deeper into space.

impact of the T-38 on first-line units

In 1962 the first-line units will begin to receive the T-37/T-38 trained pilot. What will the impact be? We believe these units will reap a great reward. The combat units will receive a man who is high-performance oriented, a pilot who is mentally conditioned to deal with high climb rates, high-altitude–true-airspeed navigation and formation, supersonic flight, and high-sink-rate landings. This will be true whether the graduate goes to a fighter or bomber unit, since both operate high-performance aircraft.

For example the T-38 will eliminate the requirement for the first-line units to teach their fledgling pilots about high sink rate. The student who trained in T-37's and T-33's is not prepared for this feature of high-performance combat aircraft. In the older trainers a stall is usually accompanied by big change in attitude—a dropping of the nose and a falling off on one wing. Recovery is simple; a slight nose-down attitude will "break" the stall. But in the T-38 and other high-performance aircraft a stall is predominantly an ever increasing rate of descent, not necessarily with much change in attitude. Recovery requires a large increase in power or a very steep nose-down attitude with an excessive loss in altitude. The student who flies the T-38 will learn that in landing he must make a flat, power-on approach, thus better preparing him for century-series aircraft.

It is true that the new graduate going to a first-line unit will have to familiarize himself with a highly complex new weapon system, but he will not have to attempt this while coping with a high-performance aircraft for the first time.

We believe that as a result of the new ATC pilot training program the first-line units will get a man who can become combat-ready in any weapon system with less training and with a higher degree of flying safety than has ever been possible before. This should reduce the units' training time, costs, and the number of two-seat combat-type aircraft that are required.

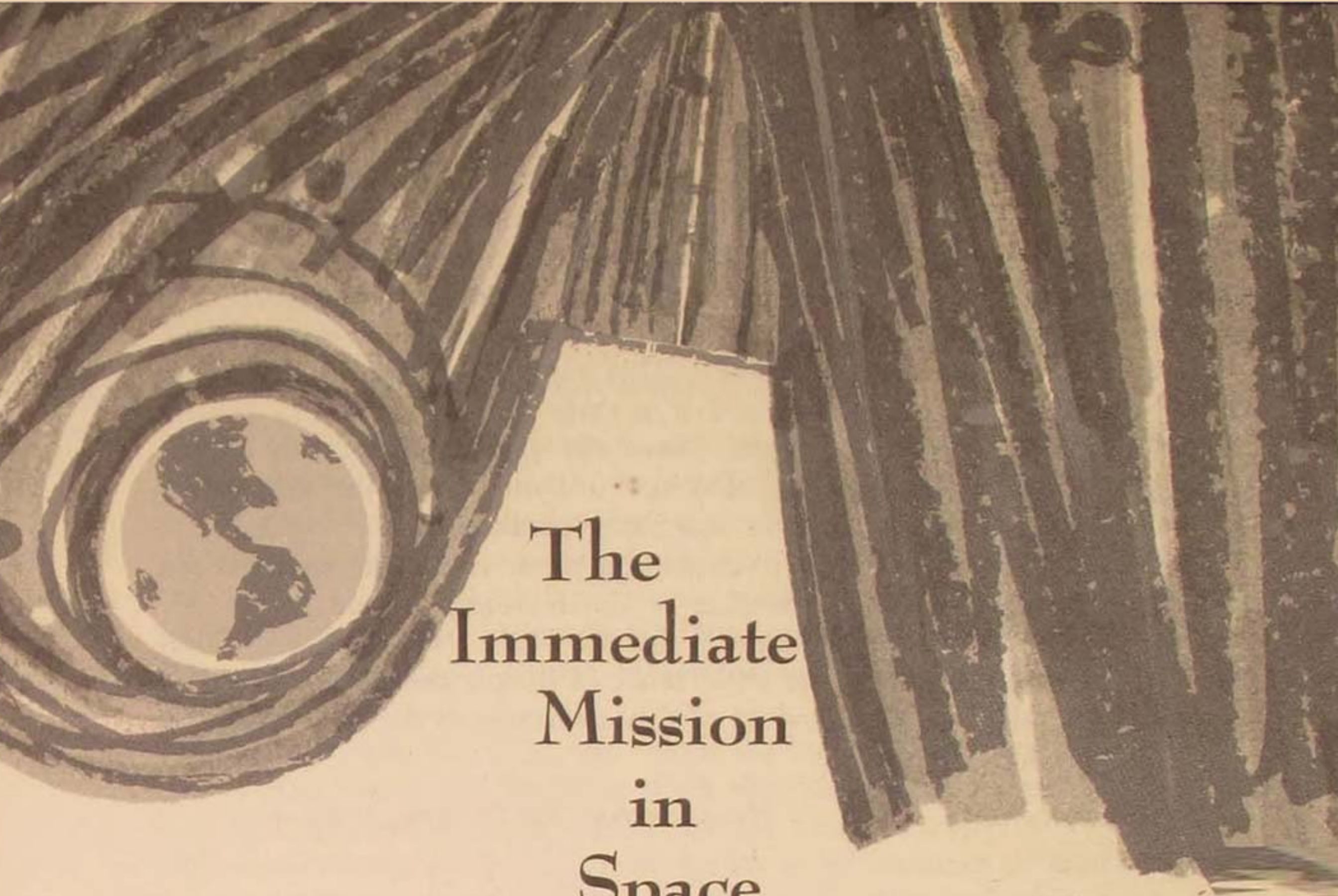
LET us summarize the over-all impact of the T-38 Talon as it enters the ATC inventory. Although the usual adjustments to the training program will be necessary, as with any new piece of equipment, the physical impact of the T-38 will not be too great. To the student pilot it means a logical and uniform progression from the rudiments of flying to the mastery of a high-performance jet.

The first-line units will receive a pilot who is already qualified in a supersonic jet and is high-performance oriented. He should be combat-ready with less training and with a higher degree of flying safety.

Every pilot remembers his first reaction to a new airplane of greater performance than what he is accustomed to. A pilot stepping up to a higher-powered aircraft is generally filled with misgivings and doubts about his ability to master the new "bird." This has always been true, whether it was a step from a BT-13 to a T-6 in early World War II, or from a T-33 to a century-series fighter. Normally pilots will quickly adjust themselves to the change, and after a few flying hours the doubts are replaced by confidence and ever increasing proficiency.

The fact that Air Force students and pilots can make this upward step is a result of careful attention to the learning process in the Air Training Command and throughout the Air Force. The Training Command long ago recognized the importance of proper mental conditioning of its student pilots. The product of this awareness is the T-38 Talon, a trainer to bridge the gap.

Headquarters Air Training Command



The Immediate Mission in Space

MAJOR RICHARD C. HENRY

FOR the military officer of today, space represents the greatest intellectual and physical challenge since the advent of powered flight. Today we pay honor to the Wright brothers and to military names like Selfridge, Foulois, Douhet, Mitchell, Anderson, Trenchard, and others who pioneered both the physical and intellectual exploration of air power. A later generation, if we are strong enough and wise enough to achieve its survival, will honor the names of those who met the challenge of space at a time when national survival rode on their courage and wisdom.

Each succeeding year of the last decade has seen this Nation more heavily committed to a space program. In the last year or two this program has assumed massive proportions in terms of national resources. The National Aeronautics and Space Administration and the Department of Defense are working closely together in forging this national space program. For military space efforts, within the Department of Defense the responsibility falls particularly upon the Air Force, both as the service assigned by the Department of Defense the primary responsibility for new space development programs and projects, including the responsibility for research, development, and operation of all Defense Department reconnaissance satellite systems, and as the service whose normal operations within the atmosphere inevitably merge into the indivisible continuum of space.

No more pressing problem exists for the Air Force of today than to define its immediate mission in space. The technological explosion of the last few years threatens to engulf the doctrine, strategy, and tactics of the air age. Space confronts us with a foreign medium, essentially hostile to man and to aerodynamics as man has known its applications. If we content ourselves with minor adaptations of our air-age concepts and tactics in an effort to make them compatible with the space environment and space operations, we will completely default the challenge and seriously endanger our country's security. It was never more essential that concepts remain ahead of technology than in this dawning of the space age. The myriad technical avenues possible in the exploitation of space may divert and dissipate the energy and resources of the space program unless an integrated, farsighted conceptual approach guides the development effort.

We do not yet understand the problems of space operations well enough to formulate operational concepts with certainty. While we have learned much in the last few years, we have only scratched the surface of what we need to know. Particularly we need to bring our knowledge and capabilities up to the point that we can conduct regular, routine space flight. It is this requirement that creates a military mission in space today. Obviously beyond its accomplishment lie more specific strategic and defensive missions, but their precise delineation must await major results from the immediate mission. Only then will we be able to speak of military operations in space with reasonable assurance.

In justifying this first mission I would like to review our current situation on the threshold of space in comparison with the situation at the outset of the air age; then to indicate what we already know about the three environmental modes of orbital operation in space—entry, orbit, and re-entry—and what these modes dictate in the way of tactical applications; and finally to note what these modes and tactical applications forecast about orbital systems for the near future. The discussion is confined to orbital systems because no other systems will be practicable until there is some major breakthrough in propulsion.

the threshold of space

The Air Force has said many times that air and space exhibit an operational continuum which should properly be considered as one entity. This is the sense in the term "aerospace." As an operational concept this entity is inescapably valid. But for day-to-day military operations it will become true only after we have systems that can operate in space in the same full sense that systems now operate in the atmosphere.

Today we do not have such a space capability. Ballistic missiles, for example, can operate *through* space but they do not operate *in* space. Our present satellites, sophisticated as they may seem for the current state of the art, are essentially passive devices that perform certain limited functions while in space. They are sensors, or receiver-transponders, or some other combination of automatic subsystems that perform in accord with preset instructions or in response to signals from the ground. In this sense they are not too different from various automatic sensors or relay stations that the military employ on the surface of the earth. No one thinks of these earthbound systems as having taken over military operations on the earth's surface, but many people seem to think that their equivalents in space can answer the full military operational requirement. And these systems are not yet launched or orbited with any degree of assurance remotely resembling the routine certainty with which 30,000 aircraft flights are conducted above the United States every day. To make space truly a part of the operational continuum with the atmosphere, we must develop systems that reduce its hostile environment to the same minimal level of hazard that high altitudes offer to the jet aircraft.

We may gain a better perspective for our assault on space if we take advantage of analogies between our beginning in space and the beginning of powered flight. Although man's step into space is in many senses as revolutionary as his step from the surface of the earth into the air, our first tentative orbits around the earth no more represent aerospace power than the Wright brothers' wavering flights around the flagpole at Fort Myer, Virginia, in 1908 represented air power. Epochal as both these events may be, they represent only beginnings. Not until very near the close of World War I did the United States have anything that resembled operational air power.

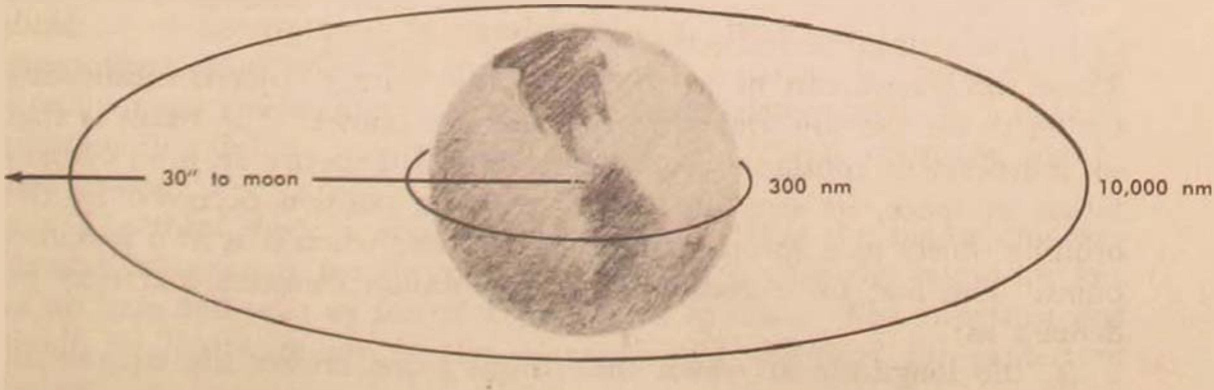
By the same token we must beware of the temptation to apply to space the concepts and techniques that have worked well for atmospheric flight operations. When the fledgling air force was being built up with officers from other corps of the Army, some took to flying like birds and later made real contributions to air concepts. Others who came into the Air Service were unable to make the mental adjustment to the new medium, being shackled by the preconception that aircraft were simply flying horses with the same old reconnaissance mission. And as a case of the misapplication of technique, in the early days of the dirigible it was "sailed" through the air on the same principles that ships were sailed on the ocean. This preconceived technique worked fairly well when the sailing was smooth but became potent for disaster in emergency situations because the crew had not yet mastered the characteristics of their new environment.

Notwithstanding caveats such as these, history reassures us that certain basic military principles continue to apply in any environment in which man can operate effectively. The tactical principles of access, mobility, security, and the like remained valid in the air as on the ground or sea. They will remain valid in military space operations for the commanders with the skill and resourcefulness and the force to express them in the terms of the new arena. Some suggest a real urgency for their exploitation.

In a more pragmatic vein, our progress in space already asserts that, although principles remain valid, old concepts and techniques cannot simply be refurbished for employments in space. They do not fit the physical parameters for space operations. No airman today dreams of applying World War I tactics to B-58's and F-105's. The air vehicles of the two time periods are not comparable in performance characteristics. Yet our first tentative leap into space has provided at one bound greater increases in speed, altitude, and range than were achieved in more than 50 years of powered atmospheric flight.

Orbital Performance. What are these jumps in performance? Consider an orbital system operating at the 300-mile altitude. It is moving at a speed of about mach 25, roughly 12 times faster than the aircraft of today. Its altitude of 300 miles is roughly 30 times the operating altitudes of today's aircraft. Its range is measurable in millions of miles and endurance in months, as against ranges of thousands of miles and endurance of mere hours for aircraft. In every performance category, then, the increase over atmospheric operations is by a factor of at least 12.

Boundaries. There is no outer limit to the space environment. The 300-mile altitude is but a small fraction of an inch above the earth as portrayed on the accompanying illustration. On this scale the moon is some 30 inches off the page. This depiction of the vast distances and volumes of the space environment reveals two fundamental aspects of its dimensional relationships. First, the 300-mile altitude is really close in and very much earth centered. Second, the moon is quite far out. Military operations in near space, then, are also very much earth centered. Speculation on the military implications of cislunar and translunar operations should await the full assessment of the potentials of near space. A lunar base would be of little value if its supply lines with Earth could not be secured. For today, it is quite reasonable to restrict discussion of the military space mission to near space—that is, out to the synchronous altitude.



Orbital dimensions

influence of the environmental modes

The space mission is complicated by the existence of three quite separate phases or "modes" in orbital space flight. We have previously referred to these modes as the entry into space or the launch, the orbital operation, and the recovery from orbit. Each provides a set of unique environmental conditions influencing the functional design and operation of integrated systems—hence the term "mode." Examination of these environmental modes in relation to tactical principles is also necessary for assessment of their influence on military space operations and hardware.

The space launch mode is characterized by the heavy impulse of energy needed to get orbital altitude and velocity, the acceleration forces attendant with the expenditure of the energy, the dynamic loads associated with passage through the atmosphere, and the accurate control required to place the payload in the desired orbit. The effects of these influences on hardware are a massive, multistage propulsive system, shielding and structure for protection against g-forces and dynamic loads, and elaborate control systems for orbital injection.

Operation in orbit is influenced by the hard vacuum and total lack of atmosphere, by the absence of gravity, and by the kinetic energy of orbit. There being no air, aerodynamic shapes are not required in orbit. Maneuverability of a vehicle in orbit is further inhibited by any extraneous mass because of the additional propulsive energy required. Thus equipment used in the space launch mode that is unusable in the orbital operation should be discarded because of the problems attendant to maneuverability and control. The environmental phenomena such as vacuum, radiation, and zerogravity influence equipment and structural design. The influence of the kinetic energy of orbit on system concept and operation is greater than that of equipment design.

A quick review of Kepler's laws of planetary motion provides a basic understanding of what is meant by the kinetic energy of orbit. Briefly stated, they are:

(1) The orbit of each planet is an ellipse with the sun at one focus.

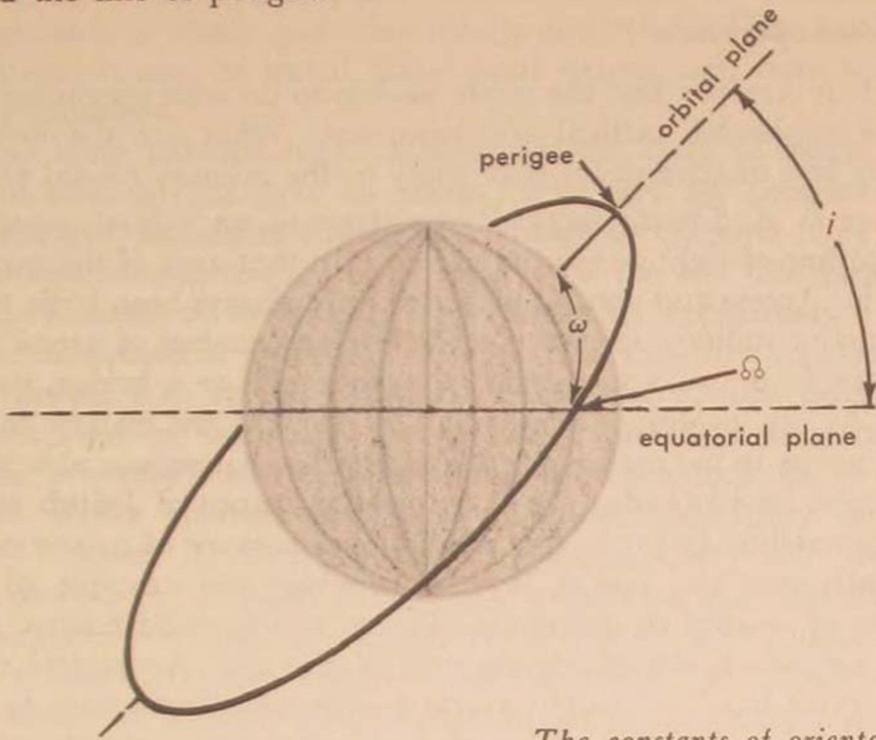
(2) The straight line joining the sun to the planet sweeps over equal areas in equal intervals of time.

(3) The square of the period of a planet is proportional to the cube of its mean distance from the sun.

These three laws can be applied to earth-orbiting objects, substituting the earth for the sun and the object for the planet. The result is that six independent constants can be derived which specify an orbit's orientation in space, its size and shape, and the position occupied by the orbiting object at a specified time, or the time when it is at a specified point. The first three constants are orientation elements and may be defined as:

Ω, the longitude at which the orbital plane crosses the equator in the ascending node *i*, the inclination, or angle, between the orbital plane and the equatorial plane

ω, the angle (on the orbital plane) between the longitudinal node point and the line of perigee.



The constants of orientation ☊, *i*, ω

The other three constants are dimensional elements and may be defined as:

a, the semimajor axis or mean distance of the ellipse of orbit

e, the eccentricity of the ellipse of orbit

T, the time of perigee passage by the orbital object.

This summary is basic and limited in scope.* Its purpose is to explain that the kinetic energy imparted to a payload during the space launch mode results in placing the payload under a relatively fixed set of conditions which are in general accordance with Kepler's laws of planetary motion. The elliptical orbit of the payload is itself fixed in space. The earth rotates within the orbit, while at the same time the payload is moving through its orbit and so around the earth. The difficulty of determining the relationship at any given time between a given fixed point on earth and the orbiting payload is apparent. But equally apparent is the easy practicality of determining a payload's position in orbit at any time, given the six orbital constants identified above.

The third mode is recovery from space. Here the major environmental influence is the dissipation of energy during the necessary loss of altitude and velocity for effective return to earth. The effects of this mode on hardware are in the structure and shielding for protection

*[For fuller discussion see Colonel John F. Babcock, "Orbits of Satellites," *Air University Quarterly Review*, X, No. 1 (Spring 1958).]

from the heat of energy dissipation in the atmosphere, the control required to effect the desired rate of energy dissipation, and the aerodynamic shape used for maneuverability and control in the atmosphere.

the orbital operation

Let us consider first the mode having to do with operations in orbit and the applicable tactical considerations. What are the tactical advantages and disadvantages that apply to the military orbital systems?

Access. A distinct tactical advantage of an orbital system comes from the line-of-sight access that it offers to that area of the earth below the orbit. Access and control of access have always been basic to success in the major military campaigns. First it was control of access provided by terrain features—a mountain pass, or a hill, or a bridge, or a crossroads. As sea power became more important, the nation that could control access to the major seaports of another nation was able to control that nation by blockade. Thus the predominance of British sea power was a controlling factor in the international balance of power during the nineteenth century. World War II provided the example of the importance of control of air access. Forces which could control access to enemy airfields could effectively control the air. An orbital system in a polar orbit has line-of-sight access at one time or another to virtually every point on the globe. Line-of-sight access can certainly be used to gain information. It may also be possible to use it for the application of force.

The trend in successive generations of weapon systems has been toward increased destructive power and shorter delivery times. The immense destructive power of the nuclear weapon and the short time to target provided by the ballistic missile make the application of the principles of initiative and surprise a great advantage to the aggressor. To achieve surprise, though, the balance of intelligence must be in favor of the aggressor. The defender's line-of-sight access provided by orbital systems could help to reduce the potential for initiative and surprise that lies in the use of the ballistic missile by an aggressor.

An orbiting system has access heretofore undreamed of. By its very nature it does not recognize international boundaries. An orbiting system at 300 miles is only 300 miles from any point in the world along its track of successive orbits, whether it is Offutt AFB, Wiesbaden, Mexico City, or Moscow. The unalterable orbit is completely different from the courses of aircraft, which embody the maneuverability and control needed to stay within defined international boundaries. It may not be possible at this time to discern all the advantages that line-of-sight access provides, but the potential is most probably more diversified than the obvious first promise of information gathering and transmission.

Dispersal. A second tactical advantage offered by orbital operations is the opportunity for dispersal of forces to achieve security. The large volume of the orbital environment permits dispersal heretofore unachievable. This characteristic could be used to protect forces from surprise attack or to hide forces to achieve surprise.

Immobility. Once found, an orbital system can be tracked and its future positions in space and time closely predicted. This is a tactical disadvantage; it may be stated that orbital systems are, from this view, relatively immobile.

There is no paradox here. Mobility in the classical military sense is used to gain surprise over an enemy; it is used for protection; and it is used to gain tactical or strategic advantage by bringing force to bear at points disadvantageous to the enemy. It is the tool for gaining the initiative. Because of its tactical importance, its application has been judged a fundamental principle of war. But can the advantages of mobility derive from orbital systems? Within our defined time period, the answer must be no. Once a system is identified, it is immediately vulnerable to enemy action because all its future positions will be known.

What is the environmental cause for the immobility of orbital systems? A system in orbit has a fixed track in space with the earth rotating beneath it. Mobility of the type associated with maneuverable terrestrial systems is difficult to achieve in space. The physics of the problem shows why. The velocity vector required to redirect another velocity vector is directly proportional in terms of magnitude to the magnitude of the original vector. The force required to redirect a mass moving at mach 25 is much higher than the force required to redirect by the same amount that same mass moving at mach 2. This does not preclude the type of maneuverability for small altitude, direction, and velocity changes such as might be necessary for rendezvous, docking, and transfer of men and materials. The basic cost in energy that must be expended to extensively maneuver an orbiting system is simply so high that it must be applied with great care and deliberation. The maneuverability of space systems cannot be considered in the same context with that of atmospheric systems. Conservation of energy for unexpected situations will be a major consideration in the tactical employment of orbital systems.

Vulnerability. A second tactical disadvantage of orbital operations derives from the absence of natural physical protection in the environment. An orbiting system is vulnerable if found. Tactics and techniques to counteract this disadvantage are under study, but they cannot be fully evaluated except by future experience. Survival might be achieved, for example, by distance, where the orbiting unit is established so remote from the enemy that ample time is available for defensive action. Such separation, of course, works also to the advantage of the enemy, if the friendly force is to be employed in military counteraction. Capability for dispersal has been mentioned as a tactical advantage of orbiting units, but dispersed units are subject to piecemeal attack—a disadvantage. Survival might be pursued by ruse or camouflage, with decoy or other techniques. Nonetheless orbiting systems are basically vulnerable, and their survival would appear to lie not in any one technique but in a combination of dispersal, active defense, distance, and ruse.

Response Time. A third tactical disadvantage is that orbiting systems are transients to any selected point in space. This means that the use of an orbital system to apply force at or from a selected point is an extremely complex tactical problem. For example, let us assume a need to apply force against an enemy at a fixed point on or over the earth's surface within five minutes after a decision had been taken. A unit capable of applying the desired force would be in position to apply it for only a very brief time, after which it would have passed on for another circuit of the earth. This is commonly referred to as the absenteeism problem. Favorable response to a commitment to apply force within a given time against a preselected point requires a stream or belt of orbiting units. Cost and control problems are obvious.

Kinetic Energy. A fourth characteristic which appears to offer a tactical disadvantage at this time is that an orbiting system represents a state of energy unlike that of past weapon systems. A ballistic missile has basically potential or stored energy, which is expended only in combat. The energy of an orbiting system is predominantly kinetic or active energy—that energy required to achieve the altitude and speed required for orbit. It is true that an orbital system must still contain potential energy for accomplishing its mission, but this will in almost all cases be less than the energy expended to achieve orbit. Energy expended represents resources committed. An orbital system must stand the comparison with alternative methods for force delivery. It is subject to the question: Do the tactical advantages outweigh the increased energy expenditure?

Time–Distance. The time–distance problem for the delivery of force into, in, or from orbit is of a different magnitude than the same problem with terrestrial forces. This factor represents a tactical advantage or disadvantage. The distances are very large, the velocities of orbiting units very high, and the time interval and distance consumed between force commitment and application can range from a few minutes and hundreds of miles to several hours and hundreds of thousands of miles.

Comparative Analysis. The tactical advantages, disadvantages, and other factors associated with orbiting systems might now be summarized:

Advantages

An orbiting system has line-of-sight access.

An orbiting system can be dispersed and hidden in the large volume of space.

Disadvantages

An orbiting system is immobile.

An orbiting system is vulnerable, once found.

An orbiting system is transient, which complicates the application of force within a specified period of time.

An orbiting system represents energy already expended, which complicates the cost problem.

Advantage or disadvantage

The time–distance problem for the delivery of force is of a different magnitude and nature than with terrestrial weapon systems.

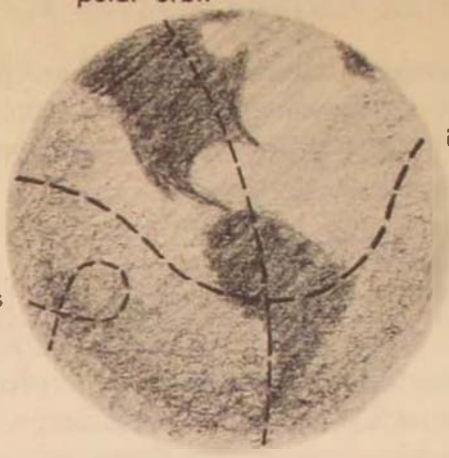
It would cursorily appear that the tactical disadvantages of orbiting systems outweigh the advantages. Note, however, that the advantage of access and the control of access has been a key factor in the power struggles of the past and in fact has often been the key to victory. This is probably the one aspect of orbital operations that gnaws at every military officer who seriously considers the military applications of the space environment. Every professional soldier, regardless of service, knows the importance of access control to a military campaign. If access control should be gained to the extent that the space environment is denied to all but the favored few, those few can control the earth. This is simply a recognition of the importance of access and of space systems as the tools for providing routine access on a scheduled basis to any point on earth. The threat is not new, the argument on the principle of access is not new, but control of access to all nations is a tool never before available.

entry into space

Now let us consider the tactical implications of another of the three environmental modes, the space launch. All man-made orbital systems originate on the earth, and the earth provides the primary base of support. So the ability to enter space at will is fundamental to military applications. An immediate operational problem or tactical disadvantage associated with this mode is that a point, or object, moving along a specified orbit, in addition to being transient to a fixed point in space, is also transient to a fixed point on the earth.* The result is that it is extremely difficult to apply force from earth against a hostile orbiting object within a specified response time. To meet the response time, the advantages of using only a few launch bases, thus expending extra propulsion energy to gain flexibility, must be weighed against the development of a dispersed complex of launch bases that can provide the same flexibility by variety of location. This same problem is applicable to the situation where a payload is to rendezvous with a friendly vehicle for logistic support or rescue.

Whereas the tactical advantages and disadvantages of the orbital operation mode are primarily reflections of the nature of the environment,

*This statement is not valid for an object in a synchronous-altitude orbit, that is, at about 19,200 nautical miles altitude and so placed in orbit that the ground track holds to a fixed point on the earth because orbital speed is synchronized with the earth's rotation.



Typical orbital ground tracks

the tactical considerations of the space launch mode are more a reflection of the state-of-the-art in launch hardware capabilities. Present capabilities are centered on the large rocket engine and the vertical-take-off, zero-lift launch vehicle. The results are massive vehicles, a down-range impact of the stages, a dilemma as to recovery and re-use of the launch vehicle, and large, expensive ground facilities. It has been said that the rocket engine emancipates man from the atmosphere and makes him independent of the wing. A closer examination suggests that there are still distinct advantages to fruitful use of the atmosphere and the wing en route to orbit.

First, if wings are used for lifting the orbital system at take-off, the thrust-to-weight ratio does not necessarily have to be larger than unity, as it does with the vertical-take-off rocket. Second, if wings are used at relatively low speeds en route to orbit, there is a degree of maneuverability in orbit selection that is not normally practical with the vertical-take-off, zero-lift rocket. The wing could be used to get to the desired orbital plane and to accomplish the final corrections before the climb and orbital injection. Third, the atmosphere contains oxygen, which represents a source of energy that might be usable for thrust. The ability to tap this source of energy en route to orbit should logically give an increased capability over the vertical-take-off rocket, which must store all the energy it consumes. Furthermore use of a winged, minimum-stage launch vehicle would provide distinct advantages in orbit selection and coverage. The ability to use the extensive and dispersed network of existing air bases throughout the globe multiplies flexibility in choice of orbits and increases prelaunch security through dispersal.

re-entry and recovery

The third fundamental mode is re-entry and recovery—re-entry for the application of force, or re-entry and recovery for men and equipment. The basic problem is controlled dissipation of the orbital kinetic energy. The principal tactical advantage that may be offered by the exploitation of this mode is improved penetration capability for the delivery of force on the enemy. The use of the orbiting system offers the opportunity to penetrate at very high speeds and from a wide variety of approach avenues. As in the space launch mode, re-entry is paced primarily by technological state of the art. There are two known methods of re-entry and recovery: ballistic and lifting.

Ballistic Re-entry. A ballistic re-entry does not provide for flexibility in selection of a landing or recovery area once the commitment to disorbit has been made. Intolerances in disorbit timing are directly reflected in a dispersion of the landing point. The lack of control after disorbit represents a potential hazard to facilities and personnel in the landing area—a tactical disadvantage. The probability of dispersion in landing areas brought about by disorbit intolerances inhibits planning for turnaround and re-use—another tactical disadvantage.

Lifting Re-entry. The other method of re-entry and recovery is the use of a lifting surface to control the rate of energy dissipation and to provide maneuverability for landing at a preselected point. This method offers good flexibility in terms of disorbit timing tolerance and landing point selection—a tactical advantage. It permits positive control of the disorbiting vehicle—a tactical advantage. It improves the probability of reasonable turnaround and re-use capabilities—another tactical advantage. A tactical disadvantage is that the time spent in re-entry and the distance covered are longer. Up to several thousand miles may be traversed in the re-entry phase. It must be logically assumed that a system would be most vulnerable during the re-entry phase.

the mission and the capabilities

Admittedly discussion of tactical advantages and disadvantages of orbital operations is conjectural, for there is no known short route to confirmation at this time. Our discussion has presupposed that the operating proficiency and experience required for military space operations have been achieved—something which is not true today.

A fuller assessment of tactical application requires a more thorough understanding of the environment. The only course to this understanding is to get into space and sense, observe, test, and evaluate. This is the genesis of defining the immediate Air Force mission in space. Without waiting for a threat or a specific military requirement, we need to gain in understanding of the space environment, to become proficient in operating in that environment, and to build the experience that will provide a sounder basis for strategic and tactical applications. These fundamental capabilities have to be achieved before military capabilities can be exercised. The control of access on a global basis, which is a potential in the military exploitation of the orbital environment, lends urgency to the immediate mission.

The course of military history is filled with parallels to the existing situation. An example is the airplane. The basic airplane had to be developed, routine reliability had to be achieved, and reasonable performance capabilities exercised before the military applications became self-evident. And throughout the history of aviation these military applications have been revealed and have become operable at a time rate directly proportional to the resources and priorities that were allowed the military for their exploitation.

The immediate military mission is more than new discoveries, or research, or development; it is to move from the experiment and the test to the routine operation. The fundamental capabilities involved are not solely in the province of the military, but their application to the national security is in that province. This application is unique in terms of operating characteristics, just as the bomber is different from the transport, although it may require the same fundamental capabilities of power plants, auxiliary power, communications, control equipments, and crew accommodations.

Fundamental Capabilities. What are the fundamental capabilities of orbital operations? They may be defined on the basis of simple logic. Early military participation in their achievement and application is vital to the timely genesis of valid strategic and tactical concepts.

- All orbital operations require a launch capability for orbital injection—launch in terms of payload, facilities, ground support equipment, and guidance.
- If orbit transfer or in-space maneuverability is required, then in-space propulsion is necessary to provide the thrust to reorient the kinetic energy of orbit.
- If man is aboard the orbital system, then life-support equipment is required to sustain life and permit man's functional operation under the conditions of hard vacuum and zerogravity.
- Vehicular design must be based on the best available data on the environment.
- Any space mission involving more than one vehicle in space requires an ability to rendezvous with another vehicle, establish physical contact, or dock with the vehicle and then transfer men and materials. This capability must precede any permanent manned space stations if personnel are to be replaced and maintenance accomplished.
- The operation of any equipment in space requires power supplies. This is a problem that has been solved on earth and in atmospheric flight by tapping power from the main propulsion engine and converting it as required to run subsystems incident to the mission. The problem in orbiting vehicles is different, because there is no need for a main propulsion engine to be operating at all times to keep the system in orbit.
- Guidance, control, and observation in orbit require sensors that operate in the environment, taking advantage of what the environment offers and surmounting the problems that the environment causes. The vast distances associated with the environment make perception and the establishment of reference planes unique problems.

• The exchange of information between orbital systems and between an orbital system and the earth dictates a need for communications equipment.

• The design criteria must be established for the evolution of vehicles that incorporate a routine capability for re-entry and recovery from the high speeds of orbit.

• Finally, the launch, control, and recovery of orbital systems require extensive ground facilities.

Capability Integration. The basic achievement of the enumerated fundamental capabilities still does not suffice for the assessment of operating tactics and techniques. With the exception of the launch capability fundamental to all space operations, there is a need to integrate the capabilities into basic hardware.

The hardware of space is today specialized and designed for specific accomplishments. The advent of automatic control and computer technology, coupled with the harsh environment of the orbital altitudes, has led to much serious and conscientious debate on the need for man in space and particularly on his usefulness there in accomplishing military tasks. While his functional value and his weaknesses may invite serious questions, there can be no question that he provides on-the-spot judgment. With this judgment man provides a degree of flexibility and selectivity most difficult to achieve with automatic systems and remote control.

Perhaps it is appropriate here to draw once again on the lessons of military history. Battles and campaigns have been won or lost by the judgment exercised on the field of battle. At best, combat is a state of confusion. The ability to perceive an enemy's weaknesses and to recognize the course of action to take advantage of his weaknesses has often been the deciding factor in victory. In every maneuver and war game the one missing element is the persistence of man to keep fighting in the face of overwhelming odds. History is not without instances where this factor extracted victory from what by the initial logic of strategy and tactics might have been complete defeat. In the face of this experience, there is no military alternative but to proceed on the assumption that man has a vital military role to play in the space environment. He must go into space and find out conclusively and unquestionably what his limitations and capabilities may be.

Making, then, a basic assumption of the requirement for man in space operations, we can focus the fundamental capabilities required for space flight on two categories of manned orbital hardware, one recoverable and the other nonrecoverable. Launch vehicles and proficiency in their operation are of course basic to both. The first may be designated as a manned recoverable spacecraft, and the second as a manned space station. These two vehicular systems together provide the ability to integrate the fundamental flight capabilities into definable hardware, still independent of specified military tasks.

• Spacecraft. The manned recoverable spacecraft provides for testing re-entry and recovery techniques. It is one half of the rendezvous, docking, and transfer operation. It requires communications equipment, sensors for orientation and control, life-support equipment for short durations in orbit, and power supplies for subsystem operation. Once proficiency in spacecraft operations has been achieved, growth of military applications in the traditional military mission areas is a relatively small step. The spacecraft provides the basis for evaluating such concepts as orbital interceptors, reconnaissance vehicles, maintenance and resupply vehicles, and possible weapon delivery systems.

• Space Station. The space station, designed for more permanent operations in orbit, permits the testing and development of the fundamental capabilities for longer flight durations and larger payloads. It enables testing and development of life-support equipment capable of operating for weeks or months. It can be the stable complement of the docking and transfer operation. Techniques for in-space maintenance and resupply can be developed and tested. A stable platform in orbit offers growth potential into several military mission areas, such as resupply, surveillance, weapon delivery, and command and control.

These two hardware achievements may be defined as near-term military objectives. They are steppingstones to the exploitation of the military potential that the orbital operation may offer. They are the military requirements in space today. It is important that they be recognized as such, independent of the future military requirements for reconnaissance, offense, defense, and support. There is every reason to believe that the strategic and tactical considerations of orbital operations will become self-evident as proficiency and experience are gained in their operation.

The immediate military mission of the Air Force in space can therefore be defined. It is to achieve a proficiency in the Air Force in the fundamental capabilities for operation in space, to determine how these capabilities may be exercised in military applications, and to integrate these capabilities into definable hardware. All these early processes are prerequisites to effective military space operations.

The tools for mission accomplishment and the integration and application of the fundamental capabilities are a manned recoverable spacecraft capable of landing at a preselected point and a manned space station designed to remain in orbit permanently. Each is a basic building block leading to the ability to surveil, survive, control, and deliver force.

The prime strategic or tactical advantage posed by the use of orbital systems is global line-of-sight access and the opportunity to control access to any part of the world. The potential threat inherent in this advantage if in hostile hands, and the concurrent potential for improved national security if in our hands, lend great urgency to our efforts to gain the goal.

Headquarters United States Air Force

AIR FORCE MISSIONS IN LATIN AMERICA

Colonel Frank L. Gailer, Jr.

SOUTH of the border the United States Air Force has its own contribution to increasing understanding and efficiency. Its name? The USAF mission system, which today operates in 15 of the 20 Latin-American countries. The mission is neither new nor original in concept. After 35 years in existence the basis of its strength still derives from one tenet—greater efficiency through new ideas. In this perspective our blue-suited "tech reps" to the air forces of the other Americas represent a dynamic, on-the-spot approach to good-neighborism.

The basic principles envisioned in the Air Force Latin-American mission program concern the sending of language-trained, highly motivated advisers to foreign lands to improve military effectiveness through efficiency. Once in place they work side by side with the nationals of the host country, providing know-how that will increase efficiency and understanding at little or no extra cost. If the adviser is trained in the language and culture beforehand his chance for success is enhanced considerably. It is in this perspective that the USAF mission system should be considered if it is to be understood and properly evaluated.

The Air Force missions in Latin America—the only area where the mission system presently operates—are composed of specialized military representatives. They work with the air force in the host country to improve technical and administrative capabilities in consonance with the desires of the host government and to standardize military equipment in the Western Hemisphere. The training, advice, and assistance parallel USAF methods and organization. While the missions themselves are primarily military in make-up, the relationship with the host air force and government requires that their members exercise a diplomatic bent illuminated by understanding of local political and economic influences. Additional prerequisites are an awareness of the historical national aspirations of the host country and an appreciation of its culture.

organization of missions

In 1926 the U.S. Congress charged the military services with the responsibility for furnishing advisory training missions to interested Latin-American countries. The resulting mission concept may best be understood by contrasting it with two similar oversea military systems, the air attachés and the Military Assistance Advisory Groups (MAAG's).

The assignment of air attachés is the joint responsibility of the Assistant Chief of Staff for Intelligence and the Deputy Chief of Staff, Personnel, Headquarters USAF. An air attaché serves as air adviser to the U.S. ambassador in the capital city of the foreign state. He works directly for the ambassador and with the embassy staff for the attainment of United States objectives in the area. His military channels, however, are direct to the Assistant Chief of Staff for Intelligence in Washington. His chief duties as a representative of the United States Air Force are to collect air intelligence and to represent the USAF Chief of Staff at the highest military and diplomatic levels in the country of assignment.

The Air Force MAAG function is the responsibility of the Assistant for Mutual Security, under the DCS/Systems and Logistics in Headquarters USAF, and MAAG personnel are selected and assigned through the DCS/Personnel. The U.S. Air Force is authorized to assign such personnel to the host country as is mutually deemed necessary to achieve the Military Assistance Program objectives. The programing of Air Force military assistance equipment and the supervision of its use are the primary functions of the Air Force Section of a MAAG. Like the air attaché, the MAAG chief has a direct responsibility to the U.S. ambassador, who, as head of the "country team," is charged with recommending all forms of U.S. assistance—economic, military, or technical. The military channels for MAAG personnel in Latin America are through the Commander in Chief, Caribbean Command (CINCarib), to the Department of Defense in Washington.

The Air Force mission, unlike the air attaché and MAAG systems, has direct responsibilities to the air force in the country of assignment and is there by invitation of the host government. Upon receipt of a request for an Air Force advisory mission from a nation's government, the Department of State, in coordination with the Department of the Air Force, commences formal negotiation of a bilateral executive agreement. In actuality, the host government is contracting with the United States Government for technical advisers much as it might contract with a business concern. The agreement is fairly permanent and is financed out of Air Force funds (unlike the Congress-appropriated Military Assistance Program funds for MAAG). Thus a mission is not subject to cancellation by the loss of Congressional funds, and its permanence is one of its greatest assets. No promise of military equipment is given or implied, and the host country agrees to reimburse the United States for a share of the over-all mission costs. A mission is specifically precluded from intelligence activities by the terms of the bilateral agreement.

The mission also differs from the air attaché and the MAAG in that it does not have a direct connection with the ambassador as far as its military advisory duties are concerned and the mission chief is not assigned as a member of the embassy staff. When the mission has the additional responsibility for the Military Assistance Program, which is the case in a number of Latin-American countries, the mission personnel having MAP duties are members of the ambassador's advisory staff.

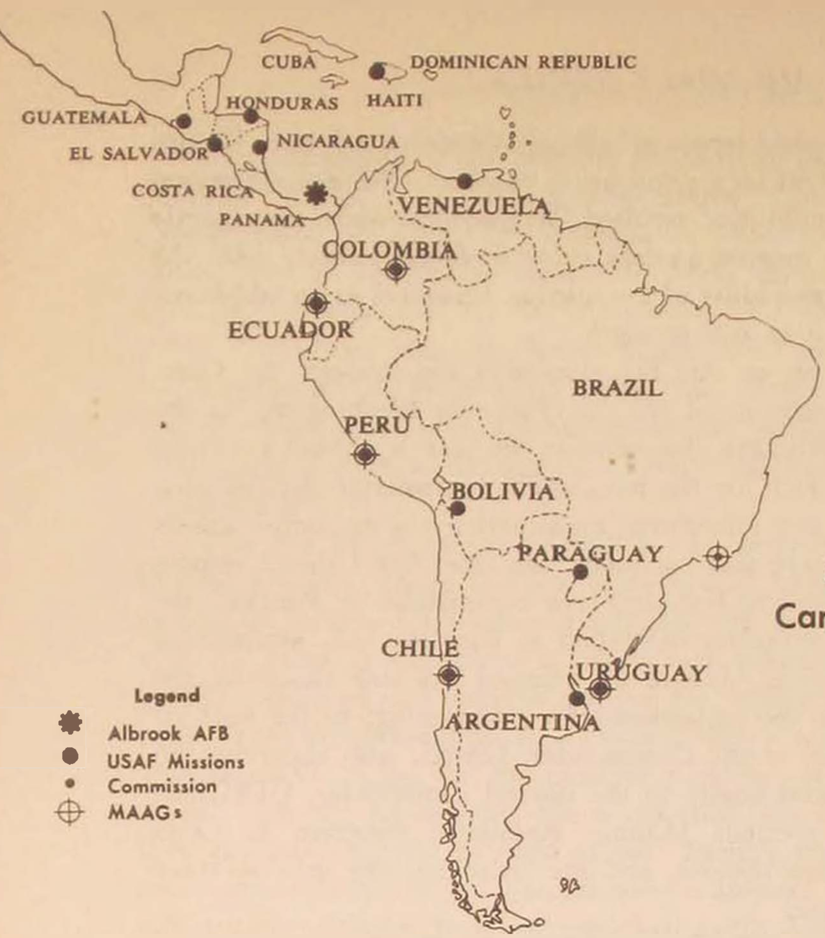
Mission responsibility for MAP functions dates back to 1954, when the

Department of Defense established separate Military Assistance Advisory Groups in Latin America. This resulted in a duplication of effort. Subsequent review of mission and MAAG responsibilities resulted in discontinuance of separate MAAG representation where a mission already existed. Since January 1958 the MAAG function has been a responsibility of the mission personnel as an additional duty, with the MAAG's reduced to zero strength.

The reporting channels for an Air Force mission are through the Commander, CAirC, to the Department of the Air Force in Washington. If the mission has a MAP responsibility, the channels for the MAP workload are those previously given for MAAG. Which hat the mission chief is wearing decides what his military channels will be; and sometimes this situation has its complications. Where the mission does not have MAP functions, the chief has a direct responsibility to the host air force and to his Air Force commander in Panama, the Commander, CAirC, with a secondary obligation to keep the U.S. ambassador informed concerning his activities. Where the mission has MAP functions, the chief is directly responsible to the ambassador for programming, to the host air force as a hired adviser, again to the Commander, CAirC, who supervises all Air Force mission activities, and finally to the unified commander, CINCarib, who is responsible for the over-all Military Assistance Program in Latin America. The ramifications are obvious, and the path that the mission MAAG chief treads is not an easy one.

In Latin America there are 18 USAF missions and the Air Force Section of the Joint Brazil-U.S. Military Commission. All the missions are located in the capital city of the host country. In several countries additional advisory

Host and guest. Brigadier General Alberto Pauwels R., Commander in Chief, Colombian Air Force, has a warm handshake for Colonel Thacker, Chief, USAF Mission.



**Geographical Area
Caribbean Air Command**

personnel are assigned to other bases to work directly with tactical and field units of the host air force. Organizationally the missions are identified as numbered detachments and assigned for administrative control purposes to the 5500th Foreign Missions Squadron, Albrook Air Force Base, Canal Zone. Responsibility for centralized control and supervision of the Air Force mission system in Latin America is specifically assigned to the Director of Operations under the Deputy Chief of Staff, Operations, Headquarters USAF.

Mission offices are normally within or adjacent to the central headquarters of the host air force. The chief of each mission is an officer in the grade of colonel. The minimum organization includes a nonaccredited support element consisting of an administrative noncommissioned officer, a crew chief, a radio operator, and an indigenous civilian secretary. Every mission is assigned at least one USAF C-47 aircraft for use within its sphere of accreditation. Unlike an air attaché, who may be accredited to more than one country, a mission adviser is accredited to only one country, thus eliminating the problem of divided interests.

The support element, assigned at USAF expense, frees the advisers to spend more time with their host air force counterparts. The mission staff also includes such technical advisers as have been requested by the host air force and deemed appropriate by the USAF. The missions vary in military strength from 8 in the smaller Central American countries to 40 in Brazil.

selection and training of personnel

Air Force personnel selected for mission duty in Latin America are probably the most carefully screened in the entire USAF. The selection procedures now in use embody the results of an exhaustive study by the Caribbean Air Command of certain personnel problems adversely affecting the mission system. This study identified three major problems: wrong technical skills, poor linguistic capability, and dependents with chronic illnesses.

Unfortunately the Air Force specialty codes (AFSC) assigned to the various personnel skills are not always shredded out to the point that the number or code exactly identifies the proper man. A mission desiring a supply adviser with warehousing background might get one with stock-control qualifications instead, the specialty code being the same for both skills. To preclude malassignments of this nature a complete word picture of each adviser position is now submitted by the mission, specifying desirable as well as mandatory skills and identifying the exact background needed.

Related to the technical skill required is the linguistic ability necessary to transmute that skill into usefulness to the host air force. The CAirC study pointed out that no matter how well qualified an adviser may be technically, his value to the mission is in direct proportion to his ability to express and exchange thoughts in the language of the country to which the mission is assigned. Language-aptitude testing of all prospective mission personnel was instituted in 1958.

A third matter bearing importantly on good selection is the medical condition of dependent personnel. Here the study revealed many instances of dependents arriving on station in need of extended medical treatment or suffering from chronic diseases known prior to departure. With the problem of obtaining medical care compounding the personal problems of the affected mission adviser, much of his effectiveness was lost to family considerations. Consequently too many advisers were being returned to the Canal Zone or the United States before completion of their normal tours. To correct this situation, prior to his selection each prospective assignee to mission duty must present a medical certificate for each dependent stating that no chronic disease is known to exist.

To fill personnel requisitions from the Caribbean Air Command, nominations are made by DCS/Personnel to the Director of Operations, Hq USAF. Upon receipt of the names the Latin American Missions Branch, D/O, reviews the complete personal file of each nominee for any indications of unsuitability and for technical qualifications substantiated by better-than-average performance ratings. Because no officer below the grade of captain is considered, nor any airman below the grade of technical sergeant, many performance ratings are available from which a reasonable evaluation can be made. After the records review, the prospective nominee is brought into Headquarters USAF for personal interview and language-aptitude testing, which form the basis of final selection. The interview is conducted in the Latin American Missions Branch by a former mission adviser, and the language testing is done by the Foreign Service Institute of the Department of State. If successful on both counts and if satisfactory dependent medical certificates have been supplied, the nominee is accepted for mission duty.

The difficulty of selecting good personnel is a major problem—past and present—confronting the mission system, and it will always remain so. But the selection can and must become ever more stringent. With all the Air Force missions located anywhere from 350 to 5000 miles from their headquarters in Panama, some personnel may succumb to the temptations of good living, high social status, additional pay, and little or no supervision. Finding men with a high moral sense of duty and a distinct awareness of the national importance of their position is paramount.

Flying Training

Flight plan and Link trainer time—Honduras.

Dead-reckoning problems and the E-6B computer.

Pilot check-out in the F-51 fighter—Guatemala.

An officer of the USAF Mission points out details of the pilot's preflight walk-around inspection of the C-47, which equips an air transport squadron recently activated in Ecuador under the Military Assistance Program.

After selection, the nominee is sent to the Foreign Service Institute in Washington for six months' language and area training—in French for Haiti, in Portuguese for Brazil, in Spanish for all other Latin-American countries. Wives of mission personnel may attend about 100 hours of language training at the same school at no cost to themselves.

Once in school, a nominee who is eliminated proves costly to the Air Force. An expensive move to the Washington area with family and household effects, valuable time, and the course matriculation fee of approximately $1400 all have been lost. Additional transfers to send the eliminee to another station and to bring in a replacement further increase the over-all cost. The elimination factor is doubly serious because the rotation cycle of mission personnel fixes all return and replacement dates at six-month intervals. Before a man can return, his replacement must be on hand. A 15-month lead time is planned for the replacement action, to allow 9 months for selections of new personnel and their PCS moves and 6 months for language and area training. But any time an individual is eliminated during school the cycle is thrown off schedule. Either the incumbent adviser must extend his period of duty or the new adviser must forego at least a portion of the needed training, depending upon how urgent his arrival is to the mission chief. The time and money spent for careful testing and screening are negligible compared to these possible costs that screening may avoid.

All officer selectees also attend the Military Assistance Institute (MAI) in Washington for training in military assistance programing, concepts, and doctrine. The MAI was set up by the Department of Defense as a result of increased interest in providing better training for people entering the worldwide Military Assistance Program.

objectives

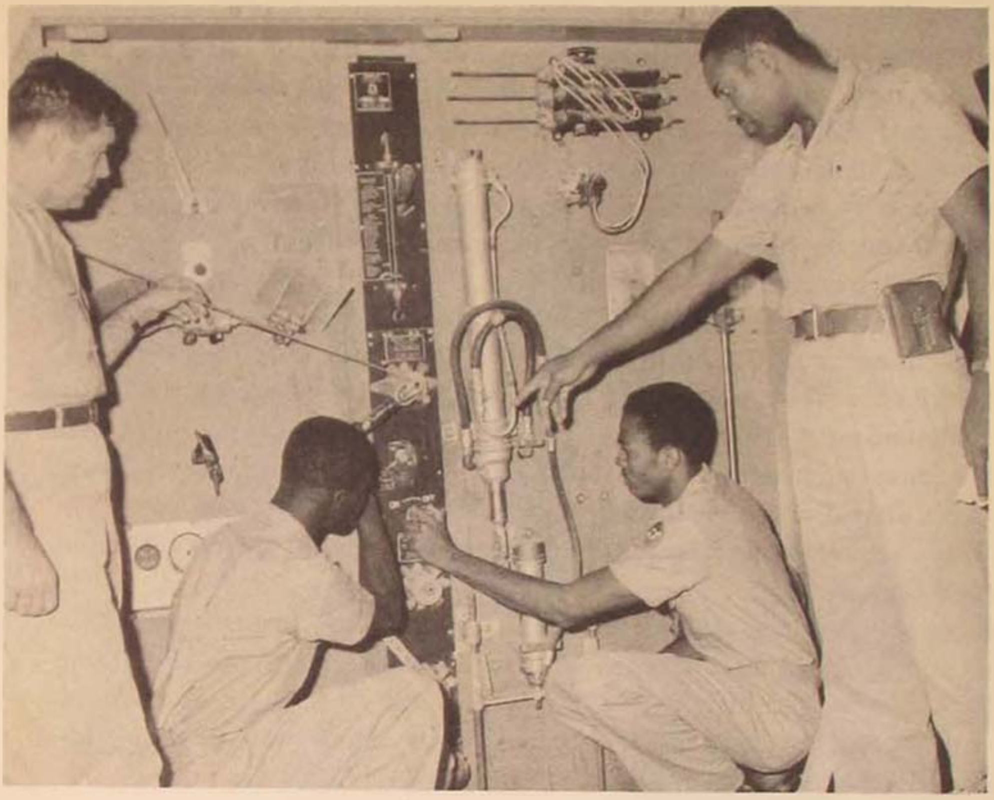
USAF missions are guided in their advisory duties and military relationships by several broad objectives. The first, which underlies all mission activities, is to contribute to the efficiency and effectiveness of Latin-American air forces by training their personnel in USAF doctrines and procedures.

Training. Most Air Force missions have established, or they supervise, on-the-job training programs as well as formal courses at the airman technical schools of the various host air forces. Particular emphasis is placed upon technical areas—ground and airborne communications equipment, jet and conventional aircraft mechanics, supply, armament, basic electronics, jet and conventional engine repair and overhaul, airframe repair, personal equipment, etc. Training aids as well as classroom instruction are provided by the mission.

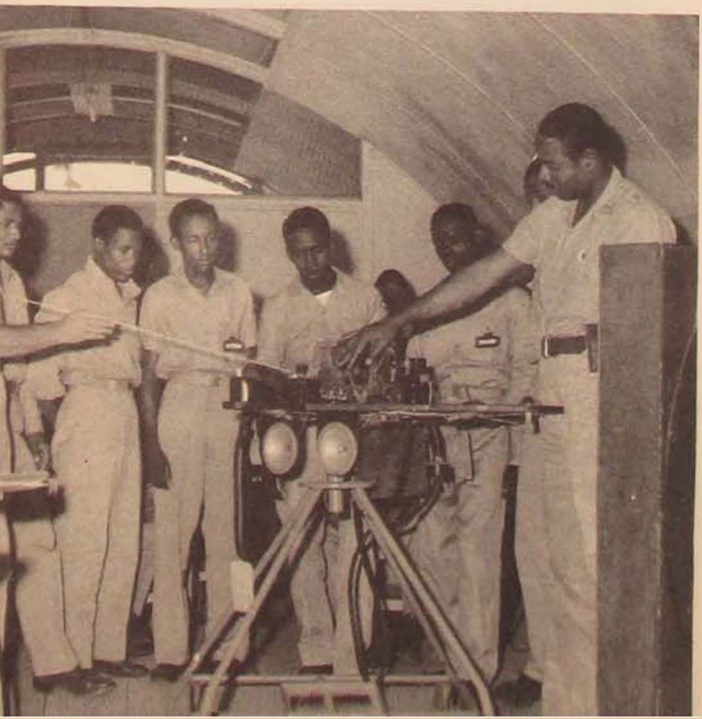
Often an adviser is assigned to work, as a counterpart, with a key staff officer of the host air force or even with a tactical group commander. In this capacity he may give instruction in tactics, gunnery, or instrument flying; or he may help to develop operational plans and programs, new supply procedures, and possibly even a maintenance or logistic manual to be translated for use by the entire host air force. If linguistically capable, the adviser will probably be asked to conduct classes or to lecture at the local air academy or war college.

Aircraft Maintenance

USAF Mission personnel assist in training of aircraft mechanics and specialists. A maintenance officer, Corps d' Aviation des Forces Armees d'Haiti, and a member of the Mission join in . . .

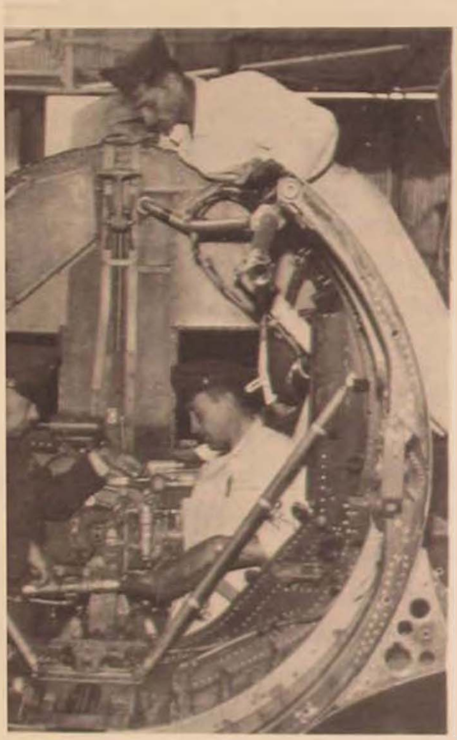


demonstrating the operation of the engine hydraulic pump selector on a mock-up of the C-47D hydraulic system, and



explaining the function of the voltage regulator in a landing and navigation electrical system.

Explaining the operation of an electric tube checker to a young officer of the Bolivian Air Force.



In Ecuador complete disassembly of the T-33.

Bench-checking aircraft radio equipment—Guatemala.

In further support of the training objective the Caribbean Air Command conducts a USAF School for Latin America at Albrook AFB, Canal Zone. The school is presently staffed to teach 250 students per class in some 18 different courses, using classroom and flight-line methods of instruction. The skill level of the courses taught varies from apprentice to supervisor. Several instructor courses are also available to aid the host countries in developing their own training capability. A recent policy decision has opened the school to Latin-American civilian as well as military personnel.

For high-cost training programs such as flying training (pilot, navigator, gunnery, instrument, etc.), flying safety, advanced communications, aircraft maintenance officer, command and staff school, advanced airman technical courses, etc., the students are sent to the U.S., under the Military Assistance Program, to attend schools of the Air Training Command and Air University. They first receive comprehensive English-language instruction at Lackland AFB. This course makes possible the selection of students on the basis of over-all ability rather than just linguistic competence.

Standardization. Another important objective of the missions is to promote standardization of military equipment and organizational procedure and to encourage use of materiel of United States design and manufacture. Some excellent progress has been made in the adoption of USAF personnel classification systems, supply accounting procedures, maintenance concepts, and operational techniques.

In the standardization of aircraft only limited progress has been made. Although the United States tries to make the same types of aircraft available to all the countries concerned, the assortment of aircraft in Latin America today runs the gamut from F-51, F-47, F-80, and F-86 fighter planes, to T-6, T-33, T-34, and T-37 trainers, to B-25 and B-26 medium bombers, to C-45, C-47, C-54, C-82, and C-123 transports, to SA-16, PBY, P2V5, and S2F U.S. Navy antisubmarine planes, to H-13 and H-19 helicopters. British aircraft now in operation include Chipmunks, Gloster Meteors, Venoms, Vampires, Canberras, and Hawker Hunters. Various German, French, and Italian planes still active in some host air forces compound the difficulty of standardization.

The standardization objective is also hindered by the fact that the United States does not produce a fighter, bomber, or cargo plane especially adapted for its neighbors to the south. Instead it has preferred to provide or sell whatever aircraft are available out of the USAF inventory. The result may be procurement of several different types of planes with no truly effective way to maintain or utilize them. Despite public and Congressional criticism, it is extremely difficult for the United States to refuse to sell or supply reasonably modern equipment simply on the grounds that such action is considered unsound. To give such a reason to a sovereign state may mean only that similar equipment will be obtained elsewhere.

The position of the mission is to attempt to dissuade the host air force from purchasing equipment believed not the best for that country's purposes.

If the purchase is a foregone conclusion, then help and advice are given as to the most economical method of purchase. Two such methods are available today: the first is through mutual security military sales under the provisions of the MAP, and the other is by direct purchase. In either event the mission or host air force can call upon USAF technical advice to ensure host air force satisfaction.

Hemisphere Solidarity. A third objective of the USAF missions is to foster friendly relations with the United States and to strengthen the ties of solidarity among American nations. The very presence of some 220 mission personnel working in close daily contact with the personnel of 15 countries favors the attainment of this objective. The fact that the mission is constantly working for the benefit of the host air force establishes an identity of interests and mutuality of goals upon which significant good will can be built.

To further this objective, the USAF, through the Military Assistance Program, has an annual program of visits and tours for Latin-American officers. Also the Commander, CAirC, invites and encourages visits of Latin-American officers to Albrook AFB to inspect its facilities, to witness the annual joint Army–Navy–Air Force exercises, to participate in the semiannual mission chiefs' conferences, and to attend the graduation ceremonies of the USAF School for Latin America.

The USAF Chief of Staff personally invites an average of five or six Latin-American air force chiefs of staff to visit the United States each year. These visits last about two weeks and encompass stops at major Air Force installations throughout the United States.

Military and Political Goals. The objectives of the USAF mission system can probably be reduced to one military and one political goal. The military goal is the attainment of self-sufficiency on the part of the host air force at the earliest possible time. Regardless of the origin of the equipment, the mission has achieved one of its purposes when it has helped the host air force to utilize its equipment properly and effectively. The political goal is to supply the need for outside military assistance. It is imperative that the United States excel in this role of the good neighbor and adviser so that this privilege will not fall, by default or disharmony, to other nations hostile to the democratic system.

A Joint Goal. The USAF must establish a clearly defined, joint USAF-mission–host-air-force goal. In principle, a specific goal with a time-phased plan for its accomplishment is desirable, although not always attainable. Without such a goal and plan there is only a sporadic, brush-fire operation, solving one problem at a time. The result is a lack of positive direction of the mission effort and confusion on the part of mission personnel.

Once a plan is adopted, a positive program to achieve the goal should be adhered to. There is a frequent complaint that USAF mission advisers tend to arrive with wild-eyed plans to create an image of SAC, TAC, or MATS in the host air force and country. This is an exaggeration but does illustrate a point.

Supply Procedures

The Mission organizational supply supervisor discusses review of stock records at the Madrid Depot with a supply sergeant

The supply adviser, USAF Mission to Colombia, checks over receipts with the Commander, Madrid Air Base, Bogota.

There is also a tendency for programs to begin with tremendous energy and drive, only to degenerate into an informal, token effort that merely meets the schedule on a wall chart. The inherent danger here is that "eyewash" on a wall chart may be the end result of purposeless planners and ephemeral accomplishments. Only through mutual interest in achievements, created by an appreciation of the over-all benefits to accrue, can plans be turned into reality.

Good Will. The mission is an effective instrument in presenting American ideas and friendship. Its very presence in the host country—staffed as it is by technical experts who are generally highly regarded by their fellow workers—provides an unexcelled situation for contact. The carefully selected mission advisers thus occupy a position which, through intimate daily contact with host air force personnel, can do much to create a favorable image of the United States and its people. Equally effective as an instrument of good-neighborliness are the training programs for Latin-American air force personnel that are provided by the USAF, under the sponsorship of the Military Assistance Program, at its training schools in Panama and in the United States.

explains bin storage, item tagging, and accountability procedures in USAF practice

and assists in taking inventory of supply at the Depot.

AMONG THE many successful mission activities over the years, some methods and attitudes stand out as hallmarks worthy of emulation:

- Where the mission chief presented reorganization or modernization ideas well, tactfully, and in a timely manner, they found a high degree of receptivity by the host air force.

- Where patience and methodical step-by-step advances were the measure of progress instead of precipitous, bullheaded, all-out assaults on plans and projects, cooperative effort and interest were more certain.

- Where the mission chief recognized and respected the many areas of difference between the host air force's methods for problem-solving and his own, common ground between the two was more easily reached.

- Where there was an understanding of host air force thinking, unacceptable proposals and inapplicable procedures were usually avoided.

- Where constructive criticism rested on a well-designed plan of operation jointly prepared, the criticism was better taken and strained relations avoided.

Personnel procedures. Major Delgadillo of the Bolivian Air Force examines the USAF officers job classification system.

• Where joint planning was substituted for unilateral action or proposals, greater desire was engendered to achieve mutual goals.

• Where plans were motivated rather than imposed, their consideration was more likely to lead to acceptance and implementation.

• Where sincerity, respect, and understanding characterized the work and attitudes of the mission, the adviser's usefulness and prestige were enhanced. Such esteem is built on constant awareness that the adviser is the invited guest of his host government.

• Where the adviser in fact advised, and did not insist, demand, or direct, his proposals more often saw the light of day. No authority for directive action is granted or implied by the host government.

• Where the mission chief matched ideas with enthusiasm, he gained more adherents for his proposals. Personal salesmanship—with the emphasis on helping and not pressuring—is the key to an adviser's success.

• Where new programs were proposed, those incorporating self-help implementation and having indigenous roots were of greatest appeal to the host air force.

• Where the adviser kept clearly before him his obligations to the host air force and his responsibilities as a U.S. representative, he was less likely to allow such personal preoccupations as hiring servants, ordering luxuries, and throwing lavish parties to obscure the fine facets of oversea life with its opportunity for worthwhile service to one's country.

In the long run, the skill and zeal which we exert in Latin America will be returned in the friendship and solidarity of purpose our Nation is striving for. In the day-to-day dedication to the job, however, let us face the fact that we must do a good job, with a determination to succeed, or others will take our place. The USAF has recognized the importance of its "mission" in Latin America and is devoting a major effort toward ensuring its success.

Headquarters United States Air Force

Human Factors in Missile System Performance

Major Robert J. Lacey

SINCE missile capabilities are essential elements of our total force structure, now and in the future, much will depend upon their reliability. A vast technical effort and enormous sums of money have been spent in testing of their individual parts, subsystems, and systems in pursuit of the elusive 99.9 per cent mechanical perfection and operational reliability of the whole machine. This effort has been necessary, and by all means it must be continued. But far less attention has been paid to the sources of equally disastrous human error in the maintenance and firing of these same systems.

Human error, in the context of the following discussion, is an error or mistake, either of commission or omission, which is made by a person and which occurs in the direct chain of events leading up to a failure or malfunction of a missile system or component. Errors occurring in the design or fabrication of the missile or its components are excluded. The operational situation, which is the subject of our attention, differs markedly from the manufacturing environment and requires a different approach for its examination.

It is generally recognized that the problem of human error becomes more acute as modern missile equipment grows more complex in design and operation. A review of the literature on human-initiated failures and malfunctions in missile systems indicates a tendency to attack the problem from one direction only—striking at a single cause or several causes within a single area, such as the design of the equipment, or the training of operations and maintenance personnel, or the need for more and better human engineering. Although each of these factors is valid, this study will suggest that human error cannot be treated within the confined framework of one discipline or technical area. It will suggest instead that a systematic and integrated approach is necessary and will propose three primary factors to be considered in this approach to

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

reduce human error in missile systems:

proper design of the equipment
operator's familiarity with the complex missile equipment
an adequate data-feedback system.

The ultimate objective of this discussion and proposals is to arrive at a means of increasing the effectiveness of missile systems through a reduction in the incidence of human-initiated failures.

The Degree and Effect of Human Error

The first step in a program to eliminate or reduce an inefficiency or waste of any type is to gain a measure of the loss. A program for reduction of human error in our missile systems can cost a great deal of money and effort. How can we be certain that the expenditure will cost less than the waste produced by human error? The answer to this question must be twofold: in terms of the *money* and of the *chance factor* involved.

The money involved is the easier of the two to handle. If it can be determined what percentage of all equipment and time losses may be attributable to the human element, some idea of the amount of money might be gathered. The chance factor, on the other hand, is an extremely difficult if not impossible element to appraise accurately. "Chance factor" is a convenient set of words used to represent the possibility of destruction of a missile or critical equipment at the time of an extremely important operation, such as a lunar probe or a man-in-space launch—not to mention the conduct of nuclear war. Here the disaster cannot be measured in terms of money alone or money plus replacement time.

During the research and development testing of the Snark missile at the Atlantic Missile Range, human-factors personnel were on hand to investigate the design of the equipment for maintainability. Their many interviews and discussions with maintenance personnel produced evidence that a number of malfunctions had been caused by human error. Although time did not permit a detailed investigation, some effort was directed to estimating the seriousness of the situation. The writer learned in personal conference with members of the team that it had made an informal estimate assigning from 20 to 25 per cent of all malfunctions to human error.

A comprehensive study was made of human error by Albert Shapero and others from the Stanford Research Institute.[1] In its search for evidence of human initiation of failures or malfunctions, the group reviewed equipment-failure reports and unscheduled-hold reports on seven missiles, plus the nose-cone systems for the Atlas, Thor, and Snark. An equipment failure or an unscheduled hold was considered to be human-initiated if the human component could be clearly identified as the causative agent in the immediate train of events leading to equipment failure. A total of 3829 equipment-failure reports and 419 unscheduled-hold reports were analyzed. Results of the study indicated that 29 per cent of all the equipment failures were human-initiated, and 20 per cent of the unscheduled holds. For the individual missile systems, the percentage of human-initiated failures ranged from 20 to 53 per cent. Three of the missiles had a human-error rate of over 40 per cent; two others had over 30 per cent. The Stanford study strongly indicates that a significant portion of all malfunctions in missile systems—from one fifth to one half—is caused by human-initiated failures.

It is difficult to determine the precise effect of human-initiated failures on the reliability of our missile systems—and subsequently on the military posture of the United States. It appears certain, however, that the equipment destroyed has cost millions of dollars. For instance, during the course of the Stanford study, interviews with contractor test personnel revealed that at least one disastrous launch or flight failure in each of the programs under review was human-initiated. If only the cost of the missiles is considered, the loss approaches the ten-million-dollar mark. There are, of course, other losses that must be considered, such as from damage to launch equipment and from time put into facility repair. Then too the prestige lost in a missile failure may be more serious to the United States internationally than the money involved.

The Causes of Human-Initiated Failures

Let us now consider, in turn, each of the three factors already mentioned as leading to the human errors that result in costly failures of missile systems or components.

equipment design

In an unfortunately large number of instances, the design of equipment has been so incompatible with human capacities and limitations that an eventual "personnel error" was inevitable. It appears that the first and foremost cause of human error is in the design of the equipment. The failure of industry to consider seriously the human element when designing equipment is reflected in reports from the field: . . . inaccessible for calibration . . . meter is unreadable . . . incorrectly set . . . human error at the test console . . . improper insertion . . . reversed connections. It is paramount that error-prone features be minimized in the design of missile system equipment before any appreciable reduction in the degree or amount of human error can be effected.

One area of design that has been a constant source of problems is the control panel. The vast array of controls, dials, and indicators confronting an operator is an excellent breeding ground for mistakes. This statement may be challenged on the basis that many operators have performed accurately for extended periods on highly complex panels. Indeed they have, but their satisfactory performance also may well represent one of the following conditions:

The console was so designed and so arranged as to be compatible with the capacities and limitations of the operator.

The operator was highly skilled, trained, motivated, and relatively resistant to stress.

The right conditions and situation to generate an error had not yet occurred.

The routine, daily exercising or training situations are not as apt to evoke serious errors in judgment or control manipulation as the real situation when it comes along. Then the tension and anxiety of the operator mount and the chances for error increase dramatically.

> A man may continue to work on a highly unsatisfactory machine or in an unsatisfactory posture for years without, apparently, suffering any great ill effects or loss of efficiency, and as a result, there is no pressing need to make changes in equipment or working methods. . . . the effect of accumulated stresses may show up only when called upon to meet an unusual situation, and then, because he is unable to meet it, disaster may result which may have dramatic and far-reaching consequences.[2]

Since it is a recognized fact that poorly designed equipment can and does lead to serious human error, what are the reasons for unsuitable design? The technical discipline known as "human engineering" intends to integrate the engineering sciences and the life sciences (psychology, physiology, anthropometry, etc.) for the optimum integration of engineered devices with the capacities and limitations of man. More simply, its purpose may be described as the engineering of machines for human use. It would seem, then, that the proper utilization of principles and techniques from this discipline would in large part solve the problem of inappropriate design.

Certain gains have in fact been made through human engineering. The human-engineering experts have found methods of minimizing the degrading effects of acceleration, noise, vibration, and temperature extremes. That their efforts are not as efficient or effective as might be desired is evident in the fact that poor equipment design continues to account for a significant number of malfunctions. To understand the reasons, it is necessary to explore the position of human engineering within industry and to examine some of the problems and frustrations that confront its practitioners.

There is a rapidly growing recognition of the importance of human engineering in military systems programs. In many cases specific human-engineering studies, analyses, and mockups are a contractual requirement. Unfortunately the growth of the electronics industry and the expansion of weapon system development occurred so rapidly that a distinct shortage developed of specialists adequately trained in human engineering. As a result the authority to provide intelligent human-factors input into the design of equipment is now, in many cases, delegated to unqualified individuals. Instead of appropriately staffing organizational units with human-engineering experts and delegating corresponding authority, design engineering groups already in existence are merely renamed. A few human engineers may then be called upon, sometimes through short-term contracts, to write reports justifying design decisions made by, say, electronic engineers. The task is sometimes not easy.

A second reason, and one of the most frustrating, is that of the belated input. Far too often the human engineer does not see the design of a component until it is so far along that major changes become very costly. As explained by E. E. Herman of Hughes Aircraft:

> Sometimes a particular project head, or in some cases a whole organization, fails to recognize the importance of human factors until after a design is in the field and is proven inoperable. Then the human engineer is brought in to convert a bastard system into usable gear without significant change—something we have heard many times. The restrictions here are obvious. Extreme compromises must be made to keep the hardware changes to a minimum. Inevitably, additional design effort is incurred, the engineer's mistakes are highlighted, and the final result is a mediocre solution for everyone concerned.[3]

In some cases human-engineering design recommendations do not find their way into the final product for another reason: a degree of unacceptance of the human engineer by industry. An explanation often given for such unacceptance is that the human engineer lacks operational experience. This complaint may take one, or both, of two forms. One is that the human engineer does not understand the operating environment, or that the real situation is much different from that simulated in the laboratory. Unfortunately the human engineer often does not have sufficient operational experience for this contention to be denied. The question may then be raised as to his competency to make the decisions that confront him.

The other form of criticism is the design engineer's insistence that the human engineer does not appreciate the magnitude or complexity of the electronic design which would be necessary to provide the output, control, or panel desired by him. This situation is most prevalent where the human engineer is almost completely psychologist (or other life scientist) and the designer is all engineer. The middle ground, the common language or common area of understanding, is missing. Without such a conductor between the two, intelligent communication is virtually impossible.

Another factor inhibiting the progress of the human engineer in eliminating error has been his characteristic penchant for concentrating on endeavors with relatively minor payoff. He has been prone to work with such matters as optimizing control handle shapes, overoptimizing control panel arrangements, or refining procedures down to the last detail. But the majority of the benefits of human engineering will accrue during early design studies, granting that some follow-up is needed as the design progresses. As more and more time is spent on a single design problem, the "goodness" of the design increases less and less per unit of time. At the extreme, the effort going into a design is virtually unrewarded. In this respect it is necessary that the human engineer attack problems beyond those of routine design. A greater portion of his time must be devoted to such basics as mission analysis, decision functions, and preliminary equipment design.

equipment familiarization

A second factor leading to human error is insufficient training and experience with complex electronic equipment. A study conducted by the U.S. Navy points up this deficiency.[4] Over 1200 errors in test-instrument operation were observed and recorded. Of these, 8 per cent were described as "accidental"—the operator's hand struck a control, another man brushed against the controls, settings shifted when the instrument was moved, and the like. The remaining 92 per cent were classed as errors resulting from inadequate familiarization with the instruments. Directly contributing to confusion were the improper design of the control panel, lack of standardization in controls, and poor functional design of the equipment. This study points up the interaction of several factors in producing a situation with high potential for errors.

To a large degree the operator's lack of knowledge of his equipment can be traced to the tremendous increase in complexity of modern devices. Training methods used on older and less complicated equipment have become ineffective. Perhaps more important, the number of people who are capable of absorbing and retaining the necessary information gradually diminishes as the level of complexity rises. The severe shortage of apt recruits was pointed out by an Air Force technical report issued in 1959 concerning personnel problems in technical specialties related to missile operation.

> Missile and manned aircraft systems are creating a demand for skilled technicians that is far in excess of the number of available men who can be trained to satisfy that demand. . . . The crucial facts are that (a) only 15 percent of the 85,000 men entering the Air Force each year are qualified by present aptitude standards for training in advanced electronic and mechanical specialties, and (b) almost half of these are among the uppermost (brightest) nine percent. In other

> words, to meet its requirements for such specialties as missile systems analyst or electronic maintenance technician the Air Force must draw upon a limited supply of highly intelligent people who are also in demand for other specialties.[5]

The report further indicates that about 95 per cent of the men in the ground support crews of present-day missile systems must be relatively highly skilled. Only 77 per cent of conventional aircraft ground support personnel need be at that level of skill. In the manning of ballistic missile systems over 50 per cent of the airmen are required to have electronic aptitude indexes of 80 or higher out of a possible 100.

With such a situation prevailing, several trends may develop. First, there is the inevitable tendency to overload those people who are qualified and well trained. This means that one man must assume the technical responsibilities of two or more men. Up to a point such an arrangement may work out more or less satisfactorily. Beyond, it may well be the cause of a disastrous error. Second, personnel with less than the required native aptitude may eventually be rated as qualified in highly technical jobs. This rating may result from routine advancements within the organization or from a critical requirement existing when only men of lower aptitude are available to fill it. The result in either case is personnel operating and maintaining complex missile equipment who may have insufficient knowledge, training, or familiarity regarding their equipment.

data feedback

If it can now be accepted that a major portion of human-initiated failures accrue from faulty equipment design and lack of adequate training or familiarization with the equipment, the question is what can be done about it. Unfortunately the question has gone largely unanswered in the past because of a third and possibly equally provoking situation, the lack of an adequate data-feedback system.

Frequently one of the primary difficulties in correcting a situation is the inability to discover what the problems are. In other words, a systematic method is necessary for identifying problem areas. Once they are identified, the information may be fed back to the designers and research and development people. Action may then be taken to correct the situation or at least to ensure that a similar deficiency is not designed into future equipment.

Such a procedure is commonly known as a data-feedback system. It was for precisely this purpose that the Unsatisfactory Report, Malfunction Report, and Unscheduled Hold Report were designed and implemented. Unfortunately these reports were not set up for the purpose of identifying human-initiated malfunctions, and they are therefore largely useless for that purpose. This is not to say that these reports

shortage of people with sufficient understanding of both engineering and life sciences to provide effective human-engineering input into new systems. Second, they would inculcate the "middle ground," the all-important common language, which is so necessary for adequate communication between the life scientist and the engineer. Communication would reduce the difficulties wherein the life scientist does not understand the engineering implications of his design recommendations. Third, the dangers of belated input and of other practices and policies that compromise equipment design will be emphasized. Fourth, once the true discipline of human engineering is taught by the universities of the country, a greater awareness of its possibilities would ensue among managers and commanders. This awareness in turn would lead to a greater emphasis within industry and the Air Force on developing equipment with the least possible potential for human error.

Within the civilian community the responsibility for initiating a drive for expanded educational offerings in human engineering could be assumed by the many professional societies, which together form a powerful force. Such organizations as the Society of Automotive Engineers, the American Medical Association, the American Society of Mechanical Engineers, the American Psychological Association, and the American Rocket Society could provide the impetus needed to bring the requirement for a human-engineering curriculum to fulfillment in universities and colleges. They could assist in setting up courses, requirements, and prerequisites. Air University, through its close association with civilian institutions, could also provide a motivating force to colleges and universities for setting up the needed curriculum.

In the military, Air University should lead the way. Close cooperation with the Air Force Systems Command, the Air Training Command, and the operating commands, especially the Strategic Air Command, is necessary. The present course in human factors offered by the Institute of Technology is not adequate to provide the required training for enough people. For the 1961-62 school year only ten master of science and two Ph.D. level openings are available.

• Once the supply of qualified human engineers begins to catch up with requirements, a greater number of such personnel should be assigned to operational organizations. The present practice is to assign the great majority to the laboratories and development centers of the Air Force Systems Command. Certainly human-engineering people are needed to develop concepts and work with contractors who are designing and fabricating Air Force equipment. It is also necessary to provide using organizations with the ability to isolate and define critical problem areas in an operational environment *before* the organization suffers a disaster caused by error-provoking design features. In brief, human-engineering experts assigned to operating units would be responsible for (a) inspecting all equipment, procedures, and practices in as much detail as possible to isolate and correct error-provoking features, (b) ensuring that the human error involved in a failure would be adequately documented, (c) disseminating reports to other units so that preventive action might be taken to preclude a similar occurrence, (d) forwarding reports to development organizations for any possible corrective action, and (e) ensuring that a similar design deficiency does not exist in other equipment within the organization.

• Proficiency or incentive pay to personnel having high electronic-aptitude indexes and working in a critical technical area should be greatly increased in amount and expanded as to application. Although the future may hold promise for improved equipment design, thus reducing the probability of an inadequately trained individual making an error, the problem of the scarcity of high-electronic-aptitude personnel may be with us for some time. Thus the need for an incentive in the form of extra pay. Such pay would be based on proven abilities as determined by oral and written tests and on periodic demonstration of efficiency in operating the equipment under high stress. All efforts presently being made by the Air Force to attract and retain highly qualified technicians should be intensified and expanded.

• To counteract the inadequate data on sources of human error or potential human error, a new but short and simple report should be initiated for use in all operating organizations and test units—everywhere, in fact, that missile system equipment is in use. An intensive educational effort would indoctrinate the personnel to be associated with the data collection and the preparation and transmission of the report. The importance and necessity of the report would be emphasized.

Two points of caution should be noted here. It should be mandatory that personal blame, or the identification of individuals involved in a human-initiated failure, *not* be included in a written report. In addition, such reports should never be used for rating an organization's effectiveness or as a basis for investigation or for administrative action, other than that normally associated with determining accident or failure causes. The success of a reporting system involving the individual is dependent upon the cooperation of all persons associated with an operation. Punitive or unusual administrative action taken against those who submit the reports or are involved in the reported action will soon stifle completely all efforts to obtain accurate information.

• During development testing great emphasis should be directed toward isolating the faulty human element as well as the substandard hardware component. In view of the obvious necessity for R&D testing to determine substandard equipment performance, it would be advantageous to use a similar testing procedure to obtain data on a system's human inadequacies. This would entail not a distinct and separate test procedure but rather a procedure that can be integrated into current test programs. A test procedure similar to that suggested by Shapero,[9] coupled with an adequate data-feedback system, would contribute greatly to the present body of information on the subject of human-initiated malfunctions. And the more information made available to designers and developers, the sooner the human cause of malfunctions will be minimized.

Space Systems Division, AFSC

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9. P. 23.

Recovering the Astronaut

Brigadier General Joseph A. Cunningham

THE United States program for putting a man into orbit around the earth is one of the most thoroughly planned and widely supported ventures in the history of science. It calls for many specialized techniques and for assistance from any branch of the Government possessing services or facilities that will contribute to the success or safety of the epochal flight.

Almost equaling the drama of launching the big rocket that will boost the astronaut aloft and into orbit is the drama of recovering the astronaut and his space capsule after he parachutes down to the earth's surface. If all goes according to plan, the landing will occur in a preplanned area of the Atlantic Ocean and the pickup will be made by Navy units prepositioned in the area.

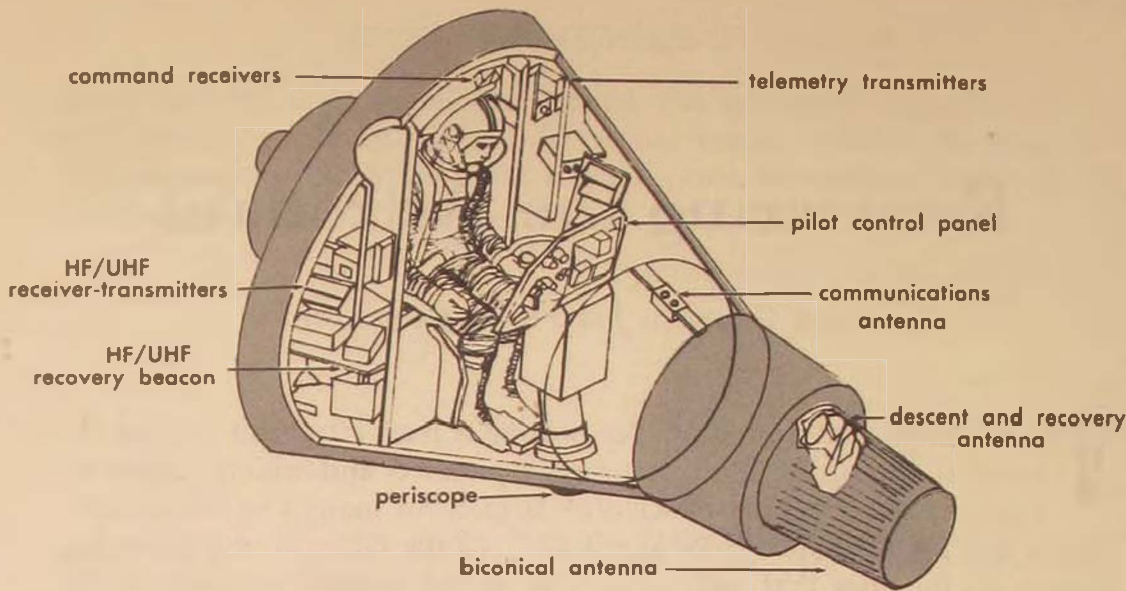
Planning must also provide for the emergency or malfunction that might cause the astronaut to descend elsewhere along his globe-girdling flight path. To accomplish a prompt recovery in case of such a contingency landing, the Air Rescue Service has been brought into Project Mercury.

Preliminary to an account of the plans, equipment, and techniques that the Air Rescue Service has developed to carry out this crucial assignment as a part of Air Force support of Project Mercury, some data may be useful concerning the general background of the project and the plans for the orbital flight.

Project Mercury

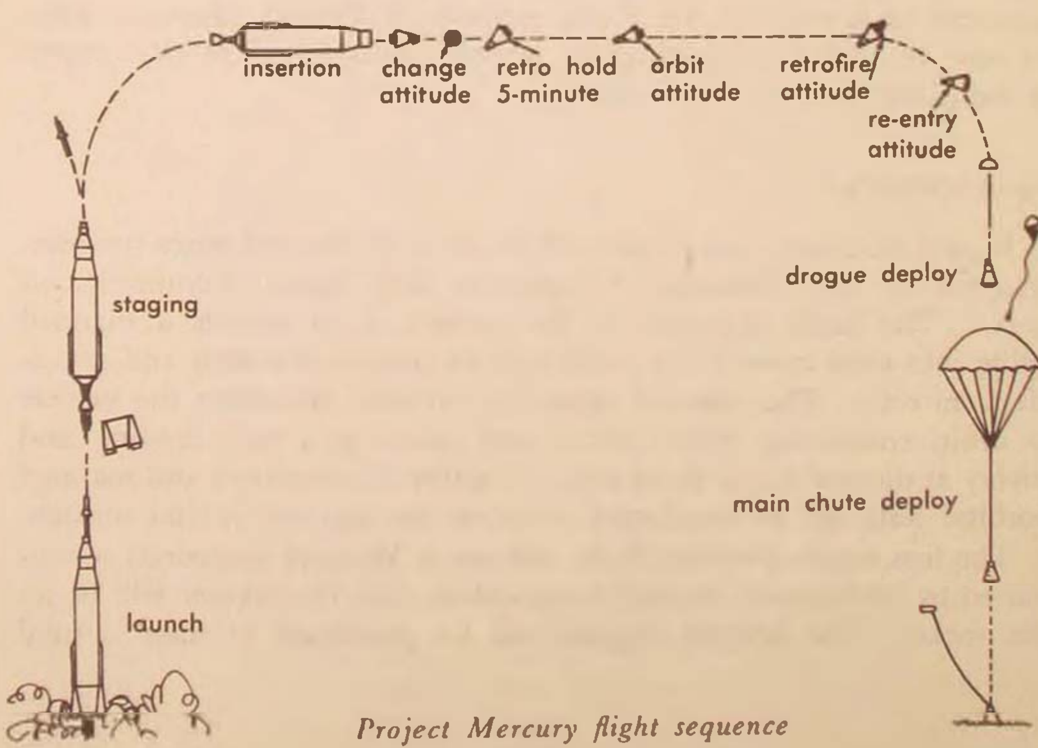
Project Mercury is an element of the civilian-directed space program conducted by the National Aeronautics and Space Administration (NASA). The basic objective of the project is to launch a manned satellite into orbit around the earth and to recover the man and spacecraft from orbit. The planned operation involves launching the vehicle into orbit, completing three orbits, and effecting a safe landing and recovery at the end of the third orbit. A series of unmanned and manned suborbital tests will be conducted prior to the manned orbital mission.

The first manned orbital flight will use a Mercury spacecraft manufactured by McDonnell Aircraft Corporation, and the booster will be an Atlas rocket. The booster engines will be jettisoned at their normal



Mercury capsule in orbit attitude

staging time, and shortly afterward the ground escape system will be jettisoned. Powered flight will continue under the thrust of a sustainer engine until conditions of velocity and attitude for orbital insertion are attained. At that time the capsule will be inserted into orbit at an altitude of about 80–100 miles, at a distance of 450 miles east of the launch site, Cape Canaveral, Florida. The capsule will orbit the earth in approximately 90 minutes, repeating until the retrorockets are fired during the third circuit to take it out of orbit and bring it back to earth. To effect a landing in the planned area of the Atlantic Ocean east of Grand Turk Island, the retrorockets will be fired about 400 miles west of Los Angeles, California, some 3300 miles from the landing site.



Project Mercury flight sequence

The flight azimuth of 74 degrees true will give the capsule an orbit inclination of approximately 32.5 degrees. The resultant ground track enables use of the existing ground range facilities in Bermuda, in Woomera, Australia, and in southern United States for all three orbits. The track also allows use of the stations in Hawaii and Johannesburg, South Africa, for ground range facilities on the second and third orbits. All the orbits pass across the continental United States and elsewhere only over friendly territory. Landing is planned for a water area. If there is an emergency, every effort will be made to land the capsule in the water. While Air Rescue Service planning is guided by this premise, land recovery from the North American and African continents has also been considered.

NASA requested Department of Defense (DOD) assistance in support of Project Mercury. This support would include not only the use of DOD facilities and forces that might assist Mercury but also the execution of specific assigned support missions. The Commander, Air Force Missile Test Center, Patrick AFB, Florida, was designated the DOD representative for Project Mercury support operations. The Commanding Officer, Naval Ordnance Test Unit, AFMTC, was designated as Naval Deputy for Mercury recovery operations and Navy support.

Recovery functions in the Atlantic Ocean will be performed by the Commander in Chief, Atlantic (CINCLANT), who has designated the Commander, Destroyer Flotilla Four, his agent to execute this task. Task Force 140 has been established in the Atlantic Fleet and is designated the Project Mercury Recovery Force for the Atlantic Command area. Recovery in all other areas will be planned by the Search and Rescue (SAR) Regional Coordinators. United States unified and specified commanders have been directed to support Mercury within their capabilities. The over-all DOD plan specifies the following recovery forces:

- The Commander in Chief, Atlantic is responsible for formulating recovery plans and conducting recovery operations with assigned forces in predetermined landing areas. Notification of appropriate SAR Regional Coordinators to execute previously established SAR procedures to meet NASA recovery requirements should landing occur outside the Atlantic Command area will be the responsibility of the Commander, Task Force 140.

- The Atlantic Missile Range and the Air Rescue Service are responsible for assisting in recovery planning as may be requested by CINCLANT or his designated representative and for providing rescue services as outlined in approved recovery plans.

- Appropriate SAR Regional Coordinators are responsible for conducting recovery operations as required in their areas of responsibility.

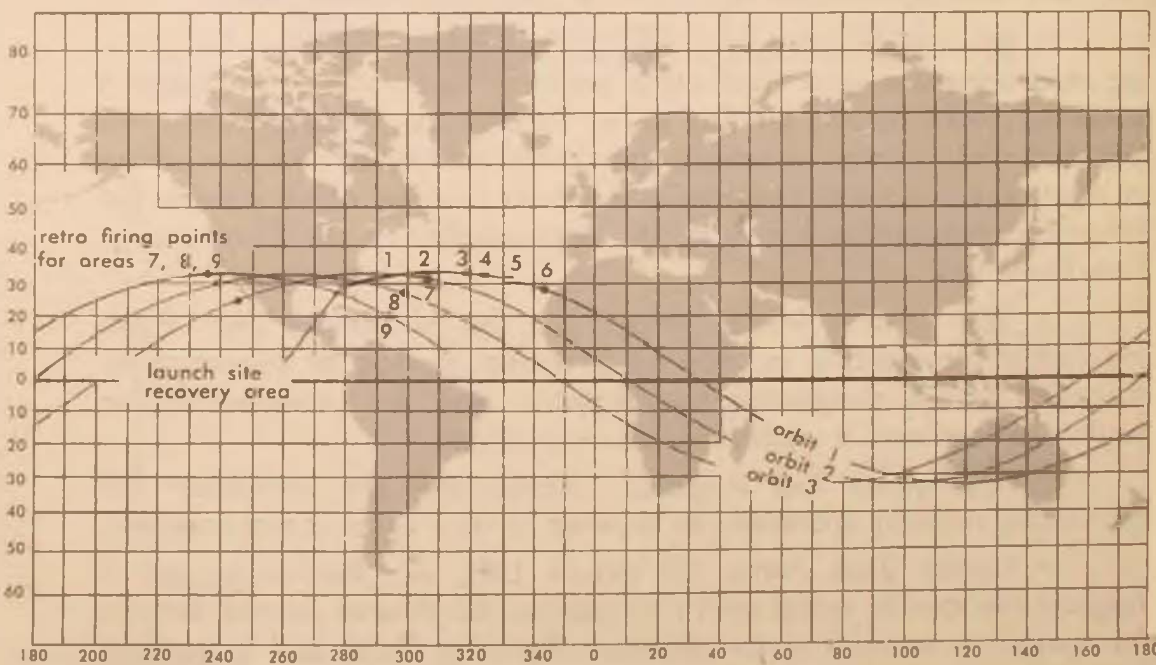
- In the Task Force 140 OPLAN 1-61, Air Rescue Service is assigned the specific responsibility to provide Air Rescue Service aircraft for operations as units of the Mercury Recovery Force and to respond to requests for participation in contingency recovery operations in areas other than the high-probability landing area.

planned recovery

There are nine planned probable landing areas in the Atlantic Ocean, each for a portion of the flight should an emergency develop during that phase. The plans of Task Force 140 for recovery of the capsule and its occupant are focused on these NASA specified areas and are defined as "planned recovery." Should an unsatisfactory condition develop during launch, including improper conditions at orbital insertion, the mission will be aborted and landing will be within areas 1 through 6. If the orbital parameters at insertion are satisfactory and if the capsule and astronaut are functioning properly, the capsule will be permitted to continue in orbital flight. In case of a "no-go" decision at insertion, the abort procedures will be such that landing will be in area 5 or 6. In case of a "go" decision at insertion, the capsule is committed to the completion of at least one orbit before it can land in a planned area. Planned recovery areas 7 through 9 afford the capability to abort or terminate the mission once each orbit. After passing the retrofiring point for area 6, approximately 70 minutes of orbital flight time is required to reach the retrofiring point for area 7. Approximately 90 minutes of flight time elapses in progressing from retrofiring point 7 to 8 and 8 to 9.

In addition to the nine numbered areas, a launch-site recovery area was designated around the launch pad in case of an abort during

Planned recovery areas



the final countdown or early in the boost phase. The launch-site recovery forces will have the capability of effecting recovery for a capsule landing on land or in shallow water. NASA has specified a time limit for recovery from each of these areas.

When re-entry occurs, the NASA operations director will be able to provide Task Force 140 with a predicted location and time of landing. In the planned landing areas, the capability of the Mercury network tracking and computing facilities will provide a landing-point estimate, called a datum, with an error of less than 100 miles. If the capsule lands in other than the high-probability areas, a completely random impact area is not likely. It is estimated that the landing will occur at a point close to the nominal track of the capsule and that the NASA estimated datum will be accurate within about 100 nautical miles along the ground track and about 25 nautical miles on either side.

contingency recovery

Recovery operations conducted in areas other than the planned landing areas are referred to as "contingency recovery." Although Task Force 140 recovery plans are focused on the NASA specified areas, provision will be made for contingency operations. If contingency recovery is necessary in the Atlantic, operations will be conducted in accordance with the Task Force 140 Contingency Recovery Plan for the Atlantic Command. For recovery operations in all other areas, Task Force 140 will effect smooth and rapid transition of operations to the control of the responsible area commander.

Backup systems have been provided for all the basic capsule systems. Although the probability of a malfunction that would cause a contingency landing is considered remote, contingency operations nonetheless must be considered. The possible causes of a contingency landing can be generalized into two broad categories: factors wherein the mission is aborted because of failure to achieve a satisfactory orbit, and factors arising after a satisfactory orbit is achieved.

In the event of an abort during the powered flight and insertion phase, a contingency landing could result from one of the following: (1) a procedural error in firing the retrorockets; (2) a retrorocket system malfunction; (3) an extreme overvelocity at orbit insertion. The overvelocity condition would occur if the Atlas booster failed to cut off at the proper time. Overvelocity could result in an elliptical orbit of fairly high apogee, with possible exposure in the earth's radiation belts; it then may be desirable to terminate the mission after one orbit.

Once a satisfactory orbit is achieved, the following situations could result in a contingency landing: (1) retrorocket sequence initiated improperly; (2) retrorocket sequence initiated properly followed by some system malfunction; (3) uncontrolled emergency, immediate re-entry required; (4) controlled emergency, short-time re-entry required. Any of the first three factors would result in a landing at some random point along the flight ground track. The fourth would afford some selectivity of landing points. NASA has designated a number of contingency recovery areas as preferred and has developed procedures for landing in them, if such a landing is required and feasible. In designating preferred contingency recovery areas, NASA considered water landing areas with good operational accessibility.

*Capsule Location Aids.** Contingency recovery planning must consider what information will be available after the landing. The capability to determine that a contingency landing has occurred and to fix the capsule's position is made possible by a world-wide network of range stations specially instrumented in support of Mercury. Additional capabilities to define the capsule position by electronic and acoustic signals could be provided in many areas by ground radio direction-finding and underwater sound listening stations. Also the capsule is an active target which will be radiating signals from re-entry until after landing, to aid homing on its position.

After re-entry the capsule will free-fall until the drogue parachute is deployed at approximately 20,000 feet. Upon main parachute deployment at 10,000 feet, one of the two sound fixing and ranging (Sofar) bombs will be jettisoned, set to detonate at a water depth of 3500 feet. The other one pound of explosive will remain on board the capsule to serve as a means of notification should the capsule sink. This second Sofar bomb will be set for a depth of 4000 feet under water. By measuring the time of arrival of sound from this source at several listening stations, a position fix can be made. This Sofar fix will not be available to the recovery forces until approximately two hours after the landing.

During main parachute deployment the Sarah beacons will begin transmitting. These beacons are small, battery-operated radio transmitters with folding spring-steel antennas. Two beacons are used, for increased reliability. The beacons transmit a pulsed, coded signal. Originally six ARS aircraft were equipped with Sarah receivers. Eventually all ARS aircraft were equipped with International Telephone & Telegraph Company (ITT) homing receivers capable of receiving signals from the Sarah beacons. Expected lifetime of the beacon is 24 hours, and detection range is line-of-sight.

The HF Seasave beacon is a lightweight rescue beacon transmitting a continuous wave signal on the high-frequency international distress frequency. A network of land-based stations operated by the Federal Communications Commission, the U.S. Navy, and some foreign stations as members of the International Telecommunications Union can obtain bearings on the HF Seasave beacon. In field tests of the beacon, ranges of 1200 nautical miles were realized at all times of the day and 2200 nautical miles at selected hours of the night. The minimum lifetime of the Seasave beacon is 24 hours.

*Location aids may be changed in accord with the results of successive tests.

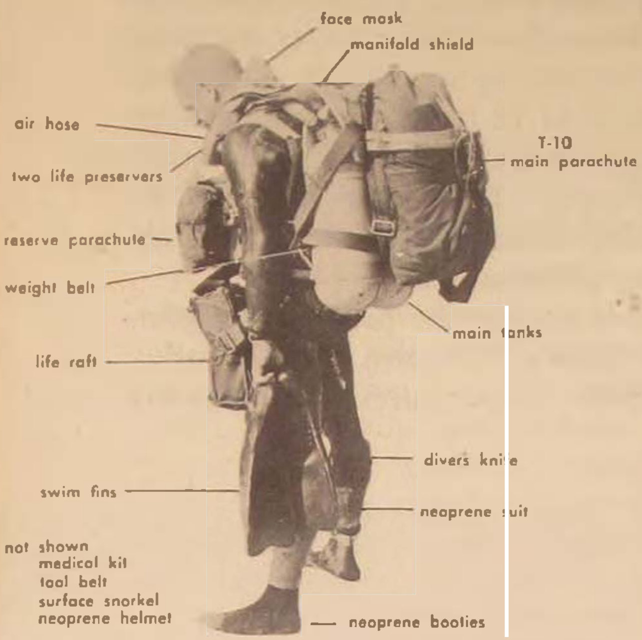
Visual aids consist of sea marker dye and a flashing light. Aluminum powder or fluorescine dye marker will be used, either of which is visible at a distance of 5 to 20 nautical miles, depending upon light conditions. Lifetime of the dye markers varies from 4 to 12 hours, depending upon the sea state. The flashing light will operate for 24 hours and is visible at distances up to 20 nautical miles at night. The flashing rate will be one pulse every two seconds with a pulse duration of two milliseconds. The intensity of the light is two million lumen-seconds.

At launch, the capsule will have two colors: the pressure compartment will be black, and the top will have a reflective metallic color. During re-entry, high heating rates and temperatures will turn the capsule into an annealed blue color.

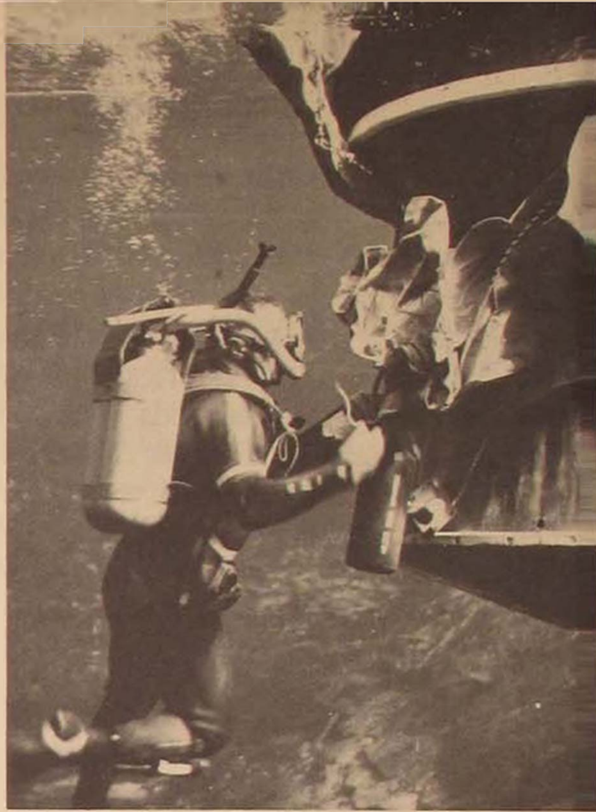
Capsule Location Aids

Type	Aid	Freq MC	Direction-Finding Receiving Equipment	Minimum Expected Life, Hrs.	Operational Range, NM	Remarks
electronic	UHF Sarah	243	Sarah receiver ECM	24	35	
	UHF Super Sarah	243	Sarah receiver ECM	24	60	
	Survival kit UHF Sarah	243	Sarah receiver ECM	24	35	with voice capability operated by astronaut after egress
	High-power UHF transceiver	approx. 300	ARA-25 ECM; voice transmissions received on any UHF receiver	12 hours or until battery depletion	80 ?	only one used at a time
	Low-power UHF transceiver	approx. 300	ARA-25 ECM; voice transmissions received on any UHF receiver		60 ?	D/F capability lost if listening on UHF or using HF
	HF Seasave	8.364	land-based D/F network (FCC & Navy)	24	1200 (all times) 2200 (selected times)	
	HF Transceiver	----	no D/F capability voice on any HF receiver	12 hours or until battery depletion	?	voice only
acoustic	Sofar bomb	....	MILS network	....	within network charted areas	depth setting—3500 ft (fixed Sofar set for 4000 ft)
visual	Sea marker	....	visual search	4-12 dependent on sea state	5-20 dependent on light conditions	either aluminum powder or fluorescine dye
	Flashing light	....	visual search	24	20 ?	

Parascuba Rescue in Action



Parascuba rescueman with gear . . .



affixing Stullken collar to capsule . . .

recovery equipment

Two of the most important factors that predominated in Air Rescue's Mercury planning were the "Stullken collar" as a flotation device and parascuba rescue teams using self-contained underwater breathing apparatus (scuba). Both were adaptations of in-being equipment and techniques requiring only a small amount of funds to produce an operational capability after R&D and testing at the unit level. The two were combined to provide a rapid recovery method not only for contingency recovery but for quick recovery in the planned landing areas as well.

The Flotation Device. Initially the flotation device was called the "Stullken collar" after its inventor, Dr. Donald Stullken of the U.S. Navy. It was devised to fit around the Mercury capsule to provide flotation and stabilization after the capsule has landed. This device was incorporated into the ARS MA-1 sea rescue kit, and in this manner the flotation gear and sea survival equipment could be dropped at the scene of landing by conventional ARS techniques. A scuba-equipped pararescue team would then parachute to the capsule, attach the device, and render any assistance needed by the astronaut. The pararescue team also would ensure the safety of the capsule and well-being of the occupant until both were recovered by air or surface vehicle.

The prototype device was an F-2A 20-man life raft minus the boarding stations, with the rubber floor removed and replaced by an adjustable purse-string attachment. Three adjacent upper and lower

collar inflating, raising capsule . . .

capsule raised, awaiting pickup.

cells of the raft were removed to obtain the proper size, and the raw ends were sealed to remain airtight. In use it was streamed around the capsule and the two ends fastened together. Tension was taken up on the cable with a hand crank and the device inflated. The cable firmly ensnared the bottom of the capsule, and the inflated device raised the capsule approximately 8 to 10 inches. The device was expected to provide a sufficiently stable base to prevent the capsule from capsizing in any wind and wave conditions short of a hurricane.

Extensive tests and modifications to the flotation gear resulted in its being constructed as a basic unit, rather than modifying a 20-man raft. Also during these tests it was found more feasible to drop the pararescue team first and then drop the flotation gear by itself. Greater accuracy in the delivery was achieved and the time element between the equipment drop and its installation to the capsule was appreciably reduced. After the capsule's stability and flotation were ensured the MA-1 kit could be dropped.

The capsule has two hatches, one on top and one at the side. To use the top exit, the astronaut has to relocate equipment within the capsule to make a passageway from his in-flight station to the top of the vehicle. Escape by this route takes approximately five minutes and requires near normal physical and mental condition of the occupant and no deformation to the capsule or malfunction of its system. In a top exit the astronaut's weight raises the capsule's center of gravity enough above the point of buoyancy to capsize the capsule. The other hatch is released by explosive means and offers the most direct escape route from the capsule. When the capsule is afloat, there is only about four inches of freeboard between the waterline and the bottom edge of the side hatch. The capsule will ship water through the open side hatch and sink in eight or ten seconds. This was the case in the Liberty Bell 7 operation. The flotation device overcomes both these problems.

Scuba. Our initial trials in November 1958 to test the performance of regular pararescue teams when dropped to aid survivors in the open sea pointed up the necessity to equip them differently for water operations.

During 1959 and 1960 the 76th Air Rescue Squadron tested various types of skin-diving and scuba-diving equipment. They ultimately chose the "wet suit" and scuba used by the Navy's underwater demolition teams, better known as "frogmen." The initial tests were made with flying suits, mae wests, and tennis shoes. The jumpers added swim fins and face masks, which increased mobility; however, the mae west and flying suit slowed their progress in water. The Navy "dry" type exposure suit was tested. While it was an improvement over the flying fatigues, it tore too easily. Discussion with Navy divers convinced the jumpers that the neoprene "wet suit" would be the better choice.

Although the pararescuemen learned to make forward progress in their improvised gear, scuba seemed to be the answer; it would enable them to swim under the surface, moving quickly and directly to their target. A scuba unit was bought, tested, and incorporated into the kit.

The first trial air tank was a modified 38-cubic-foot (at 1800 psi) CO_2 bottle from the base fire department. Pararescuemen successfully test-jumped wearing scuba equipment under their parachute harness. But the relatively large size of the air tank caused Wright Air Development Division to disapprove jumping with the tank under the parachute harness because it changed the stresses on the harness.

The pararescue section of the 48th Air Rescue Squadron developed an air-tank system which could be jumped under the harness. The air tanks consisted of two modified CO_2 bottles taken from a 20-man life raft, 39 cubic feet (at 2100 psi) per bottle. Although longer than the fire bottles, these tanks were smaller in circumference.

The Parachute. A qualitative operational requirement for a new parachute was submitted to Military Air Transport Service in June 1960 because of the operational limitations and deficiencies in the MT-1 parachute. New concepts for operational employment of pararescue teams in support of aerospace recovery operations also required the development of a parachute with substantially greater performance capabilities than the MT-1. The MT-1 parachute has marginal performance capabilities as a vehicle to deliver pararescue team members to the site of any incident. It is not capable of delivering a parascuba rescueman and his essential equipment when pararescue teams are deployed in support of Project Mercury and similar follow-on programs requiring medical, survival, and recovery assistance.

The T-10 parachute has been substituted as an interim replacement for the MT-1, and testing is under way on a pararescue personnel parachute with the following characteristics:

- low opening shock
- slow rate of descent (equal to the MT-1)
- inherent stability and steerability for positive directional control to permit "spot" jumping
- jumping permissible with a variety of accessory items
- reliable operation at airspeeds from 50 to 130 knots
- reliable operation from 800-foot altitude
- incorporation of slip risers
- basic design to include a flexible, easily adjusted nylon harness with D rings for emergency chest parachute (reserve) attachment, and two canopy releases for complete canopy jettison
- a nylon pack tray for salt-water landings
- parachute packing and maintenance to require fewer man-hours than required for the MT-1.

parascuba rescue training

The original concept of parascuba was for personnel recovery. Its usefulness to recover Discoverer re-entry vehicles during contingency operations soon became apparent. Since the Discoverer nose cone is not expected to float indefinitely, it was possible that when it was located there would not be sufficient time left to vector a surface vessel to the scene. The 76th Air Rescue Squadron therefore planned to jump a parascuba-equipped team into the ocean to recover the nose cone and place it in a life raft until it could be hauled aboard a recovery vehicle.

When Air Rescue Service became a primary agency in contingency recovery operations for Project Mercury, scuba training for all pararescuemen took on the characteristics of a crash program. Air Rescue requested and received quotas for the Navy Underwater Swimmers Schools at Key West, Florida, and Pearl Harbor, Hawaii. The first class at Key West graduated 13 scuba-qualified pararescuemen on 23 September 1960. A class was conducted at Pearl Harbor from 4 January to 10 February 1961, qualifying almost all the pararescuemen in the Far East. It is planned that in future all pararescuemen will receive their scuba training at Key West.

This, then, is the status of our preparations for contingency recovery of man and capsule in the future Project Mercury orbital flights. We feel confident that by the time the flights take place the Air Rescue Service will be fully equipped and trained for this new phase of air rescue. Nor is this the only purpose for which this equipment and the related techniques can be used. It gives us an added capability for open-sea rescue of aircraft crews, shipwreck victims, etc. Already the system has been used to recover the data capsule of Discoverer XXV, which impacted in the Pacific Ocean on 18 June 1961 some 200 miles north of its planned landing area and which would have sunk and been lost before it could have been recovered by other means. Air Rescue Service thus moves forward with the space age.

Headquarters Air Rescue Service

Basic Reliability Concepts

Captain Ed L. Battle

A FEW years ago Air Force equipment was judged by its performance capabilities, for example, the speed and service ceiling of an aircraft. Then came the weapon system approach, under which an aircraft and all equipment required to service, support, and maintain it were developed simultaneously. The performance characteristics of the aircraft alone were no longer adequate to measure its worth as a weapon. A high degree of over-all mission efficiency was demanded. This high efficiency was achieved by an evolutionary process of constant improvement.

The advent of missiles has outmoded this philosophy of "fly and fix." To maintain a modern, ready-striking force it is necessary to reduce the time spread between design and the highly reliable operational stage, to curtail the maintenance hours required to keep the missile in commission, and to drastically reduce "holds" and mission aborts. Hence the comparatively recent emphasis on reliability.

Reliability is the probability that a system will perform a required function under specified conditions, without failure, for a specified period of time.* Since it is therefore a vital constituent of a deterrence capability, it is vastly important to the Air Force mission. In consequence more and more Air Force personnel will be called upon to contribute, in some way, to its achievement. This discussion is designed to acquaint interested persons with some of the terminology and the mathematical tools used in the reliability field. It is intended for the beginner, as many very excellent articles are available on the professional level but few on the introductory level.

failure rates

From the standpoint of reliability, equipment is commonly discussed in terms of its failure rate. If, for example, a given type of equipment were found, during tests, to average one failure per 100 hours of operation, the failure rate, f, would be 0.01 per hour. The accuracy of this figure can be verified by multiplying it by the 100 hours of operation to obtain one failure, which is correct. In 200 item-hours of operation, two failures would be expected, etc. An item-hour is one article of

* From AFR 375-5.

equipment operating for one hour. Thus ten articles of equipment operating simultaneously would produce ten item-hours of test time each hour of real time. The failure rate can always be obtained by dividing one by the mean (or average) time to failure (MTTF). This relationship can be expressed symbolically:

$$f = 1/\text{MTTF} \quad (1)$$

If a large number of items were tested, some obviously would operate longer than others, since it is physically impossible to manufacture identical parts. One way to present this type of test data is to subdivide the operating time into classes and plot the number of items failing in each of the classes. Suppose, for example, 100 items were placed on test to determine the total life or wear-out time for this equipment, and the *first* failure occurred after 40 hours of operation, while some units operated as long as 200 hours before failing. The optimum number of classes would be eight for this case.* Hence each class would be 160 hours divided by 8, or 20 hours. The plotted results would resemble Figure 1. The total height of all the bars is 100 because

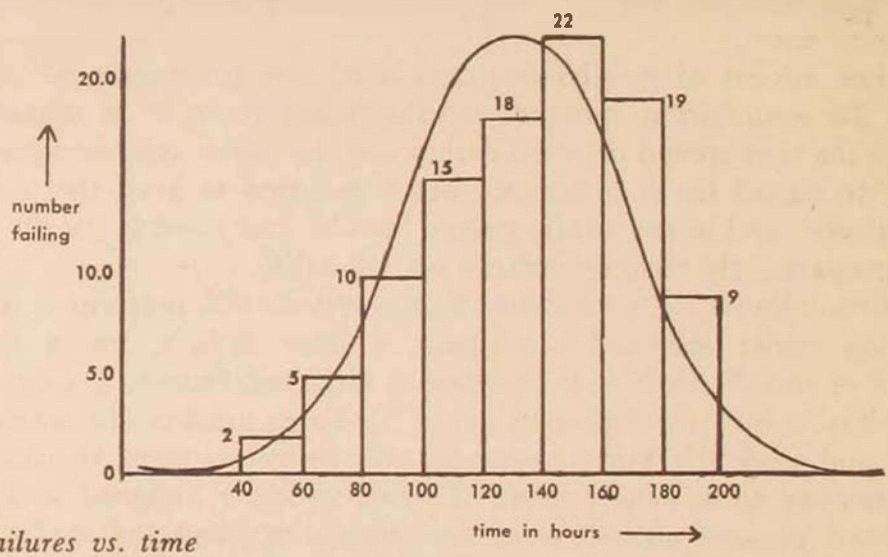


Figure 1. Failures vs. time

that is the total number of items tested. Presentations of this type, using rectangular bars, are called histograms. For wear-out failures of typical Air Force equipment the distribution would approach Gaussian as the number tested became greater. The Gaussian curve corresponding to the given test data was computed and is plotted in Figure 1. Note that the data are fairly close to Gaussian, based on only 100 samples. If 1000 items had been tested, the histogram would have been almost a perfect fit to the Gaussian curve.

A Gaussian distribution is characterized by the familiar bell-shaped curve. For example, the number of 35-year-old males with teeth num-

*From Sturges rule: $C = 1 + 3.3 \log N$, where C is the number of classes and N is the number of items tested (sample size). Thus in the example: $C = 1 + 3.3 \log 100$, or $C = 7.6$, which is rounded off to 8.

bering 5 or fewer, 6 to 10, 11 to 15, etc., would probably show a Gaussian distribution, because a homogeneous sample selected at random is represented. If the sample were heterogeneous (e.g., 15-year-olds examined along with the 35-year-olds), the result would be two Gaussian curves as shown in Figure 2. The multiple peaks are an indication of a heterogeneous sample.

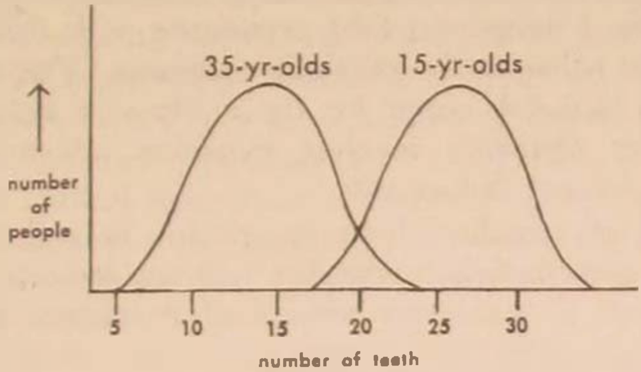


Figure 2. Heterogeneous sample

the bath-tub curve

This question of homogeneity raises an interesting point. If a very large group (universe) of a certain type of equipment was tested by selecting samples at random and correcting the cause of failure each time a failure was encountered, the "universe" would soon be extremely heterogeneous. If this process was carried further and the entire universe was modified to remove the discrepancies revealed by failures during tests, the result would be typical of a developmental program. The characteristics of the entire equipment universe would be changing with time. Tests of this nature have established that, typically, the results would be as shown in Figure 3, where failure rate f is plotted versus operating time t in item-hours.

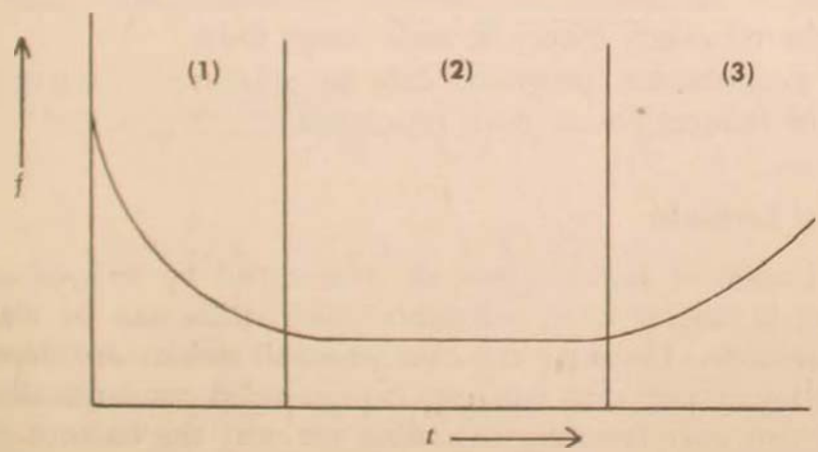


Figure 3. Failure rate vs. time

This curve, often called the bath-tub curve, reveals that the equipment fails very often when it is new, fails very seldom after the weak points have been corrected, and finally, again fails often. For convenience in discussion, this curve has been divided into three regions. Region 1 is called the "debugging" portion. The flat portion of the curve, region 2, is referred to as the Poisson portion, or simply the constant-failure-rate portion. The area of increasing failure rate, region 3, is termed the wear-out portion of the curve. If such a curve could be established only from field experience with the equipment, it would be of little value to the reliability engineer. The problem, then, is to establish a bath-tub curve for the equipment before it becomes operational. This obviously involves extensive laboratory testing to establish the equipment failure rate.

If the tests are conducted on equipment in region 1, they will reveal the instantaneous failure rate but will not indicate future failure rates. Several tests at successive periods of development will indicate failure-rate trends but will not determine the value or the time at which the failure-rate curve will flatten out. In short, if equipment is tested before it is debugged, i.e., before it reaches the Poisson portion of the operating curve, almost no conclusions can be drawn regarding the reliability of the equipment during its useful life. Although it is desirable to establish the beginning of region 3 so that maintenance and replacement may be scheduled to extend the useful life of the equipment, in no case would one want to operate equipment in this region. Region 2 is therefore indicated as the preferred operating region, by the process of elimination. Operation in this region of minimum failure rate, based upon determination of the limits of the region, is a continuing goal in the reliability program for the following reasons:

1. Considerable effort and expense are devoted to improving the equipment to the maximum extent possible in order to achieve the minimum failure rate.

2. When equipment is operated in the constant-failure-rate portion of the curve, failure rates determined early in the program are valid at a much later date. This minimizes testing.

3. Operation in the constant-failure-rate region is tacitly assumed in almost all of the reliability theory in wide usage today.

4. Orderly maintenance programs can be scheduled (determined) even though the failures are random (stochastic).

the exponential formula

The application of failure rates, as determined by tests of equipment operating in region 2, to reliability calculations can be clarified by use of an analogy. Consider the case where *P* dollars are deposited in a bank paying 3 per cent interest, compounded semiannually. At the end of the first year (two compounding periods) the balance would be $P(1 + 0.03/2)^2$. Suppose now that the interest was compounded monthly. The balance at the end of the year (after 12 compoundings) would be $P(1 + 0.03/12)^{12}$ dollars. If the interest was compounded so frequently as to be almost continually compounding, the value after n compoundings per year for k years would be $P(1 + 0.03/n)^{nk}$ where n would be enormous (approaching ∞) for each year.

The astute reader has already observed that compounding semi-annually is a big improvement over annual compounding but that compounding more frequently than quarterly leads to smaller and smaller improvements. In other words, a limit is approached. One may verify this mathematically, whereupon the similarity of the resulting expression and the Maclaurin series expansion of e^x, the exponential expansion of the base of the natural logarithms e, becomes apparent.* It therefore follows that the balance would approach e^{ik}, where i is the proportional increase per given unit of time (interest rate) and k is the number of units of time of interest (years).

This is analogous to the case where a failure rate f, in items failing per hour, has been operating continuously for t hours. The "interest rate" at that moment would be ft per cent. The fraction of equipment operating at any time t would therefore be e^{-ft} where the minus sign accounts for a decreasing balance in lieu of an increasing one as is usually the case in banking. Denoting the percentage of equipment operating by Ps, one can write the equation

$$Ps = e^{-ft} \tag{2}$$

where f is now the failure rate in items per hour and t is the operating time in item-hours; or if only one item is being operated, t is real time and Ps is the chance (or probability) that the item is still operating after t hours.

If a farmer were told that there was a 50 per cent probability that his group of N hens would lay tomorrow, he would logically expect to gather $N/2$ eggs the next day. Thus the probability of an event occurring is exactly the same as the percentage of events which occurs in a given

---

* $$\lim_{n\to\infty}\left(1+\frac{i}{n}\right)^{nk} = \left\{\lim_{n\to\infty}\left[1 + n\left(\frac{i}{n}\right) + \frac{n(n-1)}{2!}\left(\frac{i}{n}\right)^2 + \frac{n(n-1)(n-2)}{3!}\left(\frac{i}{n}\right)^3 + \ldots\right]\right\}^k$$

$$= \left\{1 + \frac{i}{1} + \frac{i^2}{2!} + \frac{i^3}{3!} + \sum_{j=4}^{\infty}\frac{i^j}{j!}\right\}^k$$

$$= e^{ik}$$

Compare the Maclaurin series expansion:

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \ldots$$

large number of trials. Equation 2 then expresses both the percentage of equipment operating and the probability of the equipment operating successfully.

It has been shown that a given type of equipment which is in the Poisson portion of its life curve (region 2, Fig. 3) has a probability of success, or reliability, of

$$Ps = e^{-ft}$$

for an operating time of t. Further, it has been noted that the failure rate f or mean time to failure MTTF can be determined by relatively short time tests and that this figure will be valid at any later time, prior to onset of wear-out. As an example, the reliability of an item of equipment with a failure rate of 0.001 per hour for a ten-hour mission would be:

$$Ps = e^{-(0.001)10} \simeq 0.99 \text{ or } 99\%$$

A plot of the reliability vs. mission time is called the exponential failure curve—the time between failures decreases exponentially with increasing time in use.

systems analysis

What if two or more components are combined to produce a larger unit of equipment? If the components have failure rates of f_1 and f_2

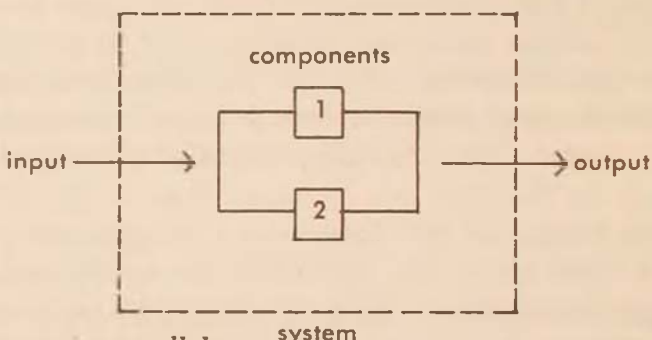


Figure 4. Components in parallel

respectively and failure of either one would cause the combined system to fail, then clearly the over-all failure rate is $f_1 + f_2$. Items so combined are said to be in series. It follows that the over-all system reliability, Ps, would be the product of the individual component reliabilities,* or

$$Ps = Ps_1 \, Ps_2$$

This is called the product rule.

If the components are combined in such a manner that the system fails only if both components fail, the reliability is only slightly more difficult to compute. Items so combined are said to be in parallel. A combination of this nature is shown in Figure 4. In the previous case

* $e^{-(f_1 + f_2)t} = e^{-f_1 t} e^{-f_2 t} = Ps_1 \, Ps_2$

the system operated only if both components operated, so the reliabilities of the components were multiplied together to give system reliability. In the case of parallel components where the system fails only if both components fail, the component unreliabilities are multiplied together to give system unreliability. Since reliabilities are identical to percentage of time operating and unreliability is identical to percentage of time not operating, it is clear that the reliability and the unreliability must add up to one (unity). Thus $1 - Ps_1$ is the unreliability of component number one, and $(1 - Ps_1)(1 - Ps_2)$ is the over-all unreliability. Subtracting this from one gives over-all system reliability, or

$$Ps = 1 - (1 - Ps_1)(1 - Ps_2) \qquad (4)$$

for systems in parallel. For practice, the reader should follow through and verify the steps involved in the reliability computation shown in Figure 5. For simplicity, the reliability of all components has been taken to be the same.

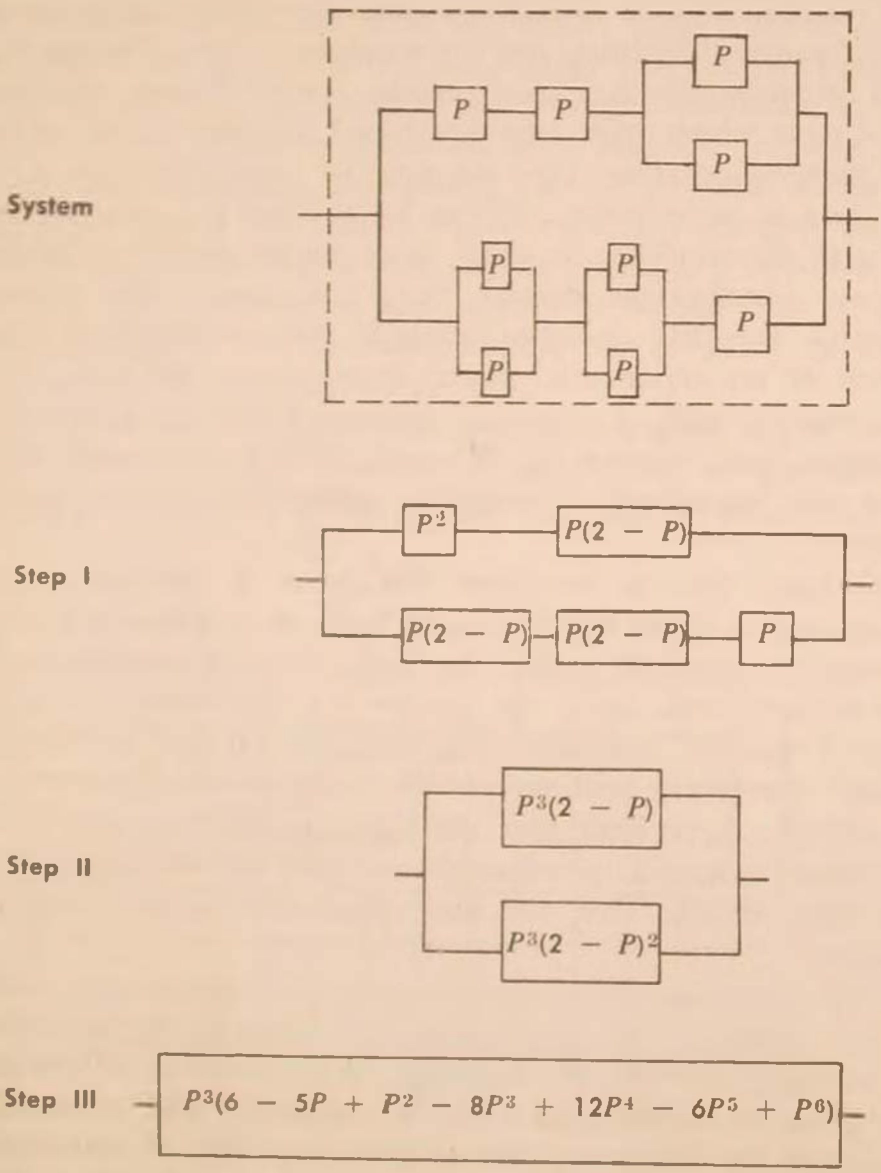


Figure 5. Steps in reliability analysis

Again to use analogy, suppose that one were running in an election with 20 voting precincts, each having 50 registered voters. If only the first precinct's votes were counted with 40 votes for candidate "A" and 10 for "B," this would hardly be cause for celebrating a landslide victory of four to one or 80 per cent of the votes. If two precincts reported the same 80 per cent for "A," would this be cause for celebration? Probably not. It is abundantly clear, however, that if 19 precincts reported, each with 80 per cent for "A," one could be quite sure that about 80 per cent of the votes were going to "A." One way to express this is to state that 80 per cent of the votes are for "A" with 95 per cent confidence (19 out of 20 precincts). In the former case, 80 per cent of the votes were for "A" but in only one out of 20 precincts, or with 5 per cent confidence. This simple case exemplifies the logic behind confidence levels and attests to the need for them. In this example we were afforded the luxury of being able to examine the entire universe (all 20 precincts' boxes) if we desired. The statistician is seldom so fortunate.

The statistician's problem is to determine, from tests of relatively few items, results which are correct for a large percentage of the entire equipment population (i.e., results to which high confidence levels may be assigned). When a part is described as at least 80 per cent reliable with 90 per cent confidence, this means that 90 per cent of the entire parts population has 80 per cent or higher reliability. Another statement which means the same thing is that, on the average, 9 out of every 10 tests will show the reliability of the part to be 80 per cent or greater. It also means that, on the average, in one out of every 10 tests the part's reliability will be less than 80 per cent.

The level of confidence one can attach to a given set of test data depends on the sample size (number of units tested or test time) and is quite easy to determine if the failure distribution is known. Tables

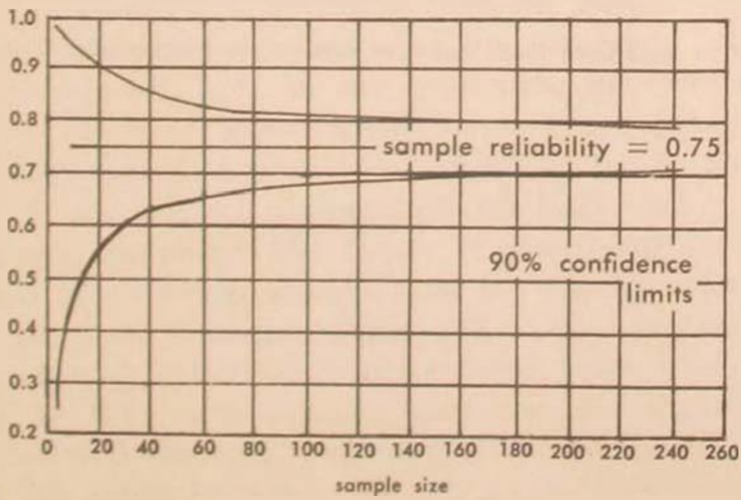


Figure 6. Confidence-limit curves for sample reliability

have been prepared and curves have been drawn* which give confidence intervals for various sample sizes. A typical curve is shown in Figure 6. This curve applies to go-no-go equipment (bombs, rockets, explosive bolts, etc.) and shows the case where three quarters of the items tested operated properly. Notice that if only 20 items were tested and one wanted to make a statement applicable to 90 per cent of the total population (90 per cent confidence), it could only be stated that the reliability was between 0.545 and 0.896. The confidence *level* would be 90 per cent, the confidence *interval* would be from 0.545 to 0.896, and the confidence *limits* would be exactly 0.545 and 0.896.

The careful reader will have drawn two conclusions: (1) a reliability statement is meaningless unless accompanied by a statement of confidence level and (2) a confidence statement, while simple in concept, can be expressed in a confusingly large number of ways.

With regard to reason 3, there are no methods currently available for determining the exact degree of conservatism. One must be content for the present merely to state that the reliability is *at least* as good as that obtained by adding failure rates.

The environment mentioned in reason 4 is determined from data obtained on previously tested equipment. It is therefore imperative that maximum practicable instrumentation be utilized on all actual applications, such as missile firings, of parts and components.

This discussion has concerned failure rates; the bath-tub curve; the exponential formula; confidence levels, intervals, and limits; and system reliability estimation, which are the conceptual terms most often encountered. More lengthy and rigorous discussions of each of these and many other topics will be found in reliability and statistical literature. It is hoped that the reader will avail himself of a portion of this wealth of knowledge.

Ballistic Systems Division, AFSC

*A computer for confidence limits has been designed and is included in SANDIA Report SCR-159 by J. O. Muench.

In My Opinion...

LEADERSHIP—THE LOST ART

MAJOR KENNETH L. MOLL

THE *U.S. Naval Institute Proceedings* for January 1961 carried a letter from a Commander L. N. Smith, who said: "Recently I graduated from the Command and Staff College at Maxwell AFB. Strangely enough, the most important thing I learned was not part of the curriculum. I learned that leadership at the mid-career officer level needs radical improvement. . . . There are too many fine articles written by too many senior officers in all the services for us not to know there is a growing concern about leadership."

The fine articles he mentions appear more than a dozen times a year in the *U.S. Naval Institute Proceedings;* so however serious the Navy's problem is, they are at least talking about it. The Army has always emphasized leadership. It is most significant that Commander Smith formed his opinion as to leadership deficiency by observing Air Force officers, for the Air Force is the only service which is contributing to its leadership problem by ignoring it.

At one time the Air Force, having gone through a very painful learning and screening process from 1942 to 1946, had reasonably good leadership habits at all levels. For some 15 years the Air Force was led by those who learned leadership the hard way in World War II. Now the Army-trained and combat-baptized leaders are going up or out. A new generation is taking over the Air Force leadership in the ranks below colonel. Most of this generation have no real leadership training or experience, even though many are approaching 20 years' service. Today there is a leadership vacuum in the field because for too many officers and noncommissioned officers leadership is a lost art.

Air Force knowledge and theory of leadership are at a confused subthreshold level. Older officers take for granted what they learned long ago, yet many younger officers and NCO's have no conception of the importance of leadership principles and practice. Leadership is so haphazard at the lower echelons that the Air Force's "unmilitary" reputation is well deserved. Admittedly the theory of military leadership is getting rather confused with the heroic-leader–military-manager split personality. There are good reasons for downgrading military spit-and-polish discipline and maybe other facets of old-Army leadership that were once considered important. Unfortunately, rather than doubling the effort to understand the changed leadership demands in the modern Air Force, the whole subject is being avoided. Without attempting to define what the changed leadership demands are, we may fairly observe that the old qualities of dedication, duty, initiative, and integrity are more important than ever. Yet they are being downgraded along with the whole subject of leadership.

This downgrading of leadership is not just academic or theoretical. It is slowly but insidiously undermining professional standards. For instance, the leader is losing his prestige. The smart thing nowadays is to get the soft job with no responsibility. A surprising number of officers today are completely disinterested in having a command or, for that matter, in any job requiring responsibility and leadership talents.

The best evidence of how leadership stands in the consciousness of the average NCO or junior or mid-career officer may be obtained by observing him at work. Too often he makes no attempt to develop subordinates, to back up superiors, or to do his best as a matter of duty without thought of personal gain. Too seldom is a junior leader honestly and unselfishly concerned with the welfare of those working for him, or with the best mission accomplishment. An amazing proportion do not even seem aware of their responsibility as leaders to do these things. Often they seem to forget such time-proven maxims as "Loyalty up—loyalty down," "Look after the troops," "Results, not excuses," "Service needs always come first." Take any leadership principle: in day-to-day operations it is violated, usually through ignorance, as often as it is observed.

Another example of downgrading is the number of subjects that outrank leadership as areas of concern. Problems are considered to be technical problems or administrative problems or occasionally disciplinary problems; rarely are they thought of as leadership problems. How often, for instance, is leadership made the subject of command correspondence or investigation as compared with safety, supply discipline, or administrative procedures? The Army and Navy and Marine Corps still make leadership probably their most important subject for NCO's and officers. The Air Force has bypassed leadership emphasis while emphasizing such things as safety and security. Not having anything against safety, security, etc. (which are only chosen as examples of areas which *are* emphasized), and certainly not wishing to be anti any of them, I will only say that leadership has not been getting its share of emphasis.

Maybe the Air Force, until recently, could better expend its efforts on the subjects which have been emphasized. Vast problems of technology and materiel management were rearing their heads. The Air Force was doing reasonably well with the leaders it had. It didn't hurt too much to ignore leadership as long as the old-timers were in the saddle. Now, with a new generation of junior leaders, it is different. All the years of neglect are beginning to be felt.

As the Secretary of the Navy said recently, "People are the key to our success." The new generation must learn to use this key. Unfortunately the art of leading people is not one to be mastered easily. Good leadership requires a lot of study, practice, and professional development. In a word, it requires emphasis.

The flying safety and ground safety people use several methods of emphasis in their field—education, exposure, example, and enforcement. Who can deny that their programs have been effective? Through these four methods of emphasis the Air Force can also build an effective leadership program.

• The formal schools (Air Force Academy, NCO schools, Command and Staff College, etc.) are already doing a good job with the education method. Such improvements as may be necessary would follow as the rest of the Air Force emphasizes leadership.

• Exposure to leadership ideas is possibly the weakest area today. Once a man leaves a school, he rarely hears of leadership. One big reason is the lack of a universal, widely read publication dealing with Air Force problems. *Air Force* magazine and *Air Force Times* do not discuss leadership. The average Air Force member is exposed to *The Airman* or *Air University Quarterly Review* hardly more frequently than to *The AMA Journal* which he reads in the flight surgeon's office. The very few articles on leadership usually discuss some esoteric angle that does little to help the average NCO or officer, however helpful it may be to higher-level planners and thinkers. Compare this low exposure to written leadership material with the ubiquitous *Aerospace Safety* or *Maintenance Review* magazines.

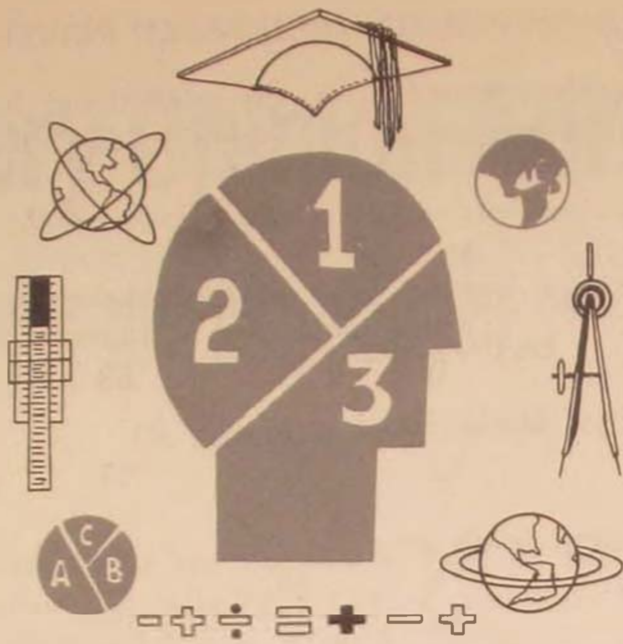
The Air Force will have to build a general publication of wide circulation and professional appeal, which it does not have today. In this publication it must include frequent and incisive articles on the problems of leadership at the lower levels. Perhaps an annual essay contest, with prizes, could be sponsored in this publication by some distinguished active or retired Air Force leader. Other methods of exposure could be by films at commander's call, pamphlets, posters, etc., pointing out the principles and methods of leadership. These should be in an interesting form, of course, concentrating on specific examples. The whole purpose is to make the "working" Air Force aware of its leadership responsibilities and how to meet them.

• The method of example is even more essential in emphasizing leadership. No one ever became a good leader only through classroom instruction or by reading articles. This is why the present leadership education is not enough. Leaders at all levels in the field must teach, show, and emphasize leadership to their subordinates. The NCO will do a better job as a subordinate, and be inspired to better performance as a leader, if his lieutenant boss gives the example of leadership. The same will be true of the lieutenant if his boss practices and demands good leadership. But all this can be accomplished only if there is an increased leadership consciousness throughout the Air Force.

• The last method is enforcement. Enforcement is needed simply because any program—whether it concerns safety, inflated efficiency reports, honest reporting, or leadership—is not convincing unless its advocates are prepared to enforce it. In this case, enforcing good leadership requires positive command action whenever poor leadership is evident at any level. This action can take the form of counseling, instruction, censure, or more severe discipline, depending on circumstances. The important thing is to seek out poor leadership and take corrective action.

The need is for this four-sided leadership program. Today's two-sided approach—education in formal schools and limited enforcement by means of the efficiency report—is not enough. To emphasize and obtain good leadership, Air Force-wide exposure and example are needed too, plus better enforcement. Without them, the Air Force leadership problem will soon become a serious weak link in the field units.

Headquarters Strategic Air Command



Educational Requirements of the USAF Officer Corps

Colonel John P. Lisack

WITH the advance of technology and its association with national strength, the new assignment to the Air Force of major responsibilities within the Nation's space program, and the press of Soviet advances and threats, there is properly much discussion concerning the formal-education level of the USAF officer corps. In this regard, a recently stated long-range Air Force objective is for all officers to achieve at least the baccalaureate educational level and proficiency in at least one foreign language. (For airmen an educational level of at least high-school graduation was also announced as the objective.)

There is much debate on the real need for college-level studies or college degrees. An Educational Requirements Board was formed to analyze each Line Officer Air Force Specialty to determine exactly the fields of study and the levels that would be needed to perform the tasks described by the Officers Classification Manual and by the incumbents of the jobs; this must be done for both current and future needs. A herculean effort was expended by the panel members selected especially for each career area, and the qualitative educational requirements have now been defined for the first time. Most of these requirements have been approved by Hq USAF; the remaining few are now in process. A "second cycle" is being readied to improve and refine the studies to date. So far this first look at educational requirements indicates that, to accomplish presently assigned tasks, the educational level of the line officers of the Air Force should be brought to the following minimum percentages:

	high school only	some college (no degree)	bachelor's degree	master's degree	doctoral degree
	0	19	68	12	0.7
Today's educational levels are:					
	22	32	41	5	about 0.5
By rank, the present levels are:					
Colonels	6	28	49	16	1
Lt Colonels	14	37	37	11	1
Majors	28	42	23	6	(less than 1)
Captains	29	35	32	4	"
Lieutenants	17	21	60	2	"

There is a curvilinear correlation between rank and baccalaureate level of education, with colonels and lieutenants having relatively high levels while the middle ranks are relatively low. Among the lieutenants and captains the high level represents the fact that present officer procurement is essentially limited to college graduates. There is an interesting correlation between higher rank and higher education.

It might be argued with justification that some officers are able to perform in their present jobs without a degree. It is very true that in many Air Force specialties knowledge of selected subjects in certain academic fields of study is necessary for competence in the specialty, although the number and level of these subjects may not add up to a degree. These qualitative educational requirements have been identified in some detail. A review of current trends and the results of the Board's studies clearly show, however, that an increase in formal educational level is needed for *future* competence in most Air Force specialties. Further, it is fairly well accepted that education is a continuum, that to stop is to regress. The long-range baccalaureate objective mentioned at the outset appears very much in order. Thereafter a continuation of educational effort by every officer is essential.

It might also be argued that the work of the Educational Requirements Board can be improved, and we intend that it will be. But certainly it would be difficult to argue that advancing one's educational level in fields of study related to one's career area is detrimental to the individual or the Air Force. There is no question about it: to build a successful career and to advance the Air Force, the probabilities are with the educated officer.

Headquarters Air University

Military Opinion Abroad . . .

SOVIET MILITARY DOCTRINE AND THE 22ND PARTY CONGRESS

Dr. Kenneth R. Whiting

THE 22nd Congress of the Communist Party of the Soviet Union was a rousing affair that included a 12-hour speech by Nikita Khrushchev, the final degradation of Messrs. Molotov, Malenkov, and Kaganovich, a gratuitous swipe at old Klim Voroshilov, and the simultaneous burying of Stalin's body and reputation. To highlight the spirit of the gathering, the much-vaunted "fifty-megaton" bomb was exploded. In the midst of such plenty it is little wonder that Defense Minister Malinovsky's speech received little coverage. However this speech was a milestone in the evolution of Soviet military doctrine, and as such it deserves close attention.

To put the speech in focus, it would seem reasonable to sketch briefly the evolution of the doctrine since the end of the Second World War. The Soviet Union was victorious in that war for a number of reasons, probably the least of which was Stalin's military genius. Nevertheless the propaganda organs immediately pulled out all stops to prove that Stalin's new military science, with its so-called "permanently operating factors for victory," was the prime cause of the Soviet victory. These factors, almost ludicrous in their simplicity, were the stability of the rear, the morale of the army, the quality and quantity of divisions, the armaments, and the organizational and leadership ability of the command personnel. As is obvious, these factors were neither original with Stalin nor the sole possession of the Soviets.

From 1945 to 1955, a full decade, all Soviet writers on military doctrine had perforce to chant this fivefold litany. No mention, other than derogatory, of the value of surprise, nuclear weapons, or strategic air power was allowed. The reason for this doctrinal stand is simple enough. The Soviets were noncompetitive in nuclear weapons and long-range delivery capability, and having just seized an enormous territory in Europe, they could view large ground forces and tactical air as the ideal instruments for incorporating this new area into the Soviet orbit.

But for all of Stalin's allegedly stagnant thinking on military doctrine, large amounts of scarce resources and even scarcer technical personnel were invested during his dictatorship in the development of weapons not encompassed in the Soviet military doctrine. By 1949 the Soviets had an atomic device, by 1953 a thermonuclear weapon. Long-range aircraft were becoming available. Even more important, missile planning and development were making progress in the last years of Stalin's life.

Stalin died in 1953, but his doctrine outlasted him for two years. It was not until February 1955, when Marshal Rotmistrov published his article on the important role of surprise in modern warfare, that Soviet military doctrine began to catch up with the technological capabilities of the Soviet weapon systems. At a secret meeting of the Party Congress in 1956 Khrushchev ridiculed the idea of Stalin as a military genius, and the dam really broke. Doctrine got a thorough overhauling.

The importance of a surprise nuclear attack became more and more a key element of Soviet military doctrine, and by 1958 Soviet theorists were also discussing deterrence and the factors of space and time in regard to victory in warfare. In summary their findings indicated that to attain victory under the prevailing conditions the Soviets must have the capability of making an effective pre-emptive attack.

The Soviet theorists, however, did not want all their eggs in the missile-cum-nuclear-weapon basket. They continued to advocate large ground forces and enormous quantities of tactical air. A General Krasil'nikov pointed out in 1956 that nuclear war did not call for drastic cuts in ground forces but the opposite. The increase in the destructive power of the new weapons meant that whole divisions could be wiped out. Furthermore in a future war the strategic fronts would probably embrace not one continent but several. He might have added that territory can be effectively incorporated by ground forces.

In January 1960, in a speech to the Supreme Soviet, Khrushchev "analyzed" the character of modern war. He pointed out that large-scale missile attacks would dominate the initial stages of the war and that the Soviets had the equipment and the strategy not only to deliver such attacks but also to form a second-strike capability. Even more to the point, he announced a drastic reduction in military personnel—concrete evidence of the increasing importance of the role of missiles and nuclear weapons in the Soviet military doctrine.

This was the situation in Soviet doctrine when the Minister of Defense, Marshal Rodion Ya. Malinovsky, made his speech to the 22nd Party Congress on 24 October 1961,* a speech that neatly summed up Soviet military doctrine. In comparison with Comrade Khrushchev's gargantuan effort, Malinovsky's speech seems the essence of brevity. Nevertheless it is long enough in its own right. As in any Soviet speech, the meat is embedded in a large amount of nonessential shell.

Yet the first thing that strikes the reader is the quick way Malinovsky brushes over the place of massive ground forces in the next world war. He indeed maintains that under modern conditions the next world war will be waged, in spite of enormous losses, by huge multimillion-manned armies. And he reaffirms the classic Soviet dictum that in spite of the very decisive role of nuclear-missile weapons the final victory will be attained only as a result of the combined actions of all arms. The words are orthodox enough, but Malinovsky, in these two briefly stated assertions, seems to be getting his obeisance to conventional Soviet military doctrine out of the way in order to move on to a more important matter, the decisive character of the new weapons.

*"Rech' tovarishcha R. Ya. Malinovskogo," [Speech of Comrade R. Ya. Malinovsky], *Pravda*, 25 October 1961, pp. 4–5.

For by far the largest share of Malinovsky's remarks on military matters is concerned with the effectiveness of missiles and nuclear weapons. After pointing out that Khrushchev had made a profound analysis of the character of modern war in his January 1960 speech to the Supreme Soviet and thus laid the basis of Soviet military doctrine, Malinovsky went on as follows:

> One of the most important theses of this doctrine is that a world war, if it is ever unleashed by the imperialist aggressors, will inevitably take the character of a missile-nuclear war, that is, a war where the chief means of destruction will be nuclear weapons and the basic means of putting them on target will be missiles. In this respect, the war will both begin differently than formerly and be waged differently.
>
> The use of atomic and nuclear weapons with unlimited possibilities of delivery to any point in a matter of minutes with the help of missiles will permit in a very short time the attainment of decisive military results at any distance and over enormous areas. Along with groups of the armed forces of the enemy, there will be shattered such objectives as industrial and population centers, communication junctions—everything that feeds a war. The next world war, if it is not prevented, will have an unprecedented destructive character. It will lead to the destruction of hundreds of millions of people and whole countries will be transformed into lifeless deserts covered with ashes.

He then went on to say that the Presidium of the Central Committee of the Party and the Soviet Government had demanded and were demanding that the armed forces pay special attention to the initial period of a possible war. The importance of this period is that the very first massive nuclear blows are capable, to a large extent, of determining the entire course of the war. It may lead to such losses in the rear and among the troops as to put the people and the country in an exceptionally difficult position.

In any realistic evaluation of this situation, Malinovsky explained, one must keep in mind that the "imperialists" are preparing a surprise nuclear attack against the U.S.S.R. and the other socialist countries. Therefore the most important, the main, the primary task of the Soviet armed forces is to be in constant readiness to repulse this surprise attack and to frustrate the enemy's criminal schemes.

Malinovsky turned next to a discussion of the rocket forces, and he leaves no doubt about their being the darling of the Soviet armed forces. The five years that have elapsed since the 20th Party Congress have been filled with important events for the military: the introduction of new technology and the rearmament of the armed forces with missile-nuclear weapons. These changes marked a genuine breakthrough stage in the development of the army and the fleet. But above all, on the initiative of Nikita Khrushchev and the Central Committee of the Party and the Soviet Government, there was created a new branch of the armed forces—the "Rocket Forces of Strategic Designation." This branch is in constant combat-readiness and already has the installations, missiles, and weapons of tremendous power to bring about the most destructive defeat of any aggressor and his country. The new Rocket Forces have more than balanced the manpower reductions carried out in the other branches of the armed forces.

According to Malinovsky, the production of missiles in recent years has grown to the point where there are more than enough. Furthermore the rocket forces have shown phenomenal accuracy in firing. Strangely enough, the long-range missiles have been fired more accurately than the short-range ones, which scored over 90 per cent "good" or "excellent." The intercontinental missiles, however, all scored either "good" or "excellent."

In his discussion of the ground forces, Malinovsky pointed out that although they had been significantly reduced in numbers their combat capability was greater than ever. They were now able "to conduct rapid, highly maneuverable combat activities at unbelievably fast tempos at great operational depth under conditions in which the opponent used nuclear weapons." The basic strength of the ground forces now lay in their missile units, equipped with tactical nuclear and conventional rockets having ranges from several to hundreds of kilometers. Exercises with combat firing confirmed the high combat capability of these missile troops: accuracy, swift deployment from marching to rocket firing, and the ability to move over great distances without the loss of combat efficiency.

Malinovsky's speech signalized the complete reversal of Soviet military doctrine between 1945 and 1961 from views that stressed conventional forces and almost frantically denied the decisiveness of surprise and nuclear weapons to an outlook upon missile-nuclear weapon systems as the decisive factor in any future general war. One can almost guess the volume of Soviet nuclear and missile production since 1955 by the importance given to these weapons in Soviet military doctrine year by year.

At the present time we are hearing a great deal about limited war as a means of giving the West a third alternative between mutual annihilation and outright capitulation. What does Malinovsky have to say on this subject?

In the first place, his description of the Soviet capabilities in artillery, tanks, airborne forces, and air transport is convincing evidence of a considerable capability for limited war. Although reduced in manpower, the motorized rifle divisions of today have four times the firepower of those in World War II, and this excluding rockets and atomic weapons. The tank divisions are powerful and numerous. In one exercise military transport aviation alone was able to airlift more than 100,000 parachutists, and this capability can be easily augmented by the Civil Air Fleet, which is being equipped with bigger and faster aircraft.

In spite of this rather awesome array of forces so well suited to limited conflict, Malinovsky takes no enthusiastic view of this type of warfare. He argues that the ruling circles in the West, well aware of the terrific destruction that would be unleashed in a world war, are now attempting to achieve their aggressive aims through "little wars" waged with conventional and tactical atomic weapons. This will not work, says Malinovsky, because "under modern conditions, any armed conflict involving the use of nuclear weapons will be immediately transformed into an all-out nuclear war. Thus, we must prepare our armed forces, our country, and all our people for a struggle with the aggressor, above all and mainly under the conditions of nuclear war."

In short the Soviet position on limited war seems to be that limited wars of any kind are very, very dangerous and that a limited war involving the use of even tactical atomic weapons will inevitably result in an all-out nuclear exchange.

This position is unbelievably adamant. It makes the late John Foster Dulles' policy of massive retaliation in places and at times of our own choosing look like the acme of elasticity. Why have the Soviets taken such a rigid position? For one thing a limited war involving tactical nuclear weapons would tend to downgrade Soviet superiority in conventional forces. To head the West off this course, the Soviets threaten to escalate any such war into an all-out conflict. In addition limited war gives the West a third alternative between total war and inaction when only limited objectives are concerned. Inasmuch as the Soviets are quite confident that the West will not initiate a total war over limited objectives, they can keep the West uncertain of the consequences of fighting a limited war with tactical atomic weapons.

If the Soviets can convince the West that limited wars are too dangerous to fool with, the West will probably not build up the forces with which to wage them. Then only the Soviets will have the capability for such conflicts, and under the canopy of their long-range nuclear threat they can use it very advantageously.

Regardless of the reasons, it would seem unbelievable that Malinovsky is serious in his adamant stand on the inevitability of all-out war resulting from limited war. The Soviets have fought for limited objectives with limited forces in the past, especially in their battles with the Japanese along the Outer Mongolian and Manchurian borders in 1938 and 1939. These are almost classics in the art of keeping wars within bounds consonant with the objectives. If Malinovsky is serious, then Soviet military doctrine has indeed become very inflexible.

Research Studies Institute

The Quarterly Review Contributors

MAJOR GENERAL ARNO H. LUEHMAN (USMA) is Director of Information, Office of the Secretary of the Air Force. Following graduation at West Point he completed flying training in 1935, then served successively as a group operations officer, as a squadron commander, and as Assistant Operations Officer, Third Air Force. He was Assistant Chief of Staff for Operations, later Chief of Staff, Thirteenth Air Force, Southwest Pacific, 1944–45. Other assignments have been as Chief, Control Division, Hq Continental Air Force, 1945–46; as a staff officer, Project Crossroads, 1946; as Assistant Chief of Staff for Plans, Hq Strategic Air Command, 1946–47; as Secretary, U.S. Representatives to the United Nations Military Staff Committee, New York, and Military Adviser to the U.S. Delegation to the Third General Assembly in Paris, and Chief of Staff to the USAF Representative in New York, 1948–49; as Commander, 3500th USAF Recruiting Wing, ATC, Wright-Patterson AFB, 1954–1957; and in the Office of Information from 1951 to 1954 and from 1957 to the present. He is a graduate of the Naval War College, Air War College, and National War College.

FIRST LIEUTENANT DOUGLAS N. JONES (B.A., University of New Hampshire; M.A. and Ph.D., Ohio State University) is Assistant Professor, Department of Economics and Geography, U.S. Air Force Academy. Previous service includes a tour as Executive Officer to the Director of Transportation, Hq Air Materiel Command, 1956–1958. He is a member of the Institute for Strategic Studies (London) and of the American Economic Association.

LIEUTENANT COLONEL ARTHUR W. BUCK (Ph.B., Carroll College) is T-38 Project Officer for the Air Training Command and for the past year has been at the AF Flight Test Center, Edwards AFB, California, as Deputy Director, T-38 Joint Test Force. He flew fighters during World War II with the Ninth Air Force, ETO, and during the Korean War with the 51st Fighter Wing. He served as Director of Training, Williams AFB, Arizona, 1952–1955, then was Assistant Professor of Air Science at the University of Puerto Rico until his present assignment in 1958. Upon completion of the Category I and II phases of the T-38 test program about March 1962, he will return to Hq ATC as Category III Test Director.

MAJOR RICHARD C. HENRY (USMA; M.S., aeronautical engineering, and M.S., instrumentation engineering, University of Michigan) is assigned to the Directorate of Operational Requirements, DCS/O, Hq USAF, with primary duty in the area of formulation of Air Force operational requirements and capabilities in space. He served on combat crew duty with the 43d Bomb Wing, 1950–1952; as SAC Liaison Officer, Air Force Missile Development Center, Holloman AFB, N.M., 1954–55; and activated the SAC Project Office at Air Force Ballistic Missile Division in October 1955. From 1958 until his current assignment in 1960 he was assigned to the 7th Air Division (SAC), for development of operating and training procedures for RAF Thor squadrons, and participated in negotiation of arrangements for deployment of IRBM's in the United Kingdom, Italy, and Turkey.

COLONEL FRANK L. GAILER, JR. (B.S., M.A., University of Maryland) is Chief, Latin American Missions Branch, Directorate of Operations, DCS/O, Hq USAF. Commissioned from flying school in 1943, he served during the war as a fighter pilot in the European Theater until shot down and taken prisoner of war. Shortly after returning to the ZI he was assigned to the 6th Fighter Wing, Canal Zone. Later, after a 5½-year tour as Operations Officer, then Deputy Commander, of a Research and Development Testing Group at Aberdeen Proving Ground, he returned to South America for a 3-year tour as Fighter Operations Adviser with the USAF Mission to Uruguay. Colonel Gailer speaks Spanish fluently, and he is a graduate by correspondence of the Air Command and Staff School and the Industrial College of the Armed Forces.

MAJOR ROBERT J. LACEY (B.A., University of Akron; M.A., Ohio State University) is a Project Officer, Systems Integration Directorate, Deputy for Technical Development, Space Systems Division, AFSC. In the Infantry 1943–1946, he saw action in Belgium and Germany. He was commissioned in the Air Force through ROTC upon graduation from the University of Akron in 1949, and then attended the Air Tactical School. After a tour at the Mobile Air Materiel Area, he attained his master's degree through the Air Force Institute of Technology in 1951, then was assigned to the Flight Research Section, Aeromedical Laboratory, Wright-Patterson AFB. With the Air Force Ballistic Missile Division, ARDC, 1957–1960, he was Chief of the Human Engineering Branch. Major Lacey is a 1961 graduate of the Command and Staff College.

BRIGADIER GENERAL JOSEPH AUSTIN CUNNINGHAM (A.B., West Virginia University) is Commander, Air Rescue Service, MATS, Orlando AFB, Florida. After completing flying training and being commissioned in 1939, he served with the 34th Bombardment Squadron and the 319th Bombardment Group, going to England as Operations Officer with the latter in 1942. He commanded the 319th in the Mediterranean Theater, 1942–43, and was Deputy Chief of Staff A-3, 12th Fighter Command, MTO, 1943–44. Subsequent assignments have been as base commander, Greenville, S.C., Charlotte, N.C., and Moody AFB, Georgia, 1944–1946; as Assistant C/S A-3, Eleventh Air Force, 1947–48; in Operations, Air Defense Command, Mitchel AFB, 1948–1950; in War Plans Division, DCS/O, Hq USAF, 1951–1954; as Commander, 317th Troop Carrier Wing, USAFE, 1954–1957; and as student, National War College, before joining Air Rescue Service in 1958. General Cunningham is a graduate also of the Command and General Staff College and the Armed Forces Staff College.

CAPTAIN ED L. BATTLE (B.S. in aeronautical engineering, Auburn University; M.S. in astronautics, Institute of Technology) is a Reliability Staff Officer, Ballistic Systems Division, Air Force Systems Command, Los Angeles. He worked in the Dynamic Analysis Group at Lockheed Aircraft Corporation, 1954–55, then entered flying training and graduated as a jet pilot in 1956. He served as Aerodynamic and Structures Project Officer in the B-66 Weapon System Project Office, Hq ARDC, prior to his present assignment in 1960.

MAJOR KENNETH L. MOLL (USMA) is Assistant Chief, Weapons Training Section, Airman Division, DCS/Personnel, Hq Strategic Air Command. He served a year in the U.S. Navy before entering West Point in 1946, and after graduation took flying training. From 1951 to 1953 he served with the 35th Fighter Interceptor Group in Japan and the 8th Fighter Bomber Group in Korea. He was assigned to the 83d Fighter Interceptor Squadron, Hamilton AFB, 1954–1956, and to Hq Western Air Defense Force as F-86D/L and F-104 Training Officer, DCS/Operations, 1956–1959. Following 12 weeks' training on the Thor missile, he served with the 99th Munitions Maintenance Squadron (SAC) in England from 1959 until his current assignment in July 1961.

COLONEL JOHN P. LISACK (B.S., M.A., Ohio State University) is Technical Director, Air Force Educational Requirements Board, Maxwell AFB. After two years in the Illinois National Guard, he was commissioned and entered the Air Corps in 1936, receiving his regular commission in 1946. During World War II he served as Aircraft Maintenance Engineering Officer with heavy bombers in both the Pacific and European Theaters. Subsequent assignments have been with the Air Technical Service Command and the Continental Air Command; as Chief, Commitments and Requirements Branch, Operations and Training Division, Hq USAFE, 1951–1955; as student, Armed Forces Staff College; and as Chief, Long Range Plans Branch, AFPDP, Hq USAF, for five and a half years preceding his current assignment.

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

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