AIR UNIVERSITY review

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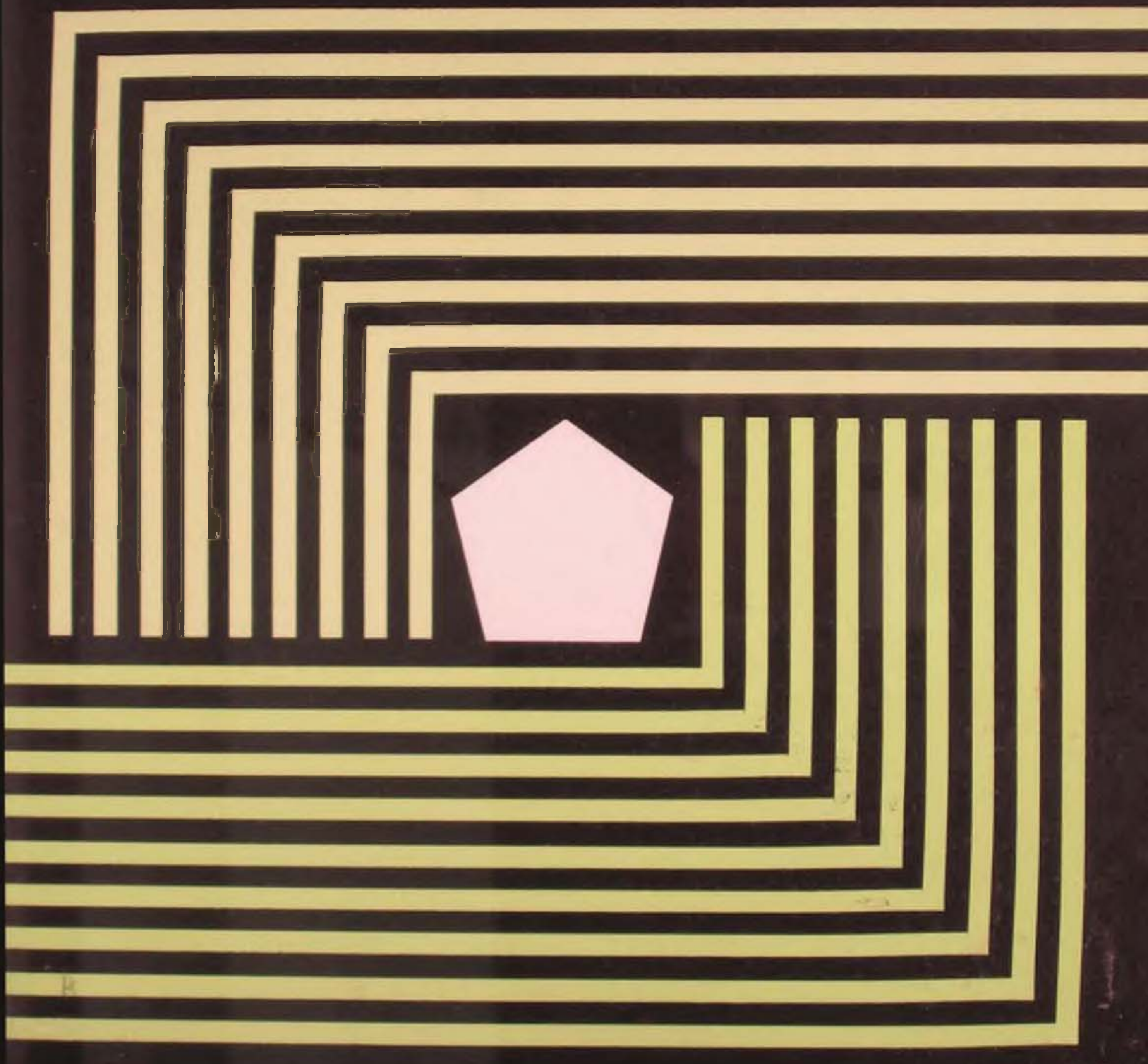

from the editor's aerie

We are happy to announce that the Basis of Issue has recently been modified to increase the availability of the *Review* for Air Force personnel. The new criteria (listed on page 15) were extracted from Publishing Bulletin No. 11, 3 June 1977. If your unit is not receiving its authorized copies of the *Review*, notify your Customer Account Representative or establish requirements directly with the servicing Publications Distribution Officer (PDO) for your organization.

This issue is devoted primarily to papers prepared for the Air Power Symposium of last spring, which was sponsored by the Air War College. If there is a unifying theme to these papers, it is one of a "forward lean." Technology is galloping ahead so fast that there is danger of losing the rider.

In peacetime one of the traditional roles of the military is to study the mistakes of past wars so they will not be repeated in the future. But this projection of lessons learned to future scenarios becomes increasingly slippery in this era of Alvin Toffler's *Future Shock*. Are we replacing battle-tested equipment and doctrine prematurely in favor of untried gadgetry, or are we sentimentally preserving the horse cavalry and muzzleloaders beyond their usefulness? Most of this issue revolves around some aspect of that question.

Preceding this block of articles, Dr. Frank N. Trager, Professor of International Affairs at New York University and Director of Studies for the National Strategy Information Center, examines the National Security Act after thirty years. He concludes that, although it has weathered our conflicts satisfactorily, the defense organization, like the weapons in its inventory, must be continually refined. Our cover by Art Editor Bill DePaola conceptualizes the Department of Defense in a constantly changing threat environment.

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ATTENTION

The *Air University Review* is the professional journal of the United States Air Force and serves as an open forum for exploratory discussion. Its purpose is to present innovative thinking and stimulate dialogue concerning Air Force doctrine, strategy, tactics, and related national defense matters. The *Review* should not be construed as representing policies of the Department of Defense, the Air Force, or Air University. Rather, the contents reflect the authors' ideas and do not necessarily bear official sanction. Thoughtful and informed contributions are always welcomed.

THE NATIONAL SECURITY ACT OF 1947

Its Thirtieth Anniversary

DR. FRANK N. TRAGER

THE WAR was over. The Continental Army was to be demobilized. The problem of a standing peacetime army, if any, had now to be resolved. The Congress, not atypically even then, turned it over to a committee headed by Alexander Hamilton, and the committee sought advice from General Washington among others. The Congress rejected the recommendations of its committee and debated the issue. A congressional resolution under the Articles of Confederation would require affirmative votes from nine of the thirteen quarrelsome states. On the last two days of the session, in June 1784, the Congress voted terms of demobilization. All officers and men of what was left of the Continental Army—excepting "80 [87 according to another authority] artillery men retained to guard military stores at West Point"—were terminated with back pay. Further, the Congress tied this decision to another: recruitment of "a new force of 700 men, comprising a regiment of eight infantry and two artillery companies." Thus was born the Regular Army.

The Articles of Confederation gave way before the real problems of the thirteen states. The Constitutional Convention began its work in the spring of 1787; and in April 1789 Washington became President and Commander in Chief with executive power, "checked," of course, by congressional power of purse and power to declare war, to raise armies, and to provide for a navy. The Congress shared power over the militia with the several states. In August 1789 the new Federal Congress enacted legislation creating the cabinet-level Department of War, one of the three departments of the new constitutional Republic of the United States of America. The other two were State and Treasury. Thus was born the department concerned with the defense of the U.S.A.

General Henry Knox, who had succeeded Washington as Commander in Chief of the Army, was named the first Secretary of the Department of War. Its jurisdiction then included all U.S. land *and* naval forces. Though there were strong voices during the years of governance under the Articles of Confederation and during the Constitutional Convention of 1787 calling for a Navy Department separate from the Army, and though the Constitution authorized Congress "to provide and maintain a navy," considerations of expense and sectional benefits and rivalries among the states continued to postpone any such decision.[1]

Thus, as the Republic started on its course —and not since then—there was one unified military department of the U.S. government to "provide for the common defense," presided over by a cabinet-level Secretary of War with a Standing Army of 700–800 officers and men.[2] With the lessons of the European wars before them, the early congresses, *except in wartime,* proved to be generally indifferent if not hostile to standing armies. The Congress of today has not wholly cured itself of such attitudes. The "improvised Revolutionary Navy" (Sprout's phrase) had been liquidated by 1785. "All of the ships had been sold or given away leaving the United States with neither a navy nor a naval program."[3]

Such depredations as holding American seamen for ransom and the pirating of American merchant ships and goods by the Barbary Coast powers renewed in the Congress the debate about a navy. And in 1794 by a narrow margin of two votes, the House of Representatives approved its special committee's report to create a "naval force of six frigates," to protect American shipping and to chastise Algerines and related Barbary Pirates. Four years later, in April 1798, the

Congress established a cabinet-level Department of Navy, separate from the War Department. A politically effective and efficient merchant of Georgetown, Maryland, Benjamin Stoddert, was appointed as the first secretary of the new coequal defense sector of the government. These two cabinet-level departments, War and Navy, were to retain their names and their mostly uncoordinated and separate development throughout peacetime and wartime down through World War II.

This is not to imply that there were no changes in U.S. civil-military thinking and organization prior to WW II—quite the contrary. The Civil War and the Spanish-American War had profound influence on both the civilian and military leaders of America's defense establishment. A great Secretary of War, Elihu Root, succeeded at the beginning of the twentieth century in getting national attention and decisions about military reforms in the Army (e.g., in the system of military education, services of supply, and command and control) while breaking down some of the "walls of separation" between the Army and Navy.[4] Earlier, the confluence of Captain Alfred Thayer Mahan, U.S. Navy, a faculty member and fast-developing author at the newly founded (1884) Naval War College, and the newly appointed (1889) Secretary of the Navy, Benjamin F. Tracy, contrived to shake up the then stultified Navy, whose line leadership in the 1880s still held to "sails" first, "steam" only as needed! It took about a decade to effect changes in the Navy, but essentially Mahan's geopolitical and other concepts of sea power and command of the sea were vindicated in the war with Spain. They were further instrumentalized by a rising young political figure, Theodore Roosevelt, who became an Assistant Secretary of the Navy in March 1897, five years after he had published his first book, *The Naval War of 1812*.[5] A disciple and friend of Mahan, Roosevelt was elected to the vice-presidency and became President of the United States in September 1901 when McKinley was assassinated. The Navy thrived.

To the political and organizational changes wrought within the two military cabinet-level departments, War and Navy, there emerged a third catalyst of change, technology, which in time would bring about further decisive legislative change. The nineteenth century had witnessed a quantum leap in the development of arms and armor. Rifled artillery, the machine gun, high-explosive artillery shells, the internal combustion engine and steam propulsion, steel and advanced armor in land and sea transport—all were products of the technological/industrial revolution of that century.

Prior to the advent of the nuclear/space age, perhaps the most important of these technological developments, certainly with respect to the development and organization of defense, was the introduction of the airplane. In August 1907, an aeronautical division was established in the Office of the Chief Signal Officer of the U.S. Army to "study" the new "flying machine" and the possibility of adapting it to military purposes. After World War I the National Defense Act of 1920 and the consequent Army Reorganization Act of the same year set up the Air Service as a separate branch of the Army. It was redesignated as the Air Corps in 1926. During World War II its fortunes were advanced as the Army Air Force, one of the three autonomous and coequal commands within the still-named War Department; the other two were the Army Ground Forces and the Services of Supply. Finally, the National Security Act of 1947 created a separate *Department* of the Air Force, coequal in status to the two earlier-created Departments of the Army and the Navy. The U.S. now had three military departments, but something happened on the way. The three, in a significant sense, were "less" than the one department of the early Republic and less than the two departments coexisting since 1798.

The National Security Act of 1947

Each of the major wars fought in the nineteenth and twentieth centuries brought about at least temporary concern for the "common defense." The lessons of the war were presumably translated into enacted policy affecting the military departments and the armed forces. As we have seen, from time to time leadership capable of effecting change in policy came from civilians, from the military itself, or from a fortuitous combination of both. The experience during and immediately after World War II proved to be no exception. Out of it there came the most important governmental restructuring for defense and reorganization of the armed forces since the beginnings of the Republic. These changes were instituted in the National Security Act of 1947 (Public Law 253, 80th Congress), signed by President Truman on July 26th of that same year. The act was subsequently amended in 1949, 1953, and 1958 and will again be amended when the present Congress acts, if it does, on the post-Watergate issue of the role and structure of what is now referred to as the intelligence community.[6]

the war and the debate

Within days after Pearl Harbor, the U.S. found itself, for the first time in its history, fighting a war on two fronts. Germany and Italy, following the Japanese attack, declared war against us. President Roosevelt was not wholly unprepared for the event. In the summer of 1940 a strategy for war had been developed with the British, based on the expected entrance of the U.S. into the war. Mobilization, by means of the first U.S. peacetime draft and stepped up industrial war production, had been initiated. The Regular Army had been put on a war footing, and the National Guard and Organized Reserves were federalized. Any public opposition to preparation for war disappeared on December 7, 1941. Later that month further planning for allied or coalition warfare was undertaken at and in response to the Roosevelt-Churchill Arcadia Conference in Washington, D.C. There it was decided to organize the Allied Combined Chiefs of Staff (CCS) "to plan and direct global strategy" with the newly authorized American Joint Chiefs of Staff (Army, Naval Operations, and Army Air Forces) and the President's personal military Chief of Staff, designated to represent the U.S. on the CCS.

Coalition warfare, never easy to conduct, proved to be even more difficult after Stalin joined with Roosevelt and Churchill to prosecute the war.[7] The task of defeating Germany and Japan was ultimately successful, but costly. On the American side there were inadequate arrangements for integrating and coordinating the roles and missions of the War and Navy departments. Error and what has been called "a low level of efficiency" stalked the war effort. Political and military objectives were not always dovetailed. Those principles of war known as "unity of command" (or, the application of the full combat power under one responsible commander), and "mass" (or superior combat power targeted for decisive purpose), and "economy of force," its corollary—principles known to every military man—were not infrequently in dispute or otherwise frustrated in application. This was true not only between and among the three American services—Army, Navy, and Air—but also between and among the Allies. During the war there was some discussion in the U.S. calling for unification of the Army and Navy, but this issue was shelved so as to get on with the war. It was relatively clear that after the war there would be congressional hearings, inquiries, and studies designed to bring about reforms and improvements in defense requirements.

The momentous events of the war, culminating in the need to decide what kind of military establishment the United States would require to guard our security and welfare and to preserve the peace, served as the springboard for the "beginning" of a great debate. Usually scholars and others will make choices and therefore dispute statements about where a beginning really began. I face that risk and arbitrarily select as my "beginning" General George C. Marshall's expressed concern during World War II for postwar military arrangements and conditions. That he was and is a revered figure in American history and that he was a great man gave weight to his views. His concern rose out of what he rightly anticipated to be postwar and interservice differences and rivalries; the loss or decline of national interest in military affairs so clearly exhibited after World War I; and the difficulty in postwar peacetime to gain acceptance for a balanced defense program. His views were funneled into the debate on what generally has come to be called the issue of unification or merger and the proper organization of the military departments and services.

In October 1943, General Marshall presented to the Joint Chiefs and to the Army initial views on the subject of reorganization and unification. The Navy thereupon countered with its proposals. In a sense, as I have suggested above, the stage for the great debate was set. The problems that the Army and Navy faced as their respective proponents pushed forward to a resolution were then, as now, strikingly evident. Among them are the following:

What should be the proper relationship between the political civilian institutions and the military under the constitutional doctrine awarding primacy to the former? How shall the professional military contribute to the interdependent mixture of policy and decision-making?

Under the President and Commander in Chief, how shall the services and service chiefs be organized for command?

What command and control arrangements should be created at the national center and in the light of "unification"; and, correlatively, what would "unification" mean for the then existing War Department (Army) and Navy Department, and the then emerging third independent service, the Air Force? What are their primary roles and missions?

Under what provisions shall we mobilize and maintain men and arms for peacetime and wartime defense?

How shall we set up and implement, and where possible standardize (nationally and internationally), current and new weapons and weapon systems? Who runs what, does what in research and development?

How shall we set up and carry out the quintessentially necessary functions of gathering, analyzing, and implementing intelligence in peacetime?

These are not the only issues that were analyzed and acted on during the great debate, but they were the major ones, and, in fact, the National Security Act (as amended), as we shall see, attempted to provide for their resolution.

The debate continued with ever growing intensity from 1943 until the act itself was passed and approved on July 26, 1947. There were a significant number of service plans presented to the various congressional committees and at various hearings. During the war, the Admiral Richardson Committee, correctly known as the Joint Chiefs of Staff Special Committee for Reorganization of the National Defense, interviewed scores of general staff officers and others in the field so as to garner their views for its April 1945 *Report.* Through the influence of the Secretary of the Navy, James V. Forrestal, the Eberstadt Committee was appointed and presented its report in September 1945. Since this was primarily Navy-oriented, or so the Army thought, the Army presented its report and set of recommendations through General J. Lawton Collins. In October 1945 and again in December, President Truman presented his proposals to Congress, calling for a strong postwar military organization and favoring some kind of merger under a single civilian Secretary of Defense (the Army view), and called attention to the views expressed in General Marshall's *Biennial Report of the Chief of Staff of the United States Army, July 1, 1943 to June 30, 1945*. The Senate Military Affairs Committee (Army) began its hearings on the several proposals emanating from civilian and military authority. The Senate Naval Affairs Committee did likewise.[8]

As in all political processes in a democratic society, bargaining and compromising are inevitably necessary in order to produce a majority consensus. The Congress, among other decisions, contributed the passage of the National Reorganization Act of 1946, merging into a single committee the Military and Naval Affairs Committees of each house, and similarly merged the Army and Navy Appropriations Committees of each house. In July 1947 the National Security Act was passed, in recognition of the need for greater unity, coordination, and integration for defense purposes. It was clearly a compromise calling for unified control, but not merger, of the services in a "National Defense Establishment" consisting of three executive departments, Army, Navy, and Air, headed by a civilian Secretary of National Defense with cabinet rank.

IF, FROM time to time, we appropriately refer to landmark decisions of the Supreme Court as those which establish significant, initiating, innovative baseline constitutional interpretation,then similarly it is appropriate to so regard the National Security Act of 1947, the thirtieth anniversary of which we are "celebrating"—if that is the right word—this year!

It can be safely said that the intention of the Congress was clear and became clearer with succeeding amendments, even where the separate provisions of the act were deliberately vague. And, I add, this was so in order to allow for experience and evolutionary development to guide the Congress and the executive branch in the future. Thus, the act was amended in 1949, in 1953, and in 1958 and has acquired minor changes since then. There have been no significant legislated amendments since 1958. Secretaries of Defense since then have been able to effect changes within the Department of Defense because of additional authority vested in them by the 1958 enactment. This was especially and necessarily true in the power-wielding era of and by Secretary of Defense Robert McNamara.

The Act of 1947 (as amended) contains this declaration of policy:

> Declaration of Policy
>
> Sec. 2. In enacting this legislation, it is the intent of Congress to provide a comprehensive program for the future security of the United States; to provide for the establishment of integrated policies and procedures for the departments, agencies, and functions of the Government relating to the national security; to provide a Department of Defense, including the three military Departments of the Army, the Navy (including naval aviation and the United States Marine Corps), and the Air Force under the direction, authority, and control of the Secretary of Defense; to provide that each military department shall be separately organized under its own Secretary and shall function under the direction, authority, and control of the Secretary of Defense; to provide for their unified direction under civilian control of the Secretary of Defense but not to merge these departments or services; to provide for the establishment of unified or specified combatant commands, and a clear and direct line of command to such commands; to eliminate un-

> necessary duplication in the Department of Defense, and particularly in the field of research and engineering by vesting its overall direction and control in the Secretary of Defense; to provide more effective, efficient, and economical administration in the Department of Defense; to provide for the unified strategic direction of the combatant forces, for their operation under unified command, and for their integration into an efficient team of land, naval, and air forces but not to establish a single Chief of Staff over the armed forces nor an overall armed forces general staff.[9]

The act as amended obviously drew on the experiences of World Wars I and II, where hastily improvised arrangements were adopted and then dismantled in peacetime. Its ultimate significance rested on the determination of the executive and congressional branches of the government to institutionalize for the common defense the lessons learned from the improvisations of the past two world wars.

main features of the amended 1947 Act

The solution to the issue of unification under civilian control was to create a new structural vehicle into which the former cabinet-level departments of War, now called Army and Navy, would be separately fitted. The Congress wanted "integration," a kind of "unification," but it emphatically and repeatedly rejected merger. The 1947 Act named this the National Military Establishment, added to it the newly created Air Force department, and subordinated all elements to the Office of the Secretary of Defense (OSD). James V. Forrestal, former Navy Secretary and one of the most prominent and influential civilians involved in debate, was named the first Secretary of Defense. The amendments of 1949 changed the name of the new cabinet-level office to the Department of Defense (DOD) and enlarged the powers of the secretary, making him "the central figure in coordinating the activities of the three Services." Corresponding to the Secretary of State, the Secretary of Defense became the principal adviser to the President on matters of defense. The service departments were placed in a second-level DOD tier and deprived of their executive character. The secretaries of the three departments, responsible to the Secretary of Defense, were also deprived of direct access to the President. Roles and missions were generally defined:

> The Army received primary responsibility for conducting operations on land, for supplying anti-aircraft units to defend the U.S. against air attack and for providing occupation and security garrisons overseas. The Navy, besides remaining responsible for surface and submarine operations, retained control of its sea-based aviation and of the Marine Corps with its organic aviation. The new Air Force received jurisdiction over strategic air warfare, air transport, and combat support of the Army.[10]

The Act of 1947 and the 1949 reorganization of the Defense establishment in itself gave major importance to the enacted legislation. Further, the act and the amendments created a number of "firsts" in the long and erratic congressional provision for the common defense. For the first time in our history, legislation established a peacetime Joint Chiefs of Staff (JCS) headed, as of the 1949 amendment, by a chairman from the military who acquired a vote in the JCS by the 1958 amendment. The chairman and the three service chiefs (the Marine Commandant sits with the Joint Chiefs when a subject pertinent to the Marines is on their agenda) are the senior military officers and advisers in peace and war. Though they report to the Secretary of Defense, they have the right of direct access to the Congress and to the Commander in Chief, the President. The JCS was provided with a support military group called the Joint Staff.

The presumed unifying instrumentality of the JCS (wherein each service chief also commands his respective service) was furthered by the Defense Reorganization Act of 1958—

amending the National Security Act of 1947—authorizing specified and combined or unified commands. A specified command, usually assigned to a single service, such as the Strategic Air Command, has a worldwide mission. The combined or unified commands, usually regional, consist of components from the three services and are commanded by an officer from one of the services assigned to that regional military section.

The act created, also for the first time, two other major national security institutions outside the Department of Defense. These are:

- The Central Intelligence Agency (CIA), whose director is also the chairman of an intelligence board or group composed of representatives from all military and civilian agencies charged with an intelligence function—including the Department of State, the Federal Bureau of Investigation, and the National Security Agency. The CIA's charter, written into the act, gave it prime responsibility for overt and covert intelligence operations.

- The National Security Council (NSC) with statutory members to advise and serve the President, at his discretion. The NSC is concerned with all matters of defense and foreign policy. Originally, the civilian service secretaries and the chairman of the National Security Resources Board (NSRB) were among the statutory list of members; the service secretaries were dropped by the amendment of 1949 and the chairman of the NSRB in 1973. Since then the NSC has been composed of the following statutory members: the President, vice-president, the secretaries of state and defense. Others *may* be chosen and added by the President. There is provision for an assistant to the President for National Security Affairs who, with the director of the CIA and chairman of the JCS, customarily participates in the NSC.

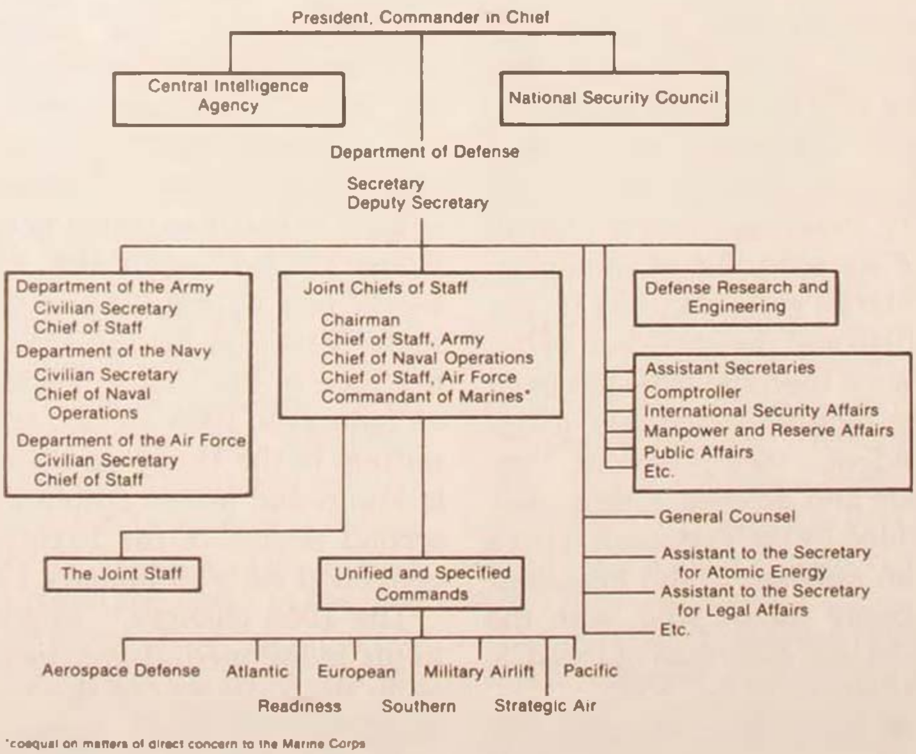
From time to time the Congress, by amendment or new legislation, has authorized other additions to, deletions from, or changes in the National Security Act. Three boards were named in the 1947 Act: the already mentioned National Security Resources Board, later renamed the Office of Emergency Preparedness (OEP) and disbanded in June 1973; the Munitions Board and the Research and Development Board, the latter two located in the Office of the Secretary of Defense. These two boards were abolished by the 1953 amendments and replaced by the far more important Office of Defense Research and Engineering (see below) in the substantial revisions of the act in 1958. Other minor changes continued to be made.

In some ways the changes brought about by the amendments to and rewriting of the act by the Department of Defense Reorganization Act of 1958 were the most significant and lasting. Two factors contributed to this. There had been ten years of trial and error since the act was passed in 1947. Its defects of organization, as well as continuing inter-service friction over roles and missions, required executive and congressional decision-making. The second factor was much more stimulating. On October 4, 1957, the Soviet Union successfully launched the first manmade earth satellite. The shock of having been bested by Khrushchev's sputnik helped to catalyze action both in the White House and on Capitol Hill. President Eisenhower had no difficulty in getting congressional attention for the Defense passage in his State of the Union message to Congress on January 9, 1958. In fact, appropriate committees of the House and Senate had begun hearings and investigations even before the second session of the Eighty-fifth Congress convened early in January 1958.

The 1958 changes,[11] in addition to those items mentioned above, increased substantially the authority of the Secretary of Defense to transfer, reassign, abolish, or consolidate service and combatant functions, including roles and missions, within certain defined time frames and constraints imposed by the Congress. The act clarified the chain of command from the Commander in Chief to the service chiefs, and to them acting jointly. It added to the number and responsibilities of the Joint Staff of the JCS.

The services retained control of training, equipping, and organizing the forces for the unified commands and of all units and individuals not assigned to these commands. They were also responsible for logistical support to all forces. The 1958 reorganization also created a powerful instrument in the new Office of Defense and Research and Engineering (DR&E). Its director (DDR&E) "is the principal adviser and staff assistant to the Secretary of Defense . . . (for) scientific and technical matters; basic and applied research; research, development, test and evaluation of weapons, weapons systems, and Defense materiel; design and engineering for suitability, producibility, reliability, maintainability, and materials conservation." He supervises all research and engineering activities of the DOD "and in coordination with the Assistant Secretary of Defense for International Security Affairs helps friendly countries in military research and development."[12] Finally, the DDR&E was added to the Armed Forces Policy Council. The latter, originally (1947) called the War Council, received a change of name in 1949. Its members are the Secretary and Deputy Secretary of Defense, the three service secretaries, the Director of DR&E, the chairman and members of the JCS, including the Marine Commandant.

The accompanying somewhat simplified chart illustrates the National Security Act of 1947 as amended, 1947–1977.



the Act as amended and implications for the future

A rather significant body of experience and data has been gathered in the thirty years of history under the act. Two wars have been fought, one ending in stalemate and the other in defeat. We have survived the trauma of Watergate. We are at the beginning of the administration of the seventh President and the thirteenth Secretary of Defense since the act was first passed. The National Security Council has functioned always in accordance with the idiosyncratic will of the President and, as a matter of fact, so has the Central Intelligence Agency. The Congress has deposed its will mainly, as its constitutional right makes clear, through the power of purse over the defense budget and through derivative powers of six committees, three each for the House and Senate: Appropriations, Armed Services, and Foreign Affairs/ Relations.

The time has come for a "new look." The issues and the questions to be addressed are virtually the same as were examined during the debate attendant on the passage of the original act and its subsequent amendments. They are the following: The proper relationship between political civilian authority and military professionalism; the organization of the military for the most effective command and control functions; the assignment of roles and missions; the efficient mobilization of men/women and materiel; the elements of policy guidance from the Commander in Chief gathered together from relevant agencies (State, CIA, Treasury, Commerce, etc., and including Defense).

Put another way, one might ask:

Has "unification" worked under its present terms? Has it gone far enough or too far? What recommendations, if any, would be made if we had a chance to improve on the present order? Is DOD, as presently structured, an appropriate "solution"? Does DOD represent a balance between civilian control and military command and control, military professionalism? Are we any closer to clarification of roles and missions? Has the National Security Council worked well or otherwise? And what of the intelligence organization?

To address these issues and to seek answers to these questions—to take a "new look"—inevitably raise an anterior issue. How "scientific" or "objective" can the "answers" be? Some parts of some issues and questions can be tested and quantified and, where relevant, should be. However, while the efficiency of men and materiel is measurable, the outcomes are not always meaningful. Hence, it is here admitted that what follows is based on reason, experience, and value judgments necessarily tainted by the subjective lenses employed in taking a "new look." Further, there is the imponderable role of tradition and its partisans. Tradition, not always reasonable, absorbs change, if it does, slowly.

Interestingly, the issues concerning institutions established by the National Security Act (as amended) *outside* the Department of Defense are easier to treat than those of the department. Since the administration of President Truman, the National Security Council as a statutory body has served those presidents who wanted to use it. But most American presidents since Washington have utilized statutory bodies, e.g., the cabinet or personally selected advisers (e.g., "kitchen cabinets") at will. The NSC fits into such a category. What should be expected from a president whether he does or does not utilize a National Security Council is clear policy guidance to the Department of Defense and to the military, the *essential* element of that arm of government.

The military, indeed the Department of Defense as a whole, however upgraded as an organization, cannot function efficiently without national security policy guidance from the office of the President. To be told to prepare for fighting two and a half wars, as in the Johnson administration, or one and a half wars, as in the Nixon–Ford administration, hardly represents guidance. It can and should prepare for war against defined putative enemies. And the President, with or without the advice of a NSC or equivalent, is the source of such definition. The military in the present nuclear/space age cannot and should not prepare for war, as such. Inevitably, generalized and less than meaningful guidance leads to preparation for the worst case rather than for prudent preparation. Military doctrine must flow from policy guidance and from a clear-cut delineation of roles and missions so as to proceed eventually to military readiness. Our military must function as professionals—as do doctors, lawyers, engineers—who can best define their profession, but they can function optimally only when they are clear about policy guidance. That they should share in the formulation of national security policy or at least have their professional input in its making seems to me to be a necessary and appropriate solution for civilian-military relations. There is no wall of separation between civilian and military participation in defense policy-making though the civilian prime responsibility is readily acknowledged. It is time to disabuse ourselves of the view that somehow the soldier should be excluded from the political decision-making process. To participate is not to dominate. The so-called historical fear of the man-on-horseback should no longer be used to invalidate the subordinated but integrated role of the military in matters of defense policy. After all, that is their profession. Nothing should prevent the military from presenting its case, whatever the case may be, to the civilian Secretary of Defense and through him or directly to the Commander in Chief. The latter, it seems to me, is preferable.

In like manner, the Central Intelligence Agency as a peacetime institution is a necessary arm of the President/Commander in Chief. Its overt and covert functions are the logical extension in our own age of the historical and traditional functions of national and international diplomacy. If the CIA were no longer to exist, it would be necessary to invent its successor. What is involved, therefore, with respect to the future of any CIA is the need for agreed presidential and congressional definitions and oversight for its operations, its mandate to perform. The present CIA has been badly marred by the events of and the congressional investigations related to Watergate. Though the damage has been severe, now that the tumult and shouting have died down, it is time to take a calmer and fresh look at the intelligence function, including its ability to prepare national estimates for the President and the National Security Council. Very little tinkering with the National Security Act is required to bring this about.

When one takes a new look at the Department of Defense itself, the task of thinking about its future is more complicated. For the DOD, not unlike the Department of Health, Education, and Welfare, is a huge conglomerate, to use a business term. Its central legislated structure is the multisided Pentagon, but its not always harmonious parts have a global purpose, outreach, and positioning, subject to episodic, sometimes unpredictable, change. The way it is presently organized may prove to be unmanageable by any cabinet secretary even though its existence over the past thirty years has brought about some desirable unifying features.

The assets and liabilities of unification within the highly structured Department of Defense are best revealed by a brief examination of the McNamara era, for this strong Secretary of Defense ruled that roost for all but the last year of the Kennedy and Johnson administrations—the longest tenure of any defense secretary. McNamara insisted on centralized military planning on functional, not service, lines. His program packages were supposedly chosen on a cost-effective basis. He gathered into a Defense Supply Agency all possible common-use items previously acquired separately by the service departments. He required that all service-gathered military intelligence be funneled into one Defense Intelligence Agency reporting to the secretary. He combined the Army's Strategic Army Corps with the Air Force's Tactical Air Command into an operational Strike (now Readiness) Command for rapid deployment in eruptive contingencies. In brief, McNamara's era may well be characterized as one in which unification under civilian control (in matters of budget, manpower, logistics, weapon design and acquisition, other R&D, etc.) made maximum headway. He was an indefatigable civilian manager, with a vise-like mind capable of absorbing all the numbers of his whiz kids, his systems analysts, and his computers. If a proposition could be quantified, it was acceptable; if it could not, it was questionable. He seemingly did not absorb the nonquantifiable arts of politics and warmaking.

The liabilities of the McNamara era are equally clear. The military were downgraded and depressed, in both senses of the latter term, not only by the civilian authority of the secretary but also by the extravagant growth in numbers and assumed powers of the civilian DOD bureaucracy. Their military professionalism was frequently ignored even in terms of fighting in a theater of war, Indochina. "McNamara on Vietnam" is a serious causal factor in the tragedy of Vietnam, a tragedy in which President Johnson and some top "military brass" shared, as did, later on, President Nixon and his NSC adviser and Secretary of State, Dr. Henry Kissinger. In sum, the McNamara era produced a dangerous imbalance in civil-military relationships and policy-making while advancing the cause of centralized managerial unification.

Whether or not others share this view, it is still the case that the lessons of the McNamara era, including the lessons of the Vietnam war, require a cool analysis free from the partisanship engendered by the troublesome events of the 1960s. I suggest that such analysis warrants legislative and organizational changes in the DOD. Such changes to be truly effective would most certainly have to consider the possibility that the vasty deep of the Pentagon and its centralized management might require at the very least some decentralizing initiatives. Conglomerates in the business world sometimes acquire too much. They decide to sell off or split off certain subordinate assets. Or, antitrust actions force them, by order of the court, to divest themselves of certain operatives. The profession of the soldier—like that of the doctor or lawyer or engineer or other—is much too complicated to be mastered by one soldier (or sailor or airman); and certainly it is much too complicated to be mastered by one Secretary of (one) Department of Defense.

I DO not propose legislative change for its own sake. I believe, however, that the kind of analysis herein suggested could lead to a resolution of some of the troublesome issues revealed by the thirty-year history of the act. For example, it is necessary to clarify further the relationship between the civil and military authorities within the DOD; to address remaining interservice differences; to come to grips with the ever present problem of the budgetary process and its relationship to the allocation of always scarce resources of manpower, force structure, and research and development. If, further, there could be a satisfactory definition and assignment of military roles and missions, a major, if not *the* major, contribution would be made. Improvements between legislative and organizational relationships would necessarily have to be related to decisions with respect to mobilization of men and materiel. It is clear that the issues of modern warfare and advanced technology can no longer rely on the kind of mobilization of men and materiel that we successfully managed in World Wars I and II. Further, we have gone from conscript armed forces to a voluntary system, and voluntarism already reveals severe limitations. It is time to take a new look at the volunteer armed forces for at least two reasons: (1) It is failing to meet the manpower and readiness requirements of the services. (2) It consumes 55 percent of the total Defense budget. Once again we face the need for re-examining whether our present voluntary system of acquiring forces ready for all contingencies is adequate. Shall we move to a national service act or to a nonprejudicial draft procedure, eliminating some of the injustices that were so marked in the conscript system during the Vietnam war?

In my judgment the institution of the military cannot be modeled on just another business or civilian professional institution though I have suggested that we can learn something from the experience of business conglomerates and from other professions. The military, however, has no counterpart in our civilian society. It is unique if for no other reason than being the only institution in American society with the right and duty to kill if necessary, and be killed if necessary. Models drawn from civilian society, therefore, are not readily applicable to this unique institution.

I do not mean to suggest that all has been bleak in the thirty-year history of the act, nor even in the McNamara era—quite the contrary. What I am suggesting is that there has been, as is proper in a democratic society, an evolutionary history and that the process itself leads to the discovery of assets and liabilities. Or, to put it another way, new challenges arise out of experience—challenges which can be met by serious re-examination and decision. Surely, for example, the silly propaganda about the military-industrial complex and the problems created by new technology when applied to weapon systems should not obscure the wisdom of having a single departmental research and development section that seeks to meet the requirements of one or more services. There is no reason why Occam's razor, the principle of scientific efficiency, should not be applied in this instance to the military in this scientific age. Incidentally, in this connection, research and development for U.S. defense would be even better served if it was a shared enterprise with advanced industrial societies allied with us.

Since the reforms of the 1958 amendments and the extraordinary use of which those reforms were put during the McNamara era, there has been no serious public consideration of the Department of Defense as a whole either by the Chief Executive or the Congress. At this time we are not in any war-danger crisis. Hence, it may be altogether "fitting and proper," as Caesar wrote in his *Gallic Wars*, to use this period of relative quiet to take a new look at the ever continuing issue of how best to organize for the defense of our country; how best to assist our allies and friends; how best to acquire information about the threat from actual or putative adversaries; how best to preserve the historic and traditional relations of the civilian authority while guiding, acquiring, and supporting a military ever prepared to do and, if necessary, die for us all.

New York, New York

Notes

1. For a brief review, see Maurice Matloff, general editor, *American Military History* (Washington, D.C.: Office of the Chief of Military History, United States Army, 1969), pp. 101–10; and Harold and Margaret Sprout, *The Rise of American Naval Power 1776–1918* (Princeton, New Jersey: Princeton University Press, 1939), chapters II–IV, pp. 7–49.

2. There were also the militias of the several states. In 1792 the Congress passed the Militia Act which made every able-bodied citizen between the ages of 18 and 50 years a potential member of the militia, officered and controlled by the states but subject to one federal system replacing the 13 separate state systems. The Militia Act remained in force until the National Defense Act of 1916, which established a maximum for the Standing or Regular Army of 175,000; renamed the Militia the National Guard at 425,-000 men; and authorized a new Reserve Corps.

3. Sprout, p. 15.

4. See *The Military and Colonial Policy of the United States, Addresses and Reports by Elihu Root,* collected and edited by Robert Bacon and James Scott (Cambridge, Massachusetts: Harvard University Press, 1916). Pertinent excerpts appear in *A History of Military Affairs in Western Society Since the 18th Century,* edited with Introductions by Gordon B. Turner (New York: Harcourt Brace, n.d. [1952–53]), pp. 257–68.

5. See Sprout, chapters XI–XV, pp. 165–249. See also Margaret Tuttle Sprout, "Mahan: Evangelist for Sea Power," in *Makers of Modern Strategy,* edited by Edward Mead Earle (New York: Atheneum Press, 1966), pp. 415–45. (The first edition was published by Princeton University Press in 1941.)

6. The Senate Select Committee on Intelligence, under the chairmanship of Senator Daniel K. Inouye, succeeded in having the Senate pass (June 24, 1977) a first bill authorizing a separate budget for the intelligence community; other proposals will be forthcoming as the committee continues its work during its second year (1977–78).

7. For a brief overview at the start of "coalition warfare" see Herbert Feis, *Churchill, Roosevelt, Stalin* (Princeton, New Jersey: Princeton University Press, 1967), pp. 3–47. For a summary discussion of President Roosevelt, the American Joint Chiefs, and civil-military relationships, see Russell F. Weigley, "Military Strategy and Civilian Leadership," in *Historical Dimensions of National Security Problems,* edited by Klaus Knorr (Lawrence: University Press of Kansas, 1976), pp. 64–69.

8. The literature is voluminous. Among the relevant documents one might want to consult:

U.S. Congress (78th and 79th), House Select Committee on Postwar Military Policy, *Hearings,* April-May 1944; and June 1945. House *Reports* 1645 (June 15, 1944), 1923 (November 24, 1944), 505 (May 2, 1945), 857 (July 5, 1945), and 1356 (December 10, 1945).

U.S. Congress, House Res. 6066, Senate 2044, *Armed Forces Merger,* Senate Committee on Military Affairs, *Hearings,* April 30–July 11, 1946, Senate *Report* 1328, May 13, 1946; Senate Committee on Naval Affairs, *Hearings,* April, May, July 1946.

U.S. Congress (80th Congress, 1st Session) Senate Armed Services Committee, *Hearings,* March 18–April 3, 1947; Senate *Report* 239, June 5, 1947.

9. This declaration amplifies the general thrust of the language in the original act, Public Law 253, 80th Cong. See, Sec. 2, Public Law 216, 81st Cong. 1949 and Sec. 2, Department of Defense Reorganization, Act of 1958, Public Law 599, 85th Cong.

10. See Maurice Matloff, *American Military History,* pp. 531–33.

11. For a comprehensive review of these, see *United States Defense Policies in 1958,* July 10, 1959 (Washington: Government Printing Office, 1959), pp. 47–60; and Ibid., Appendix C, "Department of Defense Directive no. 5100.1, Dec. 31, 1958," pp. 115–20. For a brief review, see Maurice Matloff, pp. 582–83 and pp. 602–4.

12. Ibid., Appendix D, pp. 121–23.

Basis of Issue

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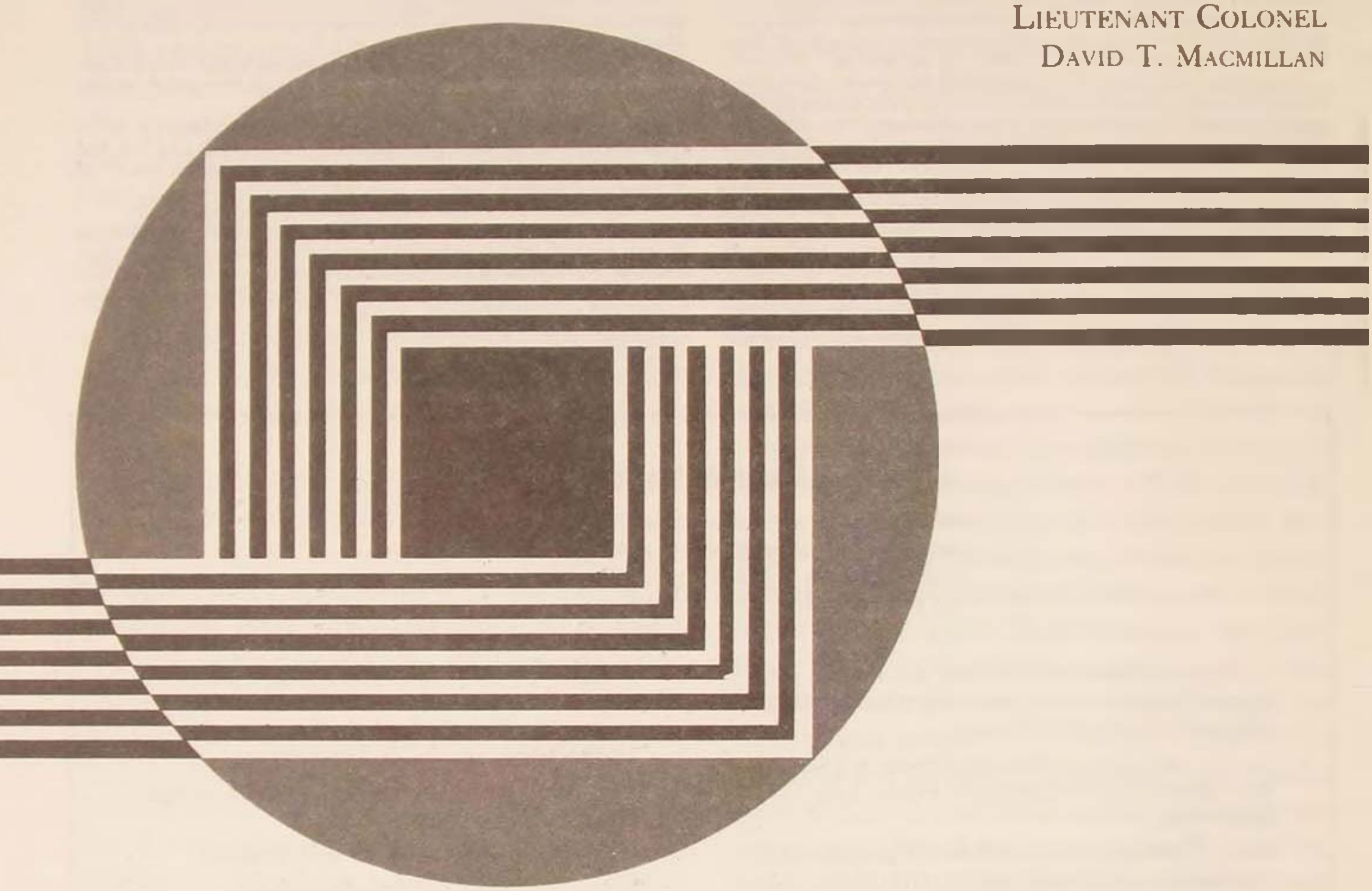
The Editor

TECHNOLOGY
the catalyst for doctrinal change

Lieutenant Colonel
David T. Macmillan



THE FIRST question that arises in any discussion of doctrine is, "What is doctrine anyway?" In answer to that question the preface to Air Force Manual 1–1, *United States Air Force Basic Doctrine,* 15 January 1975, states: "Aerospace doctrine is an authoritative statement of principles for the employment of United States Air Force resources. . . . Because of the wide range of missions and responsibilities assigned to the Air Force, different categories of doctrine are required." Basic doctrine is comprised of "the fundamental principles for the employment of aerospace forces. . . . " Operational doctrine governs "the organization, direction, and employment of aerospace forces in the accomplishment of the basic combat operational missions of strategic attack, counter air, air interdiction, close air support, aerospace defense, aerospace surveillance and reconnaissance, airlift and special operations. . . ."

The *United States Air Force Dictionary* (1956) expands on the terms as follows: Basic air doctrine is doctrine "concerned with the nature of air power, and with what can be, and what cannot be, done with it. . . . Basic air doctrine deals with the phenomenon of flight, with the new relationships that exist as a result of hitherto unrealized speeds, range, mobility, and flexibility, and their application to the principles of war, such as those of mass, dispersion, and surprise. . . . "

The dictionary shows a second sense that doctrine is "a teaching on how to do something, or on what to do in a given situation, cast in the form of a practical rule, command, or exhortation. . . . " Operational doctrine is defined in this latter sense; it "is evolved to give guidance in particular situations, ranging from how to fight a war, or from what limitations to place upon a command, . . . consideration is given both to currently accepted concepts of air power and war and to the particular plans entertained by the commander to adapt to these concepts." Basic air doctrine "changes only in response to a change in understanding of phenomena"; operational doctrine "may change with each new concept of how to do something."

Perhaps at this point one should ask, "Why be concerned about doctrine? Is not doctrine only the *history* of lessons learned?" USAF Chief of Staff General David C. Jones, in his preface to AFM 1-1, 15 January 1975, states, "Basic doctrine is derived from knowledge gained through experience, study, analysis and test. It evolves from changing military environments, concepts, and technology; and through continuing analysis of military operations, national objectives and policy." Thus experience is a necessary ingredient in formulating doctrine, but it is not sufficient. How can doctrine be structured to guide the future? We believe that the answer to this question must come by imaginative analysis of our experience in combination with prudent estimates of the nature of the future. A major influence on that future will be the emerging military capabilities represented by infant technologies.

The objective of this article is to describe some advancing technologies that are providing both a new understanding of important phenomena and stimulating some new concepts for tactical air warfare and, further, to encourage thought on the impact these technologies will have on Air Force doctrine.

Accelerating Technology

The basic tasks of warfare have remained relatively unchanged throughout history. We must be able to know where the enemy is, how to destroy or neutralize him, and how to protect ourselves while doing it. The methods for accomplishing those tasks have changed, slowly at first but lately with increasing speed. Fortress walls were an excellent defense against the bow and arrow and served for centuries. In relatively recent history, the advent of the cannon caused defenses to stress maneuverability. The moves and countermoves have continuously accelerated since then, paralleling the exponential growth of technology.

Few would deny that the evolution of technology has had a profound effect on Air Force doctrine. After all, the birth of the Air Force (actually the Aeronautical Division of the U.S. Army Signal Corps) was the result of the marriage of two technologies: aerodynamics and the internal combustion engine. Since the recent date (1903) of the first heavier-than-air flight, the rapid technological changes that have influenced and built the Air Force include the atomic bomb, the jet engine, and the intercontinental ballistic missile (ICBM). The rapidity of those changes has indeed been awesome.

The effects of accelerating technology have been stated brilliantly by Alvin Toffler, author of *Future Shock.* He explains that the reason for technological explosion "is that

Our surveillance is being transformed by the development of advanced sensors operating from various platforms. Some of these advanced sensor technologies have already had a strong impact on our strike capabilities. A beam of laser light can be used to designate the target and a sensor in the weapon for guidance to the target. USAF's Tactical Warfare Center (TAWC) project manager for the laser acquisition device (LAD) assists a fellow pilot in a preflight check-out of the LAD. Two models are being tested by Eglin's Armament Development and Test Center and TAWC.

technology feeds on itself. Technologies make more technologies possible. . . . The diffusion of technology embodying the new idea, in turn, helps generate new creative ideas. Today there is evidence that the time between each of the steps in this cycle has been shortened."[1]

Toffler goes on to describe the negative impact on individuals of the accelerating rate of change. He terms the collective impact of this change as "future shock," a condition that leads to an inability to adapt and function on the part of the victim. The victim may also develop one or more symptoms of maladaptation:

- Denial—the strategy of blocking out unwelcome reality; the flat refusal to take in new information.
- Specialism—narrowing of the slit through which one views the world; an attempt to keep pace with change in only one specific, narrow section of life.
- Reversion—a clinging to previously programmed decisions and habits with dogmatic desperation.
- Oversimplification—the belief in a single neat equation to explain the complex novelties of a rapidly changing society.[2]

Toffler stresses that organizations are similarly affected by future shock. He further states that the only way to avoid the disabling effects of shock is to look into the future so that we can understand and cope with the new world today.

If the reader doubts that an organization as large and forward-looking as the Air Force could experience future shock, we invite him mentally to review his circle of acquaintances (as well as himself) and count the number who exhibit at least one of the symptoms cited above.

The task of making Air Force doctrine a sound foundation for the application of U.S. air power is one that demands our best efforts. We must apply the lessons of experience to our vision of the future, despite the fact that this vision is, at best, very dim.

Tactical Implications of New Technologies

The evolution of tactical air warfare into the missions of counterair, air interdiction, close air support, aerospace surveillance and reconnaissance, airlift, and special operations has been the result of our experience in four major wars. Technological improvements made it possible to develop the specialized equipment and tactics to perform each of those missions. At first, the airplane merely enabled an easier, more accurate assessment of enemy force disposition. As technologies advanced, aircraft were able to fly farther with heavier loads—they could drop bombs to support land forces. The capability for defending against enemy aircraft was developed, and counterair was born. Interdiction became possible with long-range aircraft and more accurate navigation and bombing.

As technology enabled these missions to be performed and as experience was gained, individual and integrated doctrine for their use evolved. Our operational doctrine that separates the classical tactical missions has served us well. However, it must not remain static. Emerging technologies are tending to blur those classical distinctions. In order for doctrine to remain viable, it must keep pace with technology. An examination of some new technologies and their implications for doctrine is a logical first step.

The development of solid state electronics was the major technological breakthrough that spawned many current revolutionary advances. Starting with the discovery of the transistor in 1947, this field has rapidly progressed to today's integrated-circuit technology and large-scale integration (LSI) manufacturing techniques. This breakthrough has been most apparent in computer technology.

The past twenty years have seen orders-of-magnitude increases in computing speed, memory capacity, access time, and reliability. At the same time, the physical size, power consumption, and cost of computers have decreased by several orders of magnitude. Today's integrated circuits the size of a sugar cube have the same computational capacity of early computers weighing thirty tons. Similar advances are forecast for the future.[3]

Also spurred by solid state advances, electro-optics technology has led to many important developments. These include low-cost, compact television cameras, laser designators, infrared imaging devices, fiber optics, and ring laser gyros. A major advance in sensor technology was achieved through the development of charge-coupled devices (CCDs) used in miniature TV cameras. CCDs provide self-scanning, which eliminates vacuum tubes, electron beams, and filaments. Although only the size of a thumbnail, they contain more than 200,000 detectors and provide greater range and sensitivity to low-light-level viewing.[4]

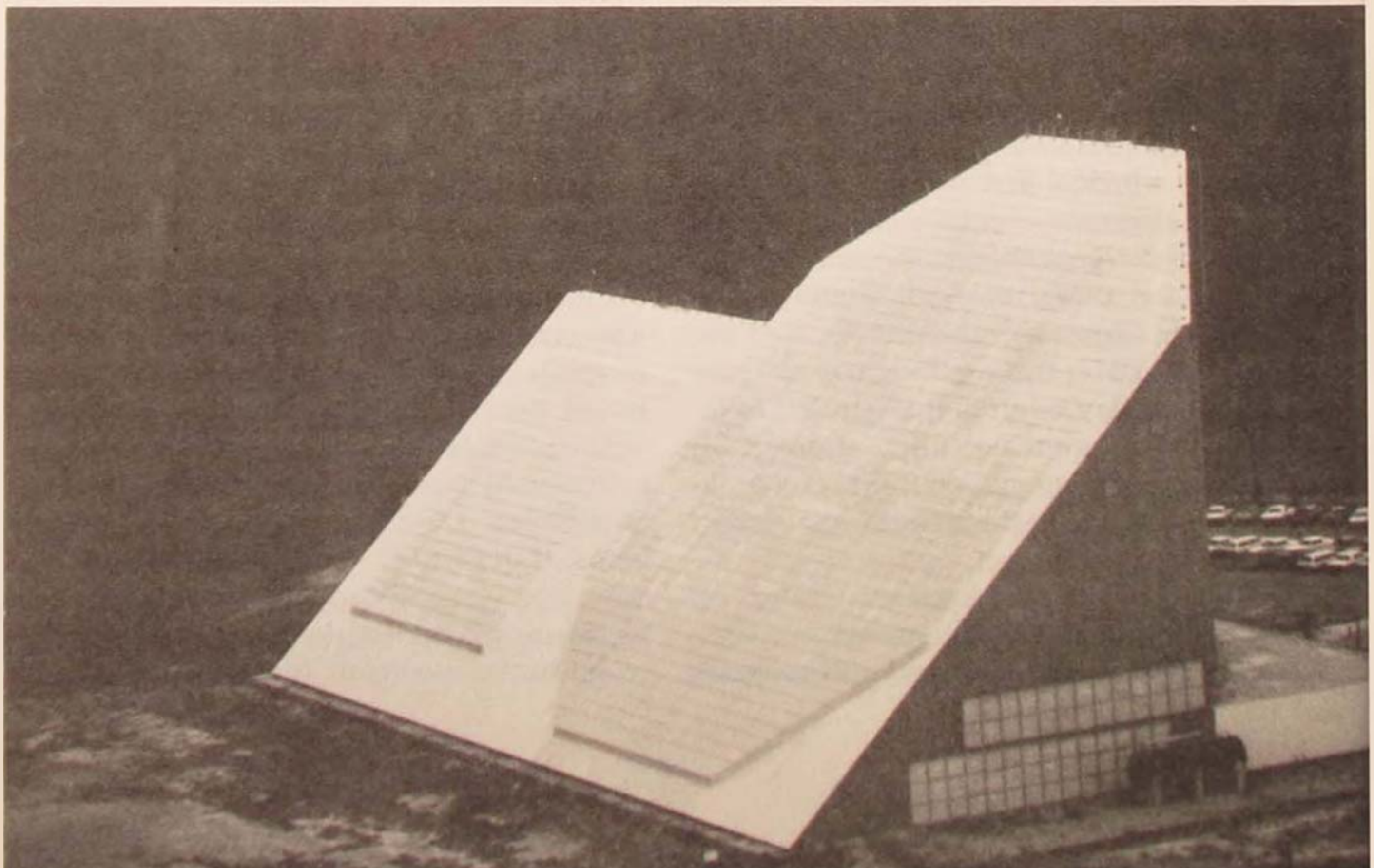
Radio-frequency and microwave technology is continuing to improve radars and communications. Again, solid state devices are fundamental to these developments. For signal generation at frequencies from ultrahigh frequency (UHF) to millimeter wave, low power requirements are now being met by solid state sources rather than klystron vacuum tubes. Low-cost, efficient, high-capacity signal processing is now available by using surface wave acoustic filters and CCD delay lines, together with microprocessors. As a result, highly capable phased-array radars have been developed. In addition, millimeter-wave radars are being designed for a variety of applications. These will provide high resolution, jam-resistant tracking.[5]

The implications of these and other technologies on our tactical capability are profound. Our ability to conduct surveillance is being transformed by the development of advanced sensors operating from various platforms. Using frequencies across the electromagnetic spectrum, these sensors will detect detailed enemy force disposition and movement. Advanced synthetic aperture radars may permit a significant improvement in cell resolution. An advanced airborne system could remain in friendly airspace and observe enemy activities from several kilometers away with near-photographic clarity at night or in bad weather. Highly complex signal processing and storage functions will take place in small, reliable, and relatively rugged devices. The information provided by such a system could be sent via data link to a fusion center, either on the ground or in an airborne center if survivability is too low on the ground. At the center, information from intercepted enemy communications and other intelligence sources could be correlated and analyzed in near real time to keep the commander continually aware of enemy movements. As sensor capabilities advance, eventually the missions of surveillance (continual observation) and reconnaissance (periodic observation) could merge. Then, when a target is located and the theater commander makes a decision to strike, the same sensor network can be used to guide and monitor the strike.

Some of the same advanced sensor technologies that will enhance the surveillance and reconnaissance missions have already made a drastic impact on strike capabilities in the form of precision-guided munitions (PGMs).

A PGM can be defined as:

The Defense Department charged USAF with developing two phased-array radars: one to increase radar coverage of advanced threats and provide better attack characterization information; it is to be augmented by AN/FPS-85, the Space Track radar at Eglin AFB, Florida, shown in aerial view. The FPS-85 consists of more than 5000 radar emitters and transmitters built into the face of a building that is a city block long and thirteen stories high. The octagon-shaped surface of the phased-array radar at Eglin is the receiver, and the square area is the transmitter.



> A guided munition whose probability of making a direct hit on its target at full range (when unopposed) is greater than a half. According to the type of PGM, the target may be a tank, ship, radar, bridge, airplane or other concentrations of military value.[6]

The precision of these munitions can be achieved using a variety of technologies. Some weapons use a beam of laser light to designate the target and a sensor in the weapon for guidance to the target. Others are guided by the target signature in the visual or infrared light spectrum. Advanced systems will be able to guide on the microwave signature of the target. In bad weather or at night, future weapons may be guided to the near vicinity of the targets using signals from the space-based Global Positioning System, accurate to within tens of feet. Alternative technologies will provide accurate guidance systems which correlate "maps" of the target or the route to the target with the signature received by an onboard radar, infrared, visual, or microwave system.

For the myriad transmitting targets the transmission itself can pinpoint target location, and advanced systems such as the Precision Emitter Location Strike System (PELSS) can pinpoint and guide a strike force to an emitting target even if transmissions cease after the strike force is launched.

Advanced technology will also help combat the high risks associated with penetration of heavily defended enemy territory and the high costs associated with the increasingly sophisticated systems required for penetration. The solution can be a force of standoff weapons with various ranges—from a few miles for a glide bomb such as the GBU-15 to several hundred miles for weapons powered by rocket or air-breathing engines. When these weapons are employed against targets that are difficult to locate and acquire, the advantages of man-in-the-loop can be added through a data link from the standoff weapon to a pilot. This weapon now becomes a remotely piloted vehicle (RPV). RPVs can be fairly complex, sophisticated vehicles recovered after each mission and used repeatedly, or they can be relatively unsophisticated, inexpensive expendable devices used on only a single mission. The effectiveness of all these weapons has been improved by the recent developments of highly efficient warheads that have great destructive potential but are lightweight.

S. J. Dudzinsky, Jr., and James Digby, of the Rand Corporation, have described the impact of some of these technologies in conjunction with military hardware. They describe airborne lasers, for example, that use frequencies just below the visible-light spectrum to guide weapons with great accuracy; small, light RPVs guided even during the terminal phase and thus independent of conditions at time and place of launch, so long as the data link is maintained. As Dudzinsky and Digby indicate, a number of these technological applications were used with dramatic success toward the end of the Vietnam war and during the Arab-Israeli War of October 1973, and many of them are "relatively inexpensive" and "relatively simple to operate."[7]

The Impact of Changing Technology

The outline of the future is discernible if we examine the impact of these technologies. In the face of sophisticated air defenses, traditional rollback tactics to achieve significant air superiority or air supremacy may be obsolete. Even if we can win the air battle, we may have lost the ground battle and, therefore, the war.

On the other hand, in the far term the technologies described above can be developed into an effective force with the following attributes:

- A continuous capability to acquire

and strike targets regardless of the weather.

- A command and control structure fusing target information and strike force status in near real time.
- RPVs which are dispersed for survivability and which can react almost instantaneously to a strike order.
- Standoff weapons that are relatively immune to air defenses.

The overall impact of such capabilities will be to blur the distinction between classical missions. The traditional air warfare sequence of air superiority, interdiction, and close air support may disappear. Forces will be orchestrated in a complex way to strike targets simultaneously or at an opportune time. "Campaign" may no longer be a useful description of an element of war. Weapon systems will lose their association with particular "missions." Apportionment and allocation of effort will be a continuous rather than a periodic process. Air-delivered weapons will be timed more like artillery but at much greater ranges. Few sorties will be preplanned, and long periods for gathering and correlating information for flight planning will be unnecessary.

In a typical concept of operations the key element will be the orchestration of sensors and electronics which will gather, process, and distribute battle and target information in almost real time and simultaneously produce a common coordinate grid to locate targets and guide weapons. The information will be fed directly into battle centers—either ground or airborne—as will information on the status of friendly forces. Battle center controllers will allocate targets to weapons that will be essentially on alert. Any required flight information as well as target location will automatically be entered into the controlling avionics of the weapons. The weapons will navigate to the target, using the coordinate grid and terminal guidance either by self-contained or external system.

Within such a concept, air-delivered firepower becomes a continuous process. Weapon controllers can respond almost as rapidly as a soldier who sees a threat and immediately shoots at it. With such a rapid response and probability of kill equal to ground-based direct fire weapons, the need for direct and indirect fire weapons on the ground will decrease. Air power will no longer supplement ground power. Rather, air and ground missions will merge and complement each other.

As we have observed, doctrine is of significant importance to the Air Force, and, hopefully, we have ignited some sparks of thought about the implications of new technologies to our existing doctrine. Those sparks may develop an illuminating fire and inspire a modern thinker to emulate the great Italian theoretician Guilio Douhet, who examined the fledgling aircraft and envisioned a doctrine of strategic air warfare before the existing technology could match his ideas. He applied the elemental truths extracted from his experience to a vision of the future. He forged concepts which the technologists took many years to validate. We need someone like him today.

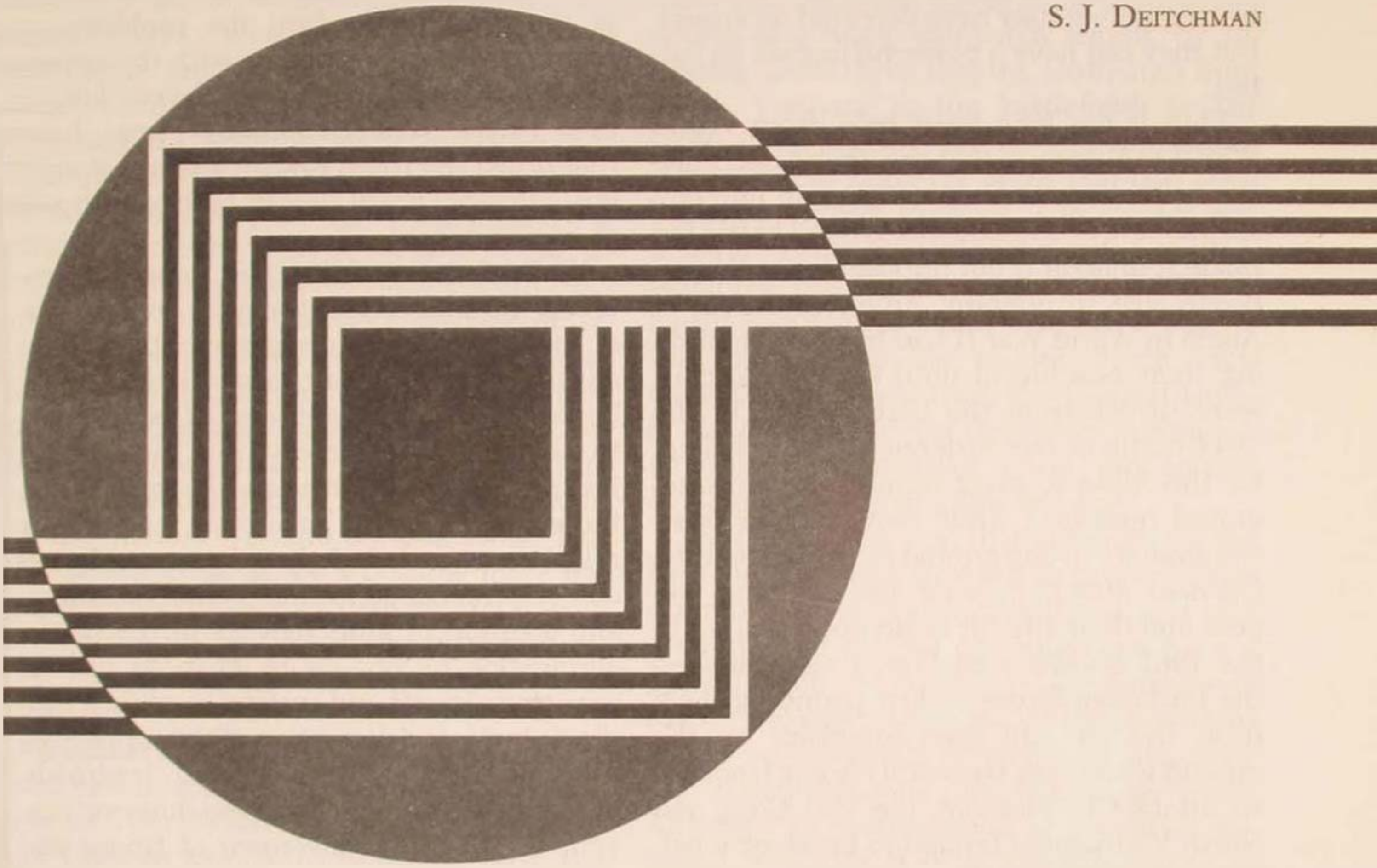
Andrews AFB, Maryland

Notes

1. Alvin Toffler, *Future Shock* (New York: Random House, 1970), p. 27.
2. Ibid., pp. 319–22.
3. R. Turn, *Air Force Command and Control Information Processing in the 1980s: Trends in Hardware Technology* (Santa Monica: Rand Report R-1011-PR, 1972), pp. 1–15.
4. Dr. Malcolm R. Currie, "Electronics—Key Military 'Force Multiplier,'" *Air Force Magazine*, July 1976, pp. 41–42.
5. Ibid., pp. 42–43.
6. This definition is slightly modified from one given by James Digby in *Precision-Guided Weapons*, Adelphi Paper No. 112, The International Institute for Strategic Studies (London), Summer 1975, p. 1.
7. S. J. Dudzinsky, Jr., and James Digby, *The Strategic and Tactical Implications of New Weapons Technologies* (Santa Monica: The Rand Corporation, 1976), pp. 6–8.

THE IMPLICATIONS OF MODERN TECHNOLOGICAL DEVELOPMENTS FOR TACTICAL AIR TACTICS AND DOCTRINE

S. J. Deitchman



LITTLE can be said about the characteristics and component functions of new weapons and aircraft that is not already generally well known from reading trade journals such as *Aviation Week*. In recent years, however, I have been able to participate in extensive analyses of the quantitative relationships among these weapons and aircraft and the tasks they must accomplish. Such analyses can help generate perspective not available from simple comparisons of the numbers and characteristics of individual systems. It is this integrated view of current and future directions in the evolution of tactical air power that I will focus on in this article.

The rapid advance of technology raises uncertainty and concerns about the use of tactical air power today. In part because of the claims of some proponents of air power,[1] there has been in the past, both remote and recent, a tendency to expect that it can, *by itself,* win key battles and wars. Experience has shown that this expectation is seldom realized. Air forces occupy no territory, and by themselves they have defeated no armies. But they can have a powerful impact on battles.

Thus it has long been true, from World War II to Vietnam, that the unopposed ability of aircraft to deliver weapons in immediate support of one side in a ground battle has made it difficult if not impossible for the opposite side to operate. American forces at Anzio in World War II had trouble establishing their beachhead until German aircraft were driven from the battle area.[2] In the 1944 battle of the Ardennes, it was difficult for the Allies to exert immediate and integrated resistance while moving their overwhelmingly strong ground forces to meet the German attack because the weather was poor and their aircraft could not operate.[3] In the 1967 Middle East War, Israel defeated the Jordanian forces by first pounding them from the air and then attacking on the ground while they were still reeling from the air attack.[4] In Vietnam, the Viet Cong and North Vietnamese tended to break off a battle on the ground when American or South Vietnamese forces received direct air support. The strong use of air power was largely responsible for preventing besieged Khe Sanh from becoming a little Dien Bien Phu.[5]

The use of air in this manner, however, is controversial among the Western world's air forces. The controversy arises from the difficulty of achieving the necessary close coordination between the ground and the air forces, especially in highly mobile war and particularly if air tactics dictate very-low-altitude flight to evade the defenses, since under those conditions target acquisition and avoidance of fratricide are extremely difficult. Less concrete, but nevertheless important, each air force has its "style" and plans for combat under particular conditions consistent with that style. An Israeli Air Force colonel remarked to me after the 1967 war that the Israeli armed forces at that time did not believe in using precious and expensive aircraft as cannon. But, in fact, the problems of economy of force, together with the opportunities for rapid massing of heavy fire, in most of the Western military forces, have reinforced the trend toward less use of artillery and more use of aircraft for close support of engaged forces.

While the desirability and means of providing close air support may be controversial, there has been no disagreement about the advantages of using air to attack the enemy beyond the immediate area of conflict between the ground forces—from the distance just past artillery range and beyond. Here, targets and missions have been many. They range through destruction of command posts and communication centers; disorganization and attrition of units moving to the battle; elimination of long-range weapons such as opposing aircraft and surface-to-surface missile systems; and disruption of the supporting transportation system—roads, railroads, bridges, tunnels, junctions—to delay or prevent the forward movement of troops and supplies.

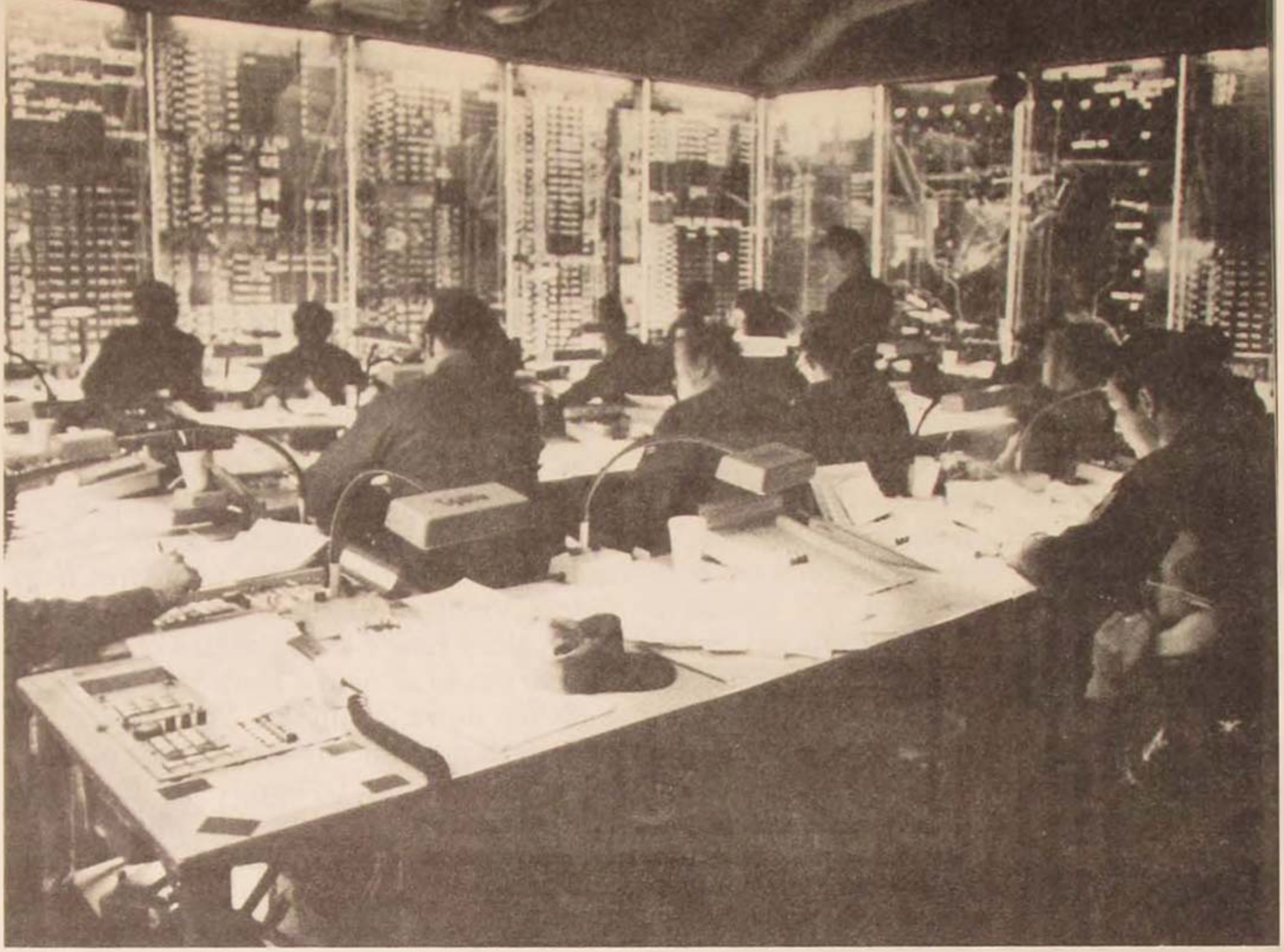
The effects of tactical air attacks in the enemy's rear tend to be more ambiguous and difficult to establish, however, than the effects of direct support of "troops in contact." The Germans felt that the Luftwaffe, in 1940, had protected the flanks of their advancing columns against French counterattacks.[6] The Allied air attacks against German installations and communication lines in France succeeded in cordoning off a large area around the invasion zone in 1944, making it difficult for the Germans to shift their forces to meet the invasion and requiring them to incur the delays attending their ability to move only at night.[7] This mode of using tactical air benefited considerably from the lessons of Operation Strangle, which had taken place earlier in Italy in 1944. This operation was supposed to prevent resupply of the German defensive Gustav line south of Rome. It did not succeed in doing that. Yet it was found afterwards, in the outcome of the battle and when the records on both sides were examined, that the extensive bombing of the supply and transport routes had prevented the German commander, Field Marshal Kesselring, from shifting units to and across the front in the face of the Allied offensive, and thereby made a critically important contribution to the success of the Allied drive north. (Even during the battle, Sir John Slessor, the Deputy Air Commander in Italy, noted that "supply denial could not be achieved without the need for ground action that would impose heavy consumption on the enemy." He also became aware that "air power could make a possibly more important contribution by denying the enemy armies their power of movement while under attack, when mobility would be at a premium."[8])

A similar attempt at supply denial in Korea (also called Operation Strangle), in the summer of 1951, failed to prevent resupply by the Chinese and North Koreans. But it did force them to move troops and supplies at night and to make extensive efforts to camouflage those movements, at a cost in prosecuting the war which we cannot know.[9] Similarly, in Vietnam (leaving aside the quasi-strategic aspects of the air campaign, designed to persuade the North Vietnamese that they did not want to pay the price for continuing the war, or to act as a "bargaining chip" in negotiations),[10] the bombing campaigns in North Vietnam and Laos failed to stop North Vietnamese support of the war and resupply of their own and Viet Cong forces in the south. But this support clearly required a large effort on their part, with extensive losses, to keep adequate supplies moving into South Vietnam along the Ho Chi Minh Trail. More important in the long run, and not commonly recognized, the incessant bombing and gunship missions against the road net in Laos prevented rapid reinforcement of Communist forces in the south in the course of a single campaign season, by requiring about three months' footmarch from North Vietnam to the battlefields in the south along jungle trails, instead of a week's ride in trucks along the roads that had been built for moving supplies. The impact was illustrated dramatically in the spring of 1975, when this restraint no longer acted, and the North Vietnamese could take advantage of the confusion of the sudden South Vietnamese withdrawal from the Central Highlands to bring the war decisively to Saigon's environs with massive troop movements along good roads in a few weeks.[11]

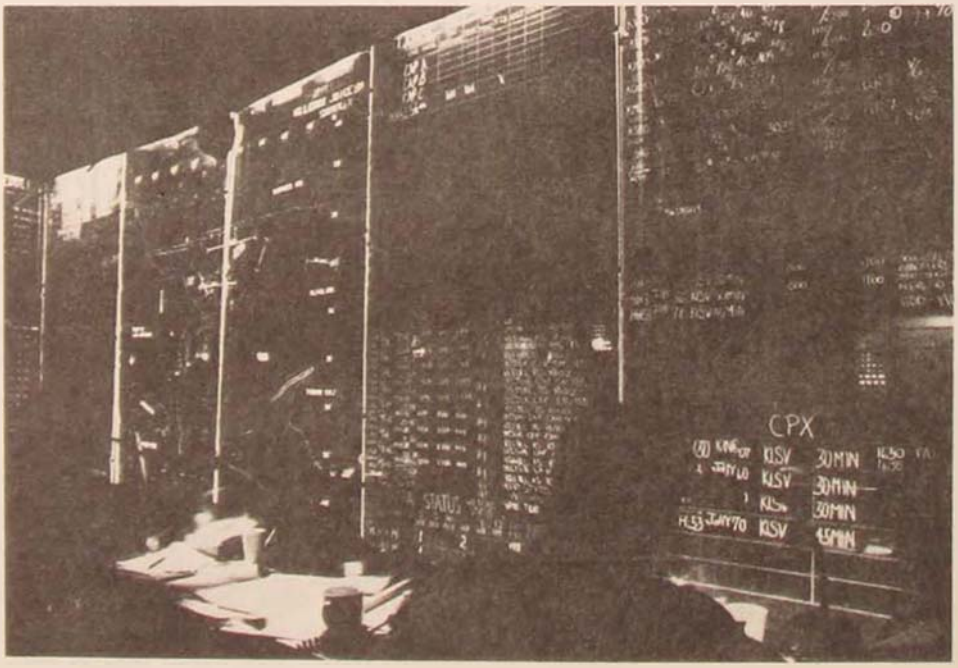
Thus, it can be seen that although on the battlefield "victory through air power" *alone* is illusory, tactical air operating as part of a concerted air-ground campaign can have a powerful and direct effect on the outcome of battles and more subtle but no less important effects on sequences of battles by attacking the communications zone behind the front. Although in consideration of a conflict between two sides, both of which have extensive and effective air forces, the drive to gain air superiority by destroying the other side's aircraft has come to symbolize the struggle between air forces, it is clear that this effort is supportive of the primary mission. Air superiority or supremacy is needed to allow one side's own air force to have the desired effect on the ground battle and to prevent the air forces of the other side from doing the same.

There have been, since the mass use of air

Continued on page 28



Operation Bold Eagle '76, a joint task force exercise conducted at Fort Erwin, California/Nellis Air Force Base, Nevada, in early 1976, provided training in simulated desert combat. Reserve and active units gained experience with recent military technological developments like those in the Direct Air Support Center (DASC), seen in overall interior view (above) with a closer look at status boards (below).



During Operation Bold Eagle '76, a mobile radar unit (above) was the Forward Air Control Post (FACP). Deployed to Angel's Peak, Nevada, the unit provided radio and radar support for the exercise. . . . Troops were airlifted from Texas to California, and combat controllers (left) visually located a C-141 and gave landing instructions. . . . The interior of the FACP (below) was technologically a far cry from the desert warfare of World War II.

power in World War II, many arguments about priority in the air-to-ground war. Until recently these arguments generally took the approach that air superiority must be gained first, with subsequent attacks against the ground. The following quotation is typical, and although it dates from 1943 it expresses views still held in many air forces (including, until very recently, parts of the U.S. Air Force):

> 16. MISSIONS.—a. The mission of the tactical air force consists of three phases of operations in the following order of priority:
>
> (1) First priority.—To gain the necessary degree of air superiority. This will be accomplished by attacks against aircraft in the air and on the ground, and against those enemy installations which he requires for the application of air power.
>
> (2) Second priority.—To prevent the movement of hostile troops and supplies into the theater of operations or within the theater.
>
> (3) Third priority.—To participate in a combined effort of the air and ground forces, in the battle area, to gain objectives on the immediate front of the ground forces. . . .
> Airplanes destroyed on an enemy airdrome and in the air can never attack our troops. The advance of ground troops often makes available new airdromes needed by the air force. Massed air action on the immediate front will pave the way for an advance. *However, in the zone of contact, missions against hostile units are most difficult to control, are most expensive, and are, in general, least effective.* Targets are small, well-dispersed, and difficult to locate. In addition, there is always a considerable chance of striking friendly forces due to errors in target designation, errors in navigation, or to the fluidity of the situation. Such missions must be against targets readily identified from the air, and must be controlled by phase lines, or bomb safety lines which are set up and rigidly adhered to by both ground and air units. *Only at critical times are contact zone missions profitable.*[12]

However , such views are currently changing because of the recognition that wars where both sides can use their air forces may not (as will be illustrated quantitatively later) last long enough for the sequence to be enforceable. Thus it is now accepted that, particularly against superior forces, it may be necessary to undertake air-to-ground warfare and the attempt to gain air superiority simultaneously.[13] But all these arguments have the same end in view: maximizing the opportunities for observing the enemy's dispositions and movements and carrying firepower against his ability to wage war on the ground.

Since World War II there has been considerable evolution of the techniques of air warfare, in keeping with the changing capabilities of both the aircraft and the defenses against them. Air attacks against ground targets on and beyond the battlefield have become complex operations requiring extensive communication, theater-wide coordination, and massive support.

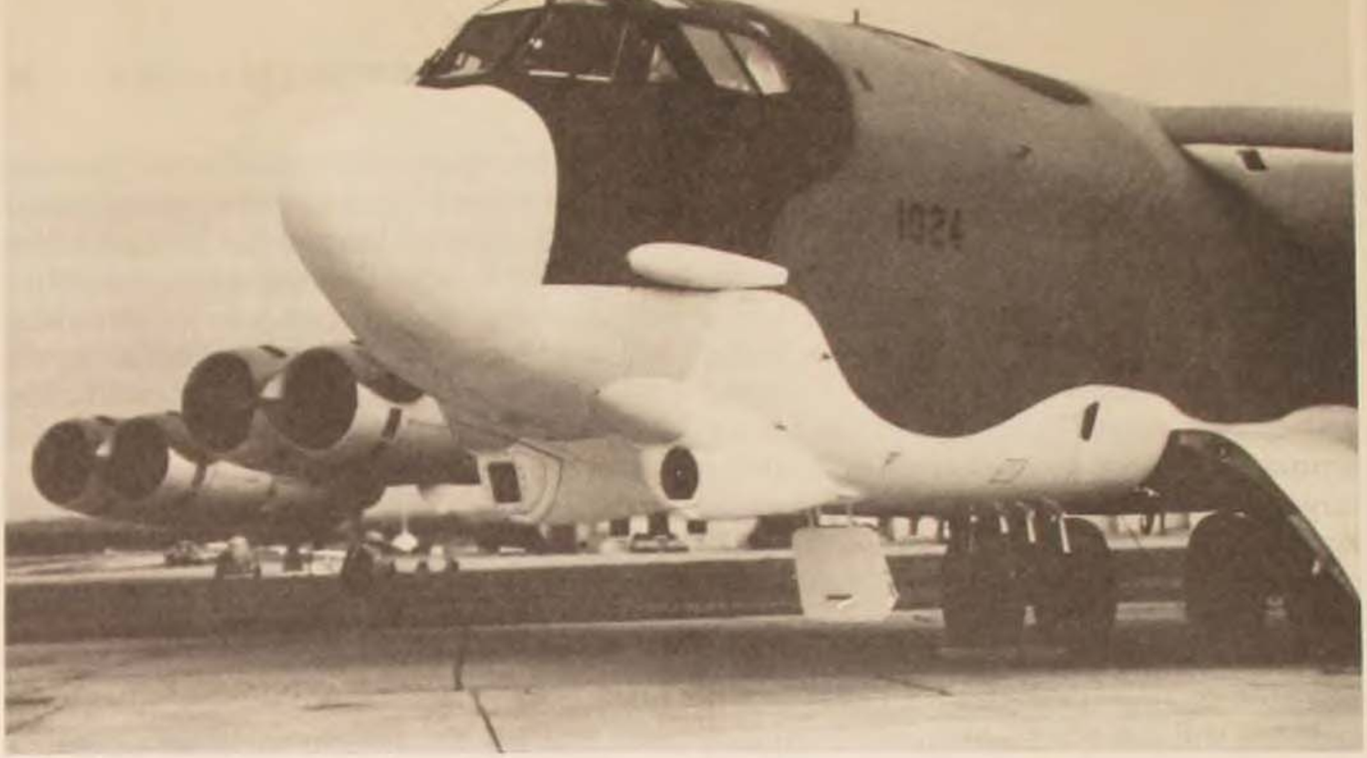
To provide direct support of troops under fire, friendly forces must explicitly designate the individual targets for air attack. In the last years of World War II, and in Korea and Vietnam, where close support aircraft did not face significant air or surface-based opposition over the battlefield, the light, slow forward air controller (FAC) aircraft flying at fairly low altitude came to fulfill this role. The designation of targets for close support can, of course, also be performed from the ground. A ground observer or ground FAC is likely to be much more restricted in how far he can see than an airborne FAC—perhaps two to four kilometers in open country and possibly much less in the heat and smoke of battle—and at critical times he may be in imminent danger of being overrun. But since he is in intimate contact with the battle, he may be required to act because the airborne FAC is not available.[14] In the future, forward observers or FACs on the ground (or in the air, if they are not driven away by the defenses) are likely to be equipped with laser designators. With laser spot seekers in the aircraft, conversion to attack then requires little further communication with the FAC, thereby greatly increasing the rapidity and efficiency of the attack sequence.

The growing power of ground-based air defenses has thrown the viability of the slow airborne FAC into question. The FAC in a fast airplane would also be vulnerable to the defenses if he must orbit in search of targets, and if he must move as part of the attack formation, he may have as great difficulty in target acquisition as the other pilots. Often, however, this "fast FAC" may be the only carrier of the target acquisition means—such as a Pave Tack FLIR/designator pod for night attack—and then he would be indispensable. In close air support, he would nevertheless still face the problem of identifying objects as enemy targets. For reasons such as these, there is experimentation with small, hard-to-detect remotely piloted vehicles,[15] which can carry various sensors and laser designators and which, it is hoped, may in time be able to replace the vulnerable airborne FAC in the close air support system.

The provision of close air support calls for continuing and extensive efforts to solve the problems posed by ever evolving weaponry and tactics. Interservice coordination on the battlefield, the determination of target priority when there are limits on the numbers and availability of close support aircraft, procedures to determine whether and when air is to be called in—all are problems requiring continuing attention. The controversies of the mid-sixties and early seventies regarding the choice between Air Force fixed-wing aircraft and Army helicopters for close support arose from these adjustments.[16] However, the U.S. Air Force's commitment to provision of close air support was confirmed in the crucible of war—during the years of Vietnam as well as in Korea—and most recently with the adoption, in 1974, of the A-10 aircraft specifically for this purpose. Vietnam also proved the value of the armed helicopter, which was able to operate in unique ways not available to fixed-wing aircraft, and today the controversies are muted with the two types of aircraft filling complementary roles.

For attacks well beyond the forward edge of the battle area (FEBA), air forces must obtain and evaluate target information without assistance from ground combat units, although the progression of the ground battle will influence surveillance and reconnaissance priorities. The data obtained by aircraft having various sensors—"eyeballs," cameras, radar, direction-finding equipment—all have different formats, precision, and time constants, and they must be processed and combined with other intelligence to produce information on the enemy, his weapons, and his movements in sufficient detail and in good time for planning effective air attacks. The rapidity of maneuver expected in war between armored forces—for example, a unit thirty to fifty kilometers to the rear of the FEBA might enter the battle in a few hours, or a missile launcher even farther back might fire at any time—requires great effort, in research and development and operational training programs, to improve the quality, focus, and timeliness of combat intelligence and target information. The problem, of course, is that the cost of the information increases dramatically as the time from sensing to presenting processed data for use decreases.

For example, as the task has been configured, an aircraft with a relatively inexpensive camera or a side-looking radar flies its mission, returns home, a recording film is developed, analyzed by photointerpreters, and the information sent to the commander, who must merge it with other inputs and then decide on target allocations. The entire process consumes from one to six hours, and during this time the armored unit mentioned earlier may have entered the battle, achieving surprise and perhaps decision. If it is desired to have the detailed information for analysis within a few minutes from the time the aircraft observes the armored unit (and



A B-52H, parked on the runway, is equipped with an AN/ASQ-151 Electro-optical Viewing System (EVS).

the unit may or may not be disposed so it is visible to the pilot*), automatic developing and scanning equipment and a data link, the latter designed to be electronic countermeasure (ECM) resistant, can be associated with the camera or radar on the aircraft. All of this equipment would raise the cost of the on-board equipment, while the photointerpretation and data distribution system on the ground, as well as the C^3-associated decision delays, would still be present. The provision of computers for information processing, synthesis, and display as well as jam-resistant communications links to transfer the data, all add to the cost, increasingly so as their capacity and timeliness increase. The attending centralization of functions also increases the vulnerability of the entire system to degradation or elimination by enemy attack.

*During the planning for the Market-Garden operation in World War II, two German armored divisions moved, unknown to the Allies, into the vicinity of Arnhem. The few observations and isolated tank photographs by reconnaissance pilots were not persuasive enough to affect the plans for the operation. See, Cornelius Ryan, *A Bridge Too Far* (New York: Popular Library, 1974), pp. 158–63.

All this, it might be noted, simply provides information of varying precision about a kind of target and where it was last seen. The attack pilots who arrive after some delay—length depending on whether they were in loiter or on the ground—must, in current circumstances, reacquire the target for attack when they arrive in the target area, if it is still there and in a form that matches the earlier description. Of course, in some circumstances on a dynamic battlefield populated by numerous forces, it may be possible to use a fixed reference that persists for some time. For example, if extensive traffic is moving through a road junction over a period of time, it may be sufficient, and may have an even greater impact on the battle, to designate anything found in the crossroads, rather than specific units, as targets.

In the attacks following target location and fragging of missions, many of the available sorties will engage in other than direct strike duties. Given the requirements for combat air patrol, defense suppression, and escort and standoff ECM support, the total number of aircraft engaged in a strike operation can exceed by a factor of two to four those actually involved in attacking primary targets on the ground. Moreover, in a surge situation such as that which might attend a breakthrough attempt by Warsaw Pact forces in a European war, several hundred attack sorties might be required in a few hours in the narrow space of a corps front and a few tens of kilometers beyond it.

The "command pyramid," including the tactical air control center, direct air support centers, and forward air control parties—all with interconnecting communications among themselves, to the ground forces, and to all the aircraft—has grown to facilitate the integration of information and close coordination required in such air operations. Further evolution will be necessitated by developments in both offensive and defensive weaponry.

Once all this complex mechanism, whose objective is to have a significant impact on enemy fighting capability, has been established, it would be desirable if it indeed had the intended effect. However, while aircraft attack performance has continued to improve, as shown in Table I, a persistent limi-

Table I. Comparative performance indicators of fighter-bombers, 1942–1976

		Approximate Performance[2]		
Year	Aircraft	Combat Speed (knots)	Radius (nautical miles)	Weapon Load (typical)
1942	A-36 Invader (version of P-51A)	280	150–200	4 .50 cal guns 2 500 lb bombs
1944	P-51 H (fighter-bomber version)	350	400	6 .50 cal guns 2 1000 lb bombs
1955	A-4C[4]	500	600–800	2 20-mm cannon 3 store sta capable of 5000 lb bomb load
1960	F-4B[4]	500[3]	850	16,000 lb of payload (e.g., 11 1000 lb bombs, or bombs plus gun pods and rockets)
1975	A-10 A	390	250 + 2.2 hours loiter over battlefield	30-mm, 6 barrel Gatling gun + 16,000 lb payload on 11 store stations

1 Source: *Jane's All the World's Aircraft* for the years indicated
2 These are simply indicators of performance which do not especially go together
Speed is less than maximum; radius with heavy weapon load would be less than shown
3 Arbitrary ground attack speed; aircraft capable of Mach 2 performance
4 These aircraft (as later versions) are still active in the forces

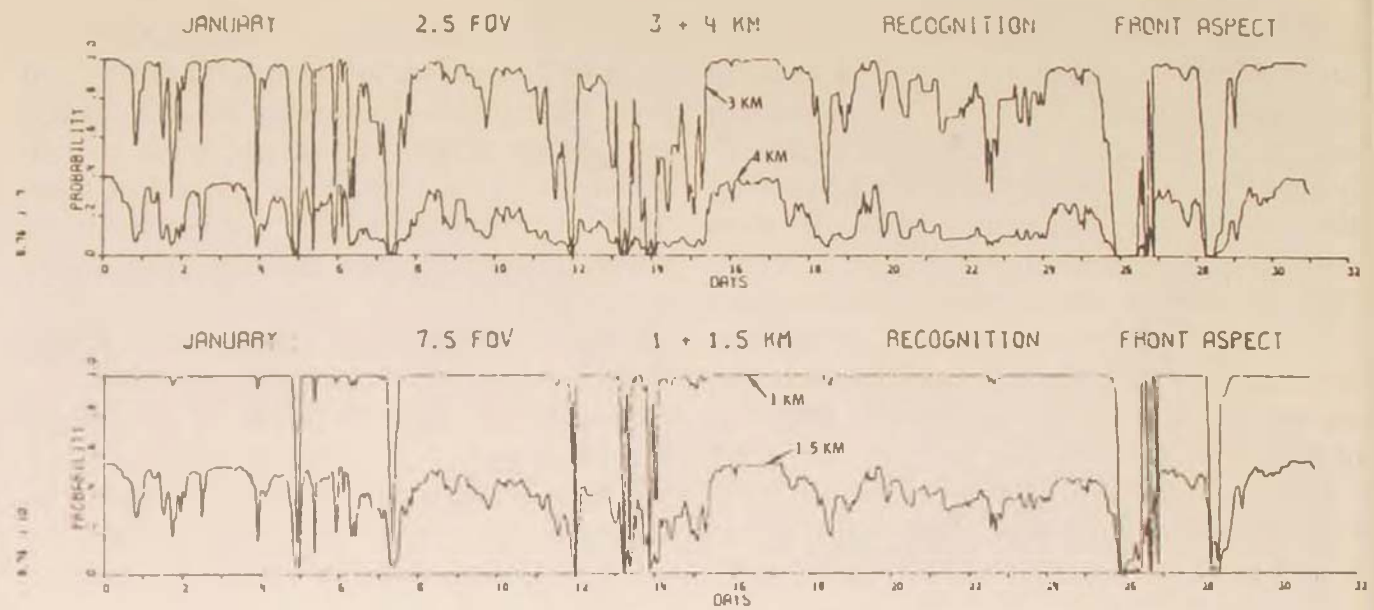


Figure 1. Probability of recognition of tank in frontal aspect, Hannover, Germany, January 1970: FLIR, 8.5–11 μm, 7-in. display; 3-km and 4-km ranges for 2.5° field of vision; 1-km and 1.5-km ranges for 7.5° field of vision.

tation on the effectiveness of tactical air has been the accuracy of weapon delivery. While the circle of error probability (CEP) of conventional (ballistic) weapon delivery can be a hundred feet or less in practice or test sessions on a bombing range, extensive experience and data show that in combat, with the uncertainty of target location and the stress of pilots under fire, typical accuracies are likely to be several times that. This is true for bombs; in some cases, such as strafing vehicles on roads, weapon accuracies can be better, but these instances, while not negligible in number, are specialized and do not typify the effectiveness of attack aircraft.

Night and bad weather have created additional problems for weapon delivery from the air. For fairly clear nighttime conditions it has been possible, although restrictive, to make ground attacks by parachuting flares to light the battlefield for a time. Low-light-level TV or infrared (FLIR) systems, under appropriate atmospheric conditions, can show targets such as tanks, trucks, or structures that stand out from the terrain. Although these devices now open up the night to "visual" attack on targets, the distances to which they can "see" and their image quality under many conditions are sufficiently limited that pilots cannot use them for random searching as they would use their eyes in the daytime. To illustrate, Figure 1 shows typical (calculated) probabilities of recognition of a tank by a forward-looking infrared (FLIR) sensor, for each hour and day of the month of January 1970, under conditions at Hannover, Germany. These data are extracted from an unclassified study originated under AGARD auspices.[17] While with appropriate optics and displays, and under good conditions, such ranges might be as high as 6-7 km, it is apparent that atmospheric conditions often prevent seeing with the FLIR at all, and that high-probability recognition ranges will not consistently be over a few kilometers. Thus in order to use these aids to night attack, pilots must know a priori where they are going and what they are looking for and be able to navigate accurately (with or without outside assistance) to a point from which target reacquisition for weapon delivery is possible.

If the weather is closed in, then air-to-ground attacks must depend on radar systems (such as TPQ-27 or MSQ-77) or on other guidance schemes that use accurate navigation (such as LORAN C/D, GPS NAVSTAR, or DME guidance) for direction to blind release points or to positions from which reacquisition by on-board radars is possible. While on-board radars may be useful for acquiring large, fixed targets, pilots need some form of external assistance (even if it is only in the form of contextual information provided from external intelligence sources in the missions briefing) to fly to the locations of small mobile targets and to identify the "blobs" on the radar screen as the targets they are seeking. If it is desired to become more certain by becoming more elaborate and spending more, moving target indication (MTI) can be added to the on-board radars. Then the aircraft would be able to attack such targets as vehicles moving on roads (and these are often the targets of greatest interest) in what might almost be an armed reconnaissance mode—provided the vehicles are moving faster than the minimum detection velocity of the radar. The latter is gradually being reduced, although the radar costs tend to rise as capabilities are added. Accurate navigation or externally assisted guidance to the general target areas, and prior or current assistance in identifying the "blobs" as the targets to be attacked, would still be necessary; navigation to known road locations in enemy territory may be sufficient if friendly forces are not nearby.

The problem with all these approaches to bad-weather bombing is that they tend to be no more accurate than visual bombing, and in most cases less so—sometimes very much less. The utility of the achievable accuracies (in either the visual or radar bombing cases) depends on the weapons and the targets. The accuracies cited might, at an earlier time, have been considered satisfactory for delivery of nuclear weapons, but CEPs of several hundred feet might not be compatible with the current desire to combine smaller yield with higher accuracy to reduce collateral damage.[18] Conventional high-explosive weapons delivered with such accuracies would be devastating to troops in the open or in unprotected vehicles or buildings, and they could also destroy large, fixed targets such as groups of buildings or arrays of stored supplies. But troops on a modern battlefield are likely to be in armored personnel carriers (APCs), and against hard targets such as concentrations of armored vehicles, any effect from inaccurate bomb delivery would have to come from the mass of weapons delivered in the area rather than from targets directly destroyed. This would be an uncertain effect and could not be relied on to be effective. Similarly, there would be little assurance that such structures as bridges could be destroyed or even seriously damaged.

In the early- to mid-1960s a number of technological advances appeared to help remedy these terminal effectiveness problems. One was the development of cluster weapons, such as Rockeye, which have distributed terminal effects. Against hard targets their effectiveness depends very much on the disposition of the targets in relation to the submunition pattern. If armor is closely spaced on a road or concentrating for an assault, such weapons can be very effective even in blind or radar-assisted release modes. Against widely dispersed targets (and the effective use of such weapons will doubtless encourage dispersion when ground units come under air attack), the weapon effectiveness falls off rapidly as CEP increases.

Two other approaches have concentrated on increasing the accuracy of weapon delivery or of the weapon itself. One has been the development of accurate bombing systems, such as that in the A-7D/E aircraft, using inertial navigation with a bombing computer for accurate target tracking and automatic weapon release. In the future, the navigation and positioning task might be done by a satellite navigation system such as the NAVSTAR, but the principle would be the same. Such systems can reduce bombing errors to about one-third of their previous value,[19] but they are expensive; and because they are complex, their reliability is not as high as might be desired.

The other new approach to accurate weapon delivery is weapon guidance. There have been guided air-to-ground weapons since World War II. The Germans made use of crude radio-guided bombs against Allied ships at Anzio,[20] and the United States was experimenting with the AZON, RAZON, and TARZON optically command-guided bombs at the end of the war.[21] The advent of laser guidance and successful optical contrast seekers led to the first practical air-to-ground weapons (popularly known as precision-guided munitions or PGMs) that could attack small, hard targets with accuracies of a few feet.

Of course, each new kind of equipment brings its own complexities, in this case such things as the need for a two-part team to use some weapons, the requirement for weapon release within the "guidance envelope" (similar to the need for a precise release point for ballistic bombs), the need for high reliability in the guidance system, and the

Table II. Comparison of World War II and current tactical air attack capability

	World War II[1]	*Current*[2]
Number of Aircraft	About 2500 (P-47, P-51, Hurricane, B-25, B-26)	100 (F-4, A-7, A-10)
Sorties per day per aircraft	.61	1-3
Typical bomb load	2 500 lb bombs or equivalent	8-18 500 lb bombs or clusters or 3-6 PGMs[3]
Tank equivalents damaged or destroyed by force, per day	60-70[4]	300-800[5] (using PGMs)
Sorties to destroy bridge over minor river	20-30	1 (using PGMs)

1. Statistics from: F M Sallager, *Operation "STRANGLE" (Italy, Spring 1944): A Case Study of Tactical Air Interdiction,* Rand Report R-851-PR, February 1972.
2. Estimated
3. Depends on number of store stations and type of PGM
4. Based on estimated effectiveness of weapons, typical accuracy, and average bomb load per sortie.
5. Depending on type of aircraft and combat conditions.

requirement for appropriate atmospheric conditions or a lack of (inadvertent or deliberate) smoke on the battlefield that might interfere with guidance. Nevertheless, even accounting for all such problems, these weapons, combined with the load-carrying capability of modern jet aircraft, have drastically changed the nature of tactical air's potential impact. Table II sums up the implications of the combination by comparing statistics for Operation Strangle in World War II with the results of performance calculations for current aircraft, in terms of an arbitrary but meaningful measure: tank-killing potential. In appropriate circumstances, noted above, cluster weapons might achieve results similar to those achievable with PGMs. It is clear that although modern aircraft are much more expensive (by a factor of 20 or more) individually, a much smaller force can now do much more than was possible in World War II.

NOW, even aside from the doctrinal differences about usage and the sometimes disappointing expectations for tactical air effectiveness that we have discussed, these advances do not yet seem to lead to the anticipation of—nor did experiences like Vietnam and the 1973 Middle East War show them to have—the unequivocal impact on modern land warfare that the numbers shown in Table II suggest they might have. Why?

First, the uses of air-delivered PGMs in recent wars were too limited to be decisive, and the awareness of their current shortcomings remains keen. Second, the high costs of the aircraft limit their numbers, so that even with the best performance in a large-scale war the available air force may well run out of sorties long before it runs out of vitally important targets and day-to-day missions. Third, tactical air will not always work as planned, either in achieving expected sortie rates or in its ability to deliver weapons under the good conditions usually incorporated in battle plans, because the enemy and the weather will not cooperate. Fourth and most important, the ground-based air defenses (which have also capitalized on guidance technology) have advanced to match the air attack capability.

Figure 2 is designed to convey schematically an impression of the type and density of overlapping coverage that can be obtained today by a complete, multistage air defense

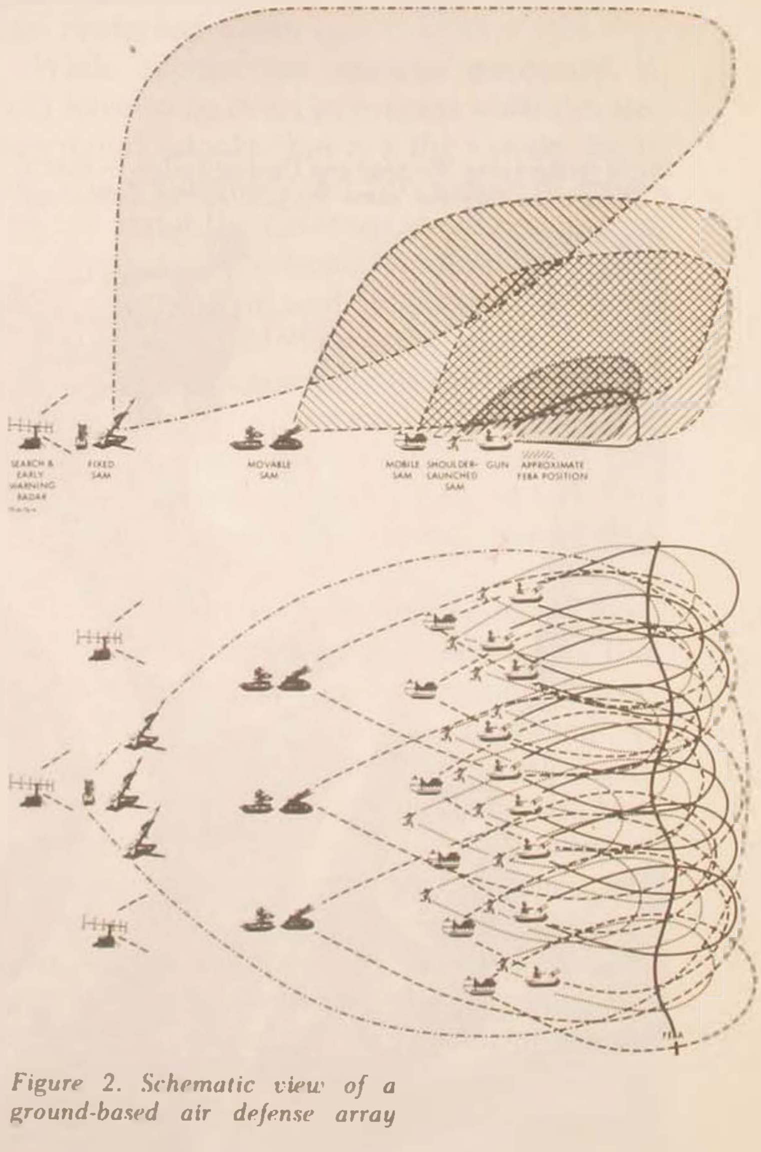
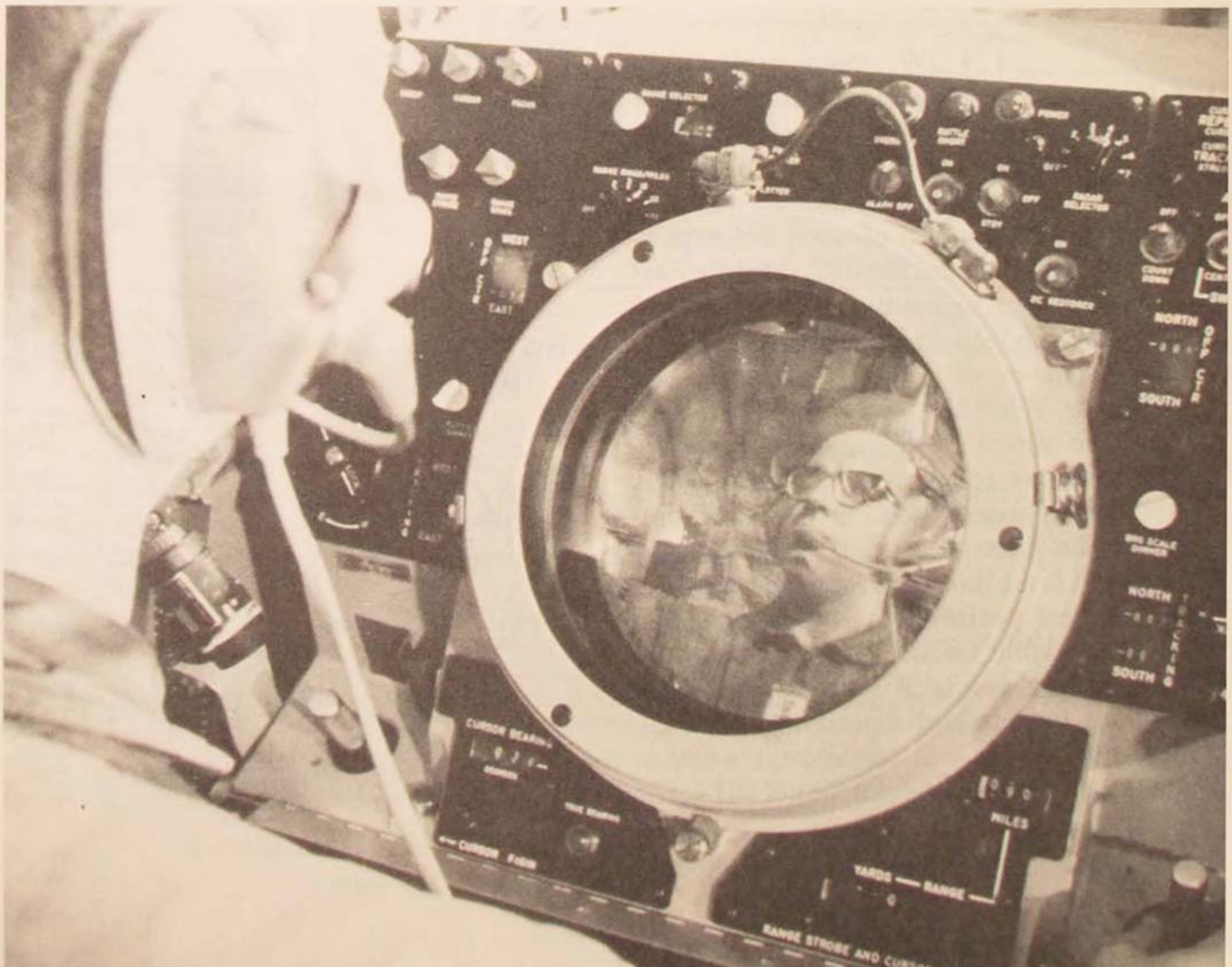


Figure 2. Schematic view of a ground-based air defense array

system using a combination of radar-directed guns and surface-to-air missiles (SAMs) having diverse radar and infrared guidance schemes. In Vietnam the presence of the relatively crude SA-2 induced our aircraft to operate at low altitude where they were vulnerable to optically and radar-directed gunfire. A defense array such as that shown in Figure 2 would be far more difficult to withstand and requires a great diversity of countermeasures, all adding to the cost and complexity of the attack. The nature of the problem was well illustrated by the Soviet air defense systems deployed by the Arabs against which the Israelis had to fly in the 1973 Middle East War.[22]

Of course, defense systems also have weaknesses; they are susceptible to jamming and deception,[23] and they are also vulnerable (after exacting a penalty) to multiple-aircraft attacks specifically designed to neutralize or destroy them. The surface-to-air missiles are large and expensive and not easy to transport and to load on launchers for sequential firings in large quantities on the battlefield. At some point a massive attack against the defenses could saturate their target acquisition and tracking capability and run them out of ammunition. However, the Soviet Union has compensated for the West's more technically advanced systems by sheer weight of numbers. Although their individual systems might be more easily countermeasured and might have to fire more

Inside an Airborne Warning and Control System (AWACS) E-3A, a crew member mans his post at the radarscope.



missiles to hit an airplane, calculations show that the great volume of fire that their numerous and diverse systems can put up could, unless tactics are changed, cause so much attrition of attacking aircraft that in a short time there would remain insufficient offensive strength to be useful. Here, then, is the obverse of the capability shown in Table II.

Clearly, for tactical air power to do its work against ground forces, the defenses must first be defeated. In Vietnam, defense suppression tactics were developed so that in every attack against North Vietnam a significant fraction of the attacking aircraft were used to countermeasure and attack the defenses. Precision-guided munitions were used in these efforts, too, including, for example, radar-homing missiles such as the Shrike.

An obvious countermeasure to radar homing is to shut the radars off; but without them, of course, there is no defense. This problem for the defense can be alleviated by extensive use of decoys and by netting the radars to permit the entire, integrated defense network to react and support opposition, even if degraded, to penetrations at particular locations. Over North Vietnam, even with suppression, the defenses took their toll of both the attack and the suppression aircraft.

The advent of time of arrival/distance measuring equipment (TOA/DME) emitter-location systems with appropriate, near-real-time processing will in the near future enable the delivery of missiles or guided glide bombs against the radar-directed defenses from standoff positions. Thus, losses during defense suppression would be much reduced, the nature of the aircraft systems required to support a strike would be changed to free more attack aircraft for their primary purpose, and fewer defenses would remain to oppose the attack aircraft. In the more distant future such standoff technology might be coupled with improvements in long-range MTI radar for use against the primary targets. However, currently and in the near future the problems of acquiring non-emitting targets, limitations on the number of weapons that can be launched and remotely controlled, and the projected high cost of the early generations of standoff weapons—all tend to inhibit the full development of the capability. The technology is likely to be used first for suppression of the longer-range, less mobile defenses, and in that mode it would assist attack of targets from altitudes above the range of the more numerous forward, highly mobile air defense systems shown in Figure 2. Weather permitting, or with the more advanced bad-weather attack systems that future radar and guidance technology may bring about, this would in any case be the preferred mode.

While suppression remains necessary, it will have to be done in concert with the air-to-ground attacks that are the reason for it all. The acquisition and processing of information about the defenses, rapid conversion to attack against them, simultaneous location, classification, and tracking of primary targets, and rapid follow-up by attack aircraft will all place new demands on the responsiveness of the C^3 system; and as noted above, they are certain to require restructuring of the system, probably toward less centralization, especially during periods of intense operations.

Aircraft losses in these operations are likely to be heaviest during the initiation of the attack and during the suppression phase, while the defenses can be expected to become less and less effective, more disorganized, and low in missile stocks as the battle progresses. There would thus be a great advantage to pressing the attack once the difficult and expensive defense suppression stage has been successfully undertaken; as in ground warfare, mass and aggressiveness are important. This may be a difficult sequence to pursue, but it may be the only way to achieve success in the air-ground war until the day when advancing technology brings the capability for massed attack from standoff in reach.

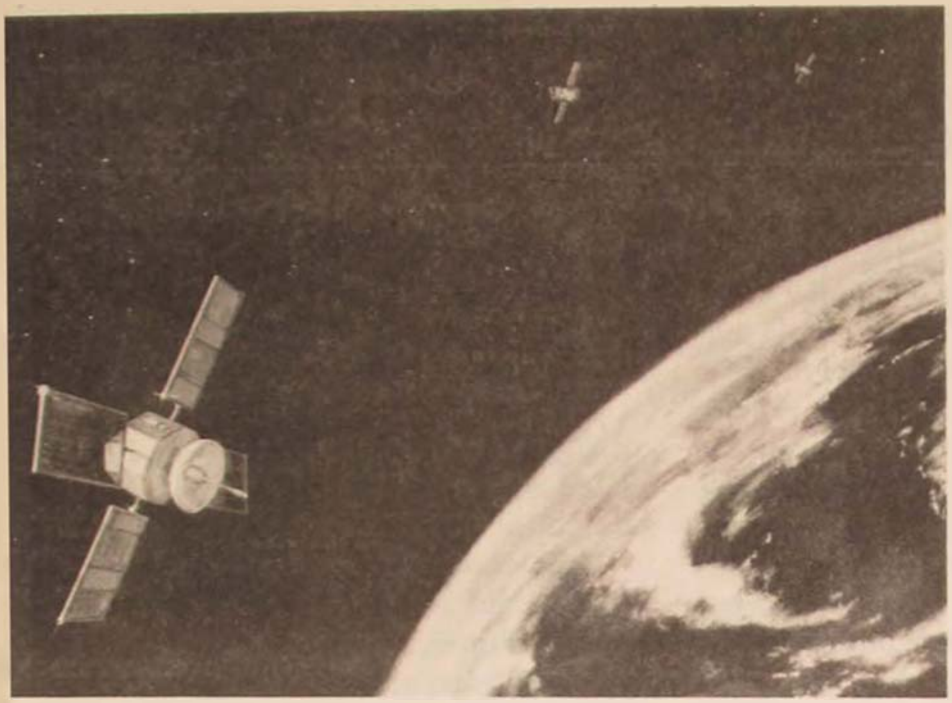
Of course, if the defenses are mobile and numerous, all will not be taken out or evaded with certainty; and some of those struck might be repaired. Thus, even the advanced technology is unlikely to defeat all defenses at once, and the outcome would not be certain for either side. What *is* certain is the growing cost all this use of advanced technology entails for both sides.

We could, as the British say, "do the sums" to add up the total cost of the attack, including the remote or standoff defense suppression and attack systems, the complex target acquisition, and the guided weapons and divide that cost by the number of targets that could be destroyed, including the effect of losing aircraft to the defenses. We could also add up the cost of the defenses, including the search and tracking radars and the netted command and control system, required to destroy some numbers of the attacking aircraft and thereby save targets on the ground from being destroyed by them. The resulting cost trend, as sophisticated attack and defense systems proliferate, would be such that either to destroy a target or to save it from destruction may come to cost more than the target itself. Thus, both sides must increasingly justify the expenditures, not on an individual-system, cost-effectiveness basis but in terms of the value of winning the battle or the war, which is not quantifiable in any practical sense.

Among the difficult-to-quantify alternatives are the tactics and objectives of air-to-ground warfare. The advent of PGMs and the consciousness of the massive armored threat that has accompanied our renewed concentration on NATO problems have encouraged a trend toward air support concepts that stress one-on-one dueling between attack aircraft and armored fighting vehicles at critical locations. But the cost trends noted, as well as the difficulties of doing the job, suggest caution about excessive reliance on this approach. Analyses show that in the environment of armored warfare, the air component may well pay for itself better by attacking supporting arms such as artillery, or by interdiction beyond the battlefield to delay and weaken the entry of second-echelon forces into the battle, than by destruction of armor per se. However, the latter will be necessary sometimes, and it might best be undertaken at locations near the FEBA, where the ground forces can help suppress the close-in mobile defenses, or against units attempting to exploit a breakthrough, when they may outrun many of their covering defenses. All this speaks for a variety of weapons and tactics, extensive and effective coordination with the ground forces, and great flexibility and responsiveness to local and strategic developments in prosecuting the air war.

USAF commitment to close air support was confirmed during the Vietnam war, and in 1974 the A-10, seen here with two CBU-67 cluster bombs on each wing and two on the fuselage, was adopted for that purpose.

Thus far we have deferred consideration of the air superiority battle and the use of interceptors and fighters

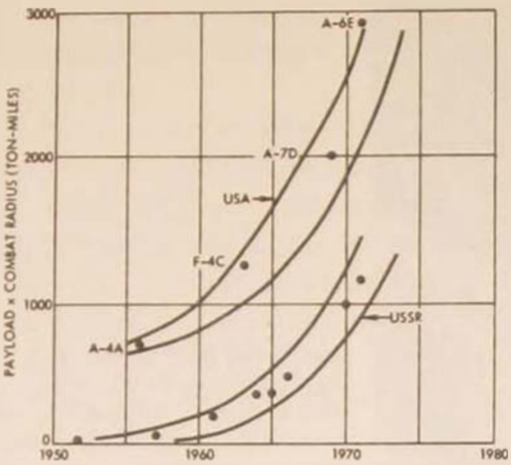


The NAVSTAR Global Positioning System, a satellite navigation system, may in the future be used for navigation and bomb positioning, perhaps reducing bombing errors by as much as two thirds.

to escort and protect or to intercept and destroy ground attack aircraft. Here the relationship between the major players is the same, withal adding greater complexity. While the United States and other Western countries have developed air-to-air technology to a higher level than the Soviet Union,[24] the U.S.S.R. has acquired greater numbers of systems.[25] Until the late 1960s, the Soviets appeared to concentrate on short-range interceptors such as the MiG-21 in various versions to supplement and back up their ground-based air defenses. NATO, while it has ground-based air defense systems, earlier concentrated more on the use of high-performance fighter aircraft, such as the F-4 and F-111, to gain air superiority primarily by destroying opposing air forces on the ground.

However, with both sides building shelters extensively (and the extension of shelters elsewhere, as the experience of the 1973 Arab-Israeli War demonstrated),[26] it is now extremely difficult to destroy an air force on the ground; thus unless nuclear weapons are used, there is little hope of success for the old doctrine. Hence there must be more reliance on air-to-air combat and effective ground-based defense systems to gain air superiority or supremacy. The new generation of Western fighters, such as the F-15 and F-16, has reversed the trend toward increasing gross weight while concentrating more on the performance characteristics useful for air-to-air combat, and a new generation of air defenses, including the Rapier/Roland/Crotale family and the Patriot (formerly SAM-D), is also appearing.

Concurrently, the Soviet Union appears to have changed the policy that concentrated on short-range interceptors and light to medium bombers in favor of increasingly heavy attack aircraft with long-range strike capability. The trend in Soviet tactical air development relative to that of the United States is shown in Figure 3.[27] This does not imply that the U.S.S.R. still adheres to the air



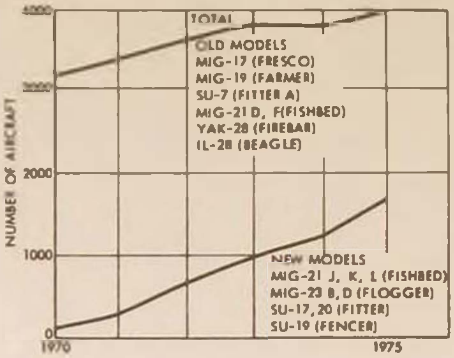
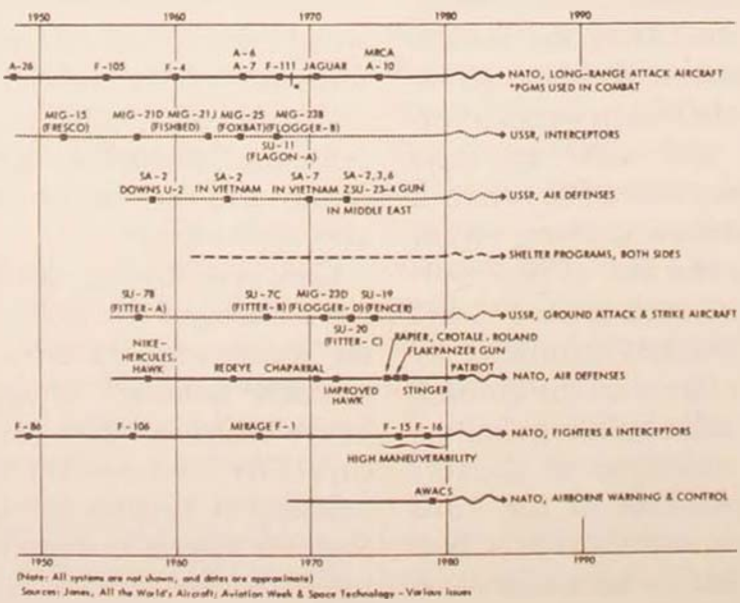


Figure 3. Trends in Soviet tactical aircraft capability

superiority doctrine that was outmoded by shelters. It does suggest, however, the growth of an offensive tactical air capability patterned on or similar to ours. The intensification of interest and effort by the U.S. and NATO in ground-based air defenses is being driven in part by awareness of this trend. Thus, as shown in the summary chart of Figure 4, the synthesis of technological opportunity and perception of the opposition imposes its own cyclic logic and convergence on both sides' capability, tactics, and doctrine.

Also shown in Figure 4 is the appearance of the U.S. Airborne Warning and Control System (AWACS) command and control system. While the idea behind the AWACS is certainly not new, this system introduces a

Figure 4. Soviet and NATO tactical air warfare systems developments



new order of capability in airborne warning and control. The central role of radar in command and control and weapon guidance in air warfare has encouraged a trend toward very-low-altitude flight to gain the advantages of a near horizon and terrain masking—this despite the attending greater difficulty of target acquisition. Both NATO and the U.S.S.R. to different degrees have undertaken each of the two possible steps to defeat this tactic: proliferation of ground-based radars and elevation of radars on aircraft. Extensive low-altitude radar coverage on the ground obviously requires considerably more men and money than are needed for the fewer radars that provide high-altitude coverage alone. In addition, a multiplicity of low-altitude SAM defenses must be proliferated with the gap filler radars, if the information they provide is to be used, or else the combat information and control system must be made more complex to control fighters after integrating data from a multiplicity of sources, or both. The Soviet proliferation of mobile SAM defenses clearly helps do part of this job for them.

But raising the radars on high-flying aircraft and providing them with ground clutter rejection and ECM resistance are also expensive, and the aircraft are, of course, exposed. If they fly at high altitude well behind the combat area, friendly fighters can give them a measure of protection—how much protection is a subject of extensive argument. All systems, including ground-based radars, are vulnerable to attack; the AWACS aircraft can be configured to carry out the equivalent of the ground-controlled interception (GCI) function from the air. In doing this they would become airborne command centers controlling the air-to-air battle. Thus, the airborne radar and associated combat control system contributes to its own protection, and it can lead to much more effective and efficient use of the ground and tactical air resources than would be possible otherwise—as long as the airborne system survives. The potential vulnerability of the AWACS system and its high unit cost (on the order of $60 million, in 1976 dollars, per aircraft,[28] for 30 to 40 aircraft) have raised considerable controversy about its acquisition, both in the United States Congress and with our NATO Allies who have been invited to purchase it. But, although less conspicuous because there are many more units of equipment, each one relatively inexpensive, a wholly ground-based system that would be equally effective across a large front such as that in Central Europe may well cost about as much and may be equally vulnerable, although in different ways.

NOW THAT we have laid out the main directions of the modern evolution of tactical air warfare, we must take stock of their meaning. In part, this depends on the comparisons we have made between trends in Western and Soviet forces and doctrines. Although Western technology continues to be more advanced, the Soviets are advancing also, so that *differences* in technology evolving over the years might be considered to remain constant, on the average. What the Soviets lack in quality they make up for in quantity, and the big question is whether the better quality of American and other Western weapons more than compensates for the greater Soviet quantity.

Without attempting an answer to this question, which depends on complex and uncertain analyses using the detailed performance characteristics of systems on both sides, it is convenient to explore another aspect of its significance in terms of "exchange ratio"—targets destroyed per attacking aircraft lost. Suppose that we retain the technological edge as technology advances on both sides, so that the exchange ratio can be assumed to remain the same even as both sides' systems improve (it would not remain the

Table III. An illustration of the accelerating pace of warfare

A: Air-to-Air Warfare —Exchange Ratio[1] = 5

	Friendly Force Parameters[2]		Outcome
World War II (later stages)	Number of aircraft:	100	
	Probability of detecting enemy:	.2	Half-life[4] of friendly force: 19 months
	Probability of engaging:	.5	
	Probability of kill:[3]	.1	Time to kill 100 enemy aircraft: 6 months
	Sorties per day:	.6	
	Losses per sortie:	.002	
1970s	Number of aircraft:	100	
	Probability of detecting enemy:	.8	
	Probability of engaging:	.5	Half-life of friendly force: 7 days
	Probability of kill:	.5	
	Sorties per day:	2.5	Time to kill 100 enemy aircraft: 2¼ days
	Losses per sortie:	.04	

B: Air-to-Ground Warfare —Exchange Ratio[1] = 100

	Friendly Force Parameters[2]		Outcome
World War II	Number of aircraft:	100	
	Vehicle kills[3] per sortie:[5]	.5	Half-life of friendly aircraft force: 8 mos.
	Sorties per day:	.6	
	Losses per sortie:	.005	Time to kill 1000 vehicles: 35 days
1970s	Number of aircraft:	100	Half-life of friendly aircraft force: 9 days
	Vehicle kills per sortie:	3	
	Sorties per day:	2.5	Time to kill 1000 vehicles: 1½ days
	Losses per sortie:	.03	

1. Enemy aircraft killed per friendly aircraft lost, or enemy vehicles killed per friendly aircraft lost; taken as constant over time in each case as a surrogate for constant *difference* in weapon quality
2. Typical values, assumed for purposes of illustration.
3. "Kill" means damage or destroy, throughout
4. Time for the force to be reduced by half.
5. Includes bombing and strafing of "soft" and "hard" vehicles; includes all detection and attack probabilities.

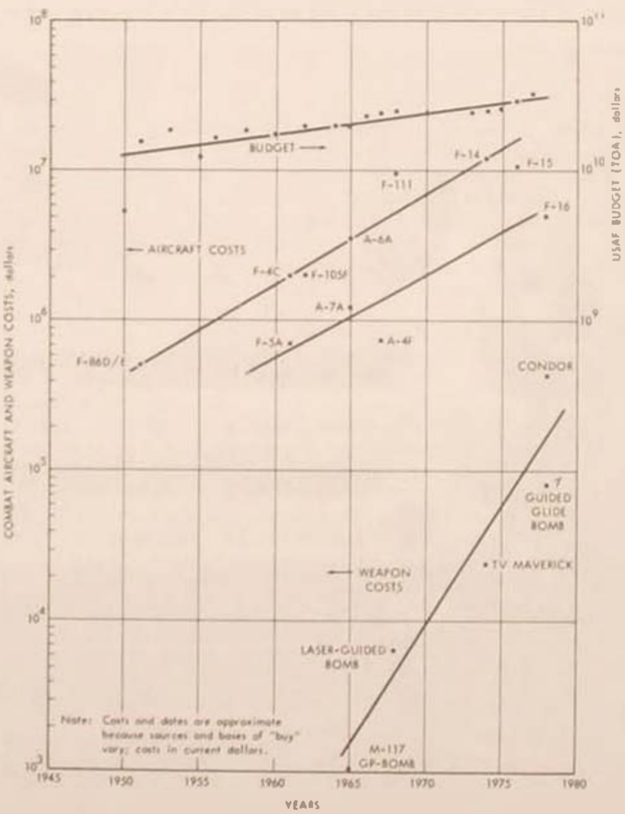
same if one side improved while the other did not). Then the increasingly greater destructive capacity attending the system improvements will cause the loss *rates* on both sides to be much higher. The effect on the pace of air warfare is illustrated in Table III. This shows the need for adjustment of air-to-ground tactics and priorities, discussed earlier, to maximize the payoff from a very large investment that may be drawn down very rapidly.

All of this describes the anticipated situation were the two strongest nations or alliances to interact militarily. But the nature of the technology is such that this kind of dénouement can take place elsewhere—it occurred, for example, in the 1973 Arab-Israeli War, where Israel had a powerful air force and Egypt and Syria had some of the Soviet air defense weapons. We also found in Vietnam, that although the North Vietnamese air force itself was very weak compared with that of the United States, we were far from having a free ride, because of the early warning systems and air defenses supplied to the North Vietnamese by the Soviet Union—and there were none of the SA-6s and few of the IR SAMs that the Israelis encountered in 1973. In some perhaps significant degree, the problems described for the worst case must be anticipated everywhere.

This development brings us, finally, to the problem of developing a force structure within a budget while incorporating the technological evolution that is becoming a revolution: advanced aircraft, navigation, and target acquisition; PGMs; standoff defense suppression and other countermeasures; AWACS. Figure 5 compares the trends in Air Force budgets and two key elements of the combat system, fighter aircraft and air-to-surface weapons, since 1950. The sequence of weapons selected also represents a progression of standoff capability, symbolizing the new attack technology. While the costs in Figure 5 have not been corrected for inflation, such correction would not change the main trend illustrated: individual system costs are increasing much faster than the overall budget. This uncomfortable relationship has led to a search for Lebensraum within the available resources, and that in turn led to the concept of the "hi-lo" force mix.

This has commonly been interpreted to mean that we would reserve relatively small numbers of the most sophisticated systems for use against the most capable enemy (e.g., in Europe) with large numbers of simple, and therefore cheap, systems for use elsewhere. The problem with this conception is that "elsewhere" may not be different from Europe in terms of opposing capability, and consequently the elements of a successful tactical air system are not separable in terms

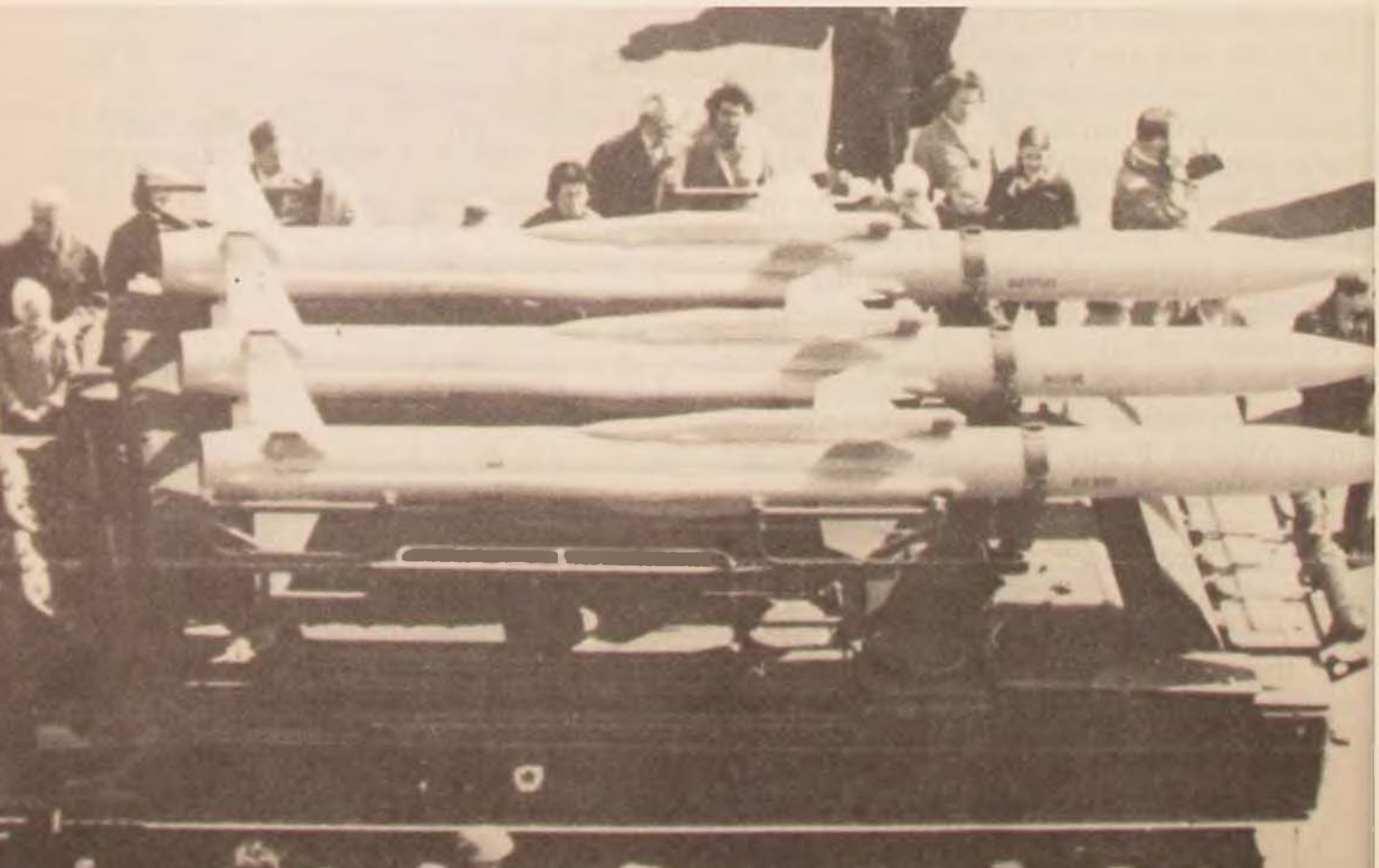
Figure 5. USAF budget and system cost trends



of scenario. But the high-low idea has merit if it is reinterpreted in terms of an integrated force structure.

It does not take sophisticated and expensive aircraft to launch standoff weapons, to carry a TOA/DME receiver, or to deliver either PGMs or close-in weapons once defenses have been effectively suppressed and targets acquired. The A-10, for example, could serve just as well as an F-4E, F-111, or F-16 in these roles—its large payload would be an advantage. For capabilities now coming into being, the sophistication lies in data processing on the ground, in ECM-resistant C^3, in countermeasures-resistant weapon guidance, and in such aids to target acquisition and weapon delivery as FLIRs and target designators. A force mix combining these elements in appropriate proportion would reduce reliance on self-sufficient aircraft, each of which can perform all of the tasks in air warfare, and would increase reliance on integrated and coordinated subsystems, some in the air and some on the ground, each performing an essential part of the task. Even with appropriate redundancy to cover loss of critical elements of such a force, it will be found that as a whole it would be less expensive and more effective than one which attempts to use "high" technology exclusively for one scenario (but is too small as a result) and to use "low" technology exclusively for another scenario (but is consequently insufficiently effective). In fact, when pressed to it by the exigencies of combat in Vietnam, the USAF adopted such an approach in the field.

The Soviet SA-6 missile, code-named "Gainful," was introduced in 1967. The 19½-foot surface-to-air weapon is part of a unit of three solid-propellant missiles on a tracked transporter.



I believe that the constraints of budget must inevitably encourage the evolution of tactical air power in this direction during peacetime preparation for the tactical air mission, in the face of evolving technology and its costs.

IN CLOSING, I might give some attention to another important philosophical aspect of this unexpected outcome of the march of military technology, which will also become a public issue in discussions of rising defense budgets: if achieving the desired effectiveness of tactical air has been made more difficult and the price keeps rising, why pay the price?

It remains that tactical aircraft are the most flexible means to mass heavy firepower on short notice and bring it where it is desperately needed; to carry firepower deep into enemy territory when that is appropriate; to shift attacks rapidly from one form of tactical target to another and from one location to another as the military situation demands; and to observe what is happening beyond the sight of the land forces so that ad hoc action can be taken to shift effort to meet shifting military situations. It is also clear that, since the anticipated effectiveness of air defenses rests, as does that of tactical air, on many uncertainties, the side that has tactical air while the other does not is still likely to be able to use it to help impose its will at critical times in a conventional military conflict. It would be difficult or impossible to win such a war without tactical air, even though tactical air cannot win it alone. (The outcome in Vietnam might seem to some to belie this, but without arguing that war here we might remember the observation made earlier: the North Vietnamese did not win until the absence of U.S. tactical air gave them greatly increased freedom of movement on the ground.) But tactical air is in a period of rapid change, and the greatest success will go to those who adapt most rapidly and effectively.

Institute for Defense Analyses

Notes

1 See, for example, A. P. de Seversky, *Victory through Air Power* (New York: Simon and Schuster, 1942); C. Bekker, *The Luftwaffe War Diaries*, translated and edited by F. Ziegler (Garden City, New York: Doubleday, 1968), pp. 148–51; R. Leckie, *Conflict—The History of the Korean War, 1950–53* (New York: G. P. Putnam's Sons, 1962), pp. 53, 318; *The Pentagon Papers* (New York: Bantam Books, 1971), pp. 307–44.

2. Samuel Eliot Morison, *The Two-Ocean War* (Boston: Atlantic Monthly Press, 1963), pp. 359–60.

3 Hugh M. Cole, *The Ardennes: Battle of the Bulge*, vol. 7 in *United States Army in World War II, The European Theater of Operations* (Washington, D.C.: Office of the Chief of Military History, 1965).

4 Author's discussion with Israeli Air Force personnel.

5 Lt Gen W. Pearson, *The War in the Northern Provinces* (Washington, D.C.: Department of the Army, Vietnam Studies Series, 1975).

6. Bekker, p. 142

7 Morison, p. 387.

8. F. M. Sallager, *Operation "STRANGLE" (Italy, Spring 1944): A Case Study of Tactical Air Interdiction*, Project Rand Report R-851-PR, prepared for the United States Air Force, February 1972.

9 Leckie, pp. 318–21

10. *The Pentagon Papers.*

11 *Washington Post*, May 30, 1976, p. A-1.

12. War Department Field Manual FM 100–20, *Command and Employment of Air Power*, 21 July 1943. Emphasis added.

13 See, for example, AF Manual 2–1, *Tactical Air Operations—Counter Air, Close Air Support and Air Interdiction*, Department of the Air Force, 2 May 1969, p. 3-2

14 Department of the Army Field Manual FM 100–26, *The Air-Ground Operations System*, March 1973.

15 *Aviation Week & Space Technology*, July 14, 1975, p. 49.

16. See, for example, *Close Air Support*, Hearings Before the Special Subcommittee on Close Air Support of the Preparedness Investigating Subcommittee, Committee on Armed Services, U.S. Senate, 92d Congress, October-November 1971

17. Figure from L. M. Biberman, *Effect of Weather at Hannover, Federal Republic of Germany, on Performance of Electro-optical Imaging Systems*, Institute for Defense Analyses Paper P-1123, August 1976.

18. Hearings Before the Subcommittee on Military Applications, Joint Committee on Atomic Energy, Congress of the United States, 93rd Congress, First Session, Part I, pp. 36–37.

19. For example, *Accuracy Demonstrations for Delivery of Iron Bombs*, Litton Systems Inc., Guidance and Control Systems Division, Publication No. 13396, September 1975

20. Morison, pp. 356, 359.

21. *Guided Missiles and Techniques* (Washington, D.C.: Summary Technical Report of Division 5, National Defense Research Committee, Office of Scientific Research and Development, 1946), pp. 27–47.

22. *Aviation Week & Space Technology*, December 3, 1973, pp. 18–21

23 For a complete discussion of electronic warfare, see *Aviation Week & Space Technology*, January 27, 1975, Special Report on Electronic Warfare, pp. 41–144.

24 See, for example, *New York Times*, September 22, 1976, technology in the MiG-25 (Foxbat) fighter.

25 See *The Strategic Balance, 1975–1976*, International Institute of Strategic Studies, London.

26. *Aviation Week & Space Technology*, May 25, 1970, p. 19, and December 3, 1973, p. 21.

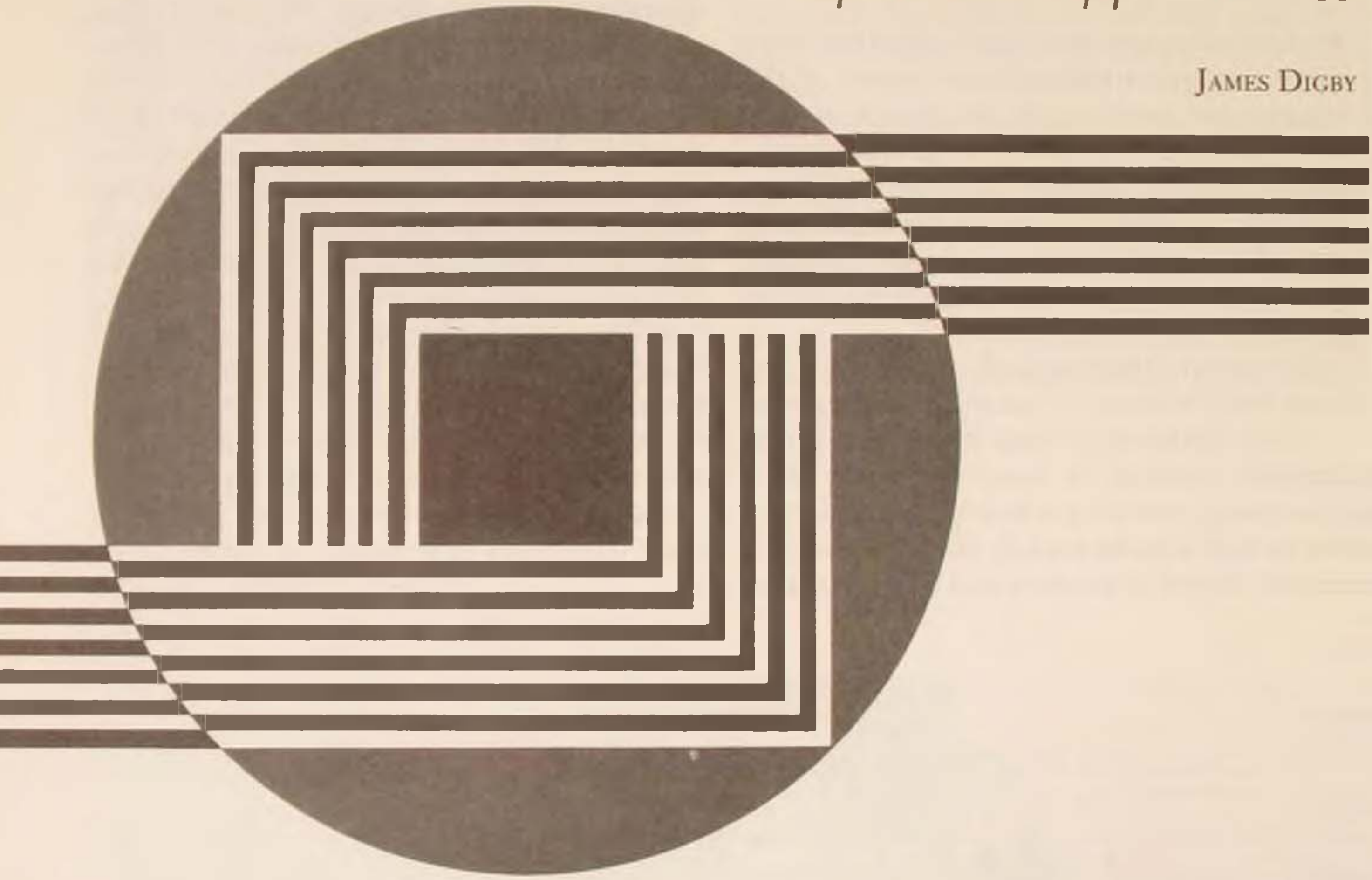
27 Data given in *Aviation Week & Space Technology*, June 28, 1976, pp. 19–20

28. Report of the Subcommittee on Defense Appropriations, Department of Defense Appropriation Bill, 1977, Committee on Appropriations, House of Representatives, 94th Congress, Second Session, p. 152.

NEW NONNUCLEAR MILITARY TECHNOLOGY

implications and exploitable opportunities

James Digby



IN RECENT years an unusually large number of technical developments have been put to practical use in new weapon systems. Some of these developments promise to make the more traditional weapons (which are often less cost effective and quite vulnerable) obsolete. The combined effect of a number of these developments is sufficient to cause some senior officials to use words like "revolutionary" to describe what is happening. It is my own view that most of the changes that could be called "revolutionary" are potential changes not yet realized.

Some Potential Developments

There is a variety of advances in weapon technology, new kinds of tank armor, new submarine hull designs, automated test equipment, to name just a few. *The Economist* (London), which had been rather excited over the prospects for precision-guided weapons eight months earlier, in a recent article selected six other developments "which may bring about equally radical changes in the way wars are fought." My summary preserves many of *The Economist's* adjectives, from the article[1] which made these points:

1. *High-energy lasers.* Although a laser beam takes a lot of energy to generate, it loses relatively little along the way to the target, so it can destroy things at a distance. It has long range, simple fire-control apparatus, easy "ammunition" supply, and nearly zero time-of-flight—thus easing the task of shooting down ballistic missiles or satellites.

2. *Seeing in the dark.* Night will soon favor the side with the better equipment and better night tactics.

3. *Artillery locators.* Guns will have to hit their targets with their first or second shot because after that they will be scrambling to avoid getting clobbered themselves. Massed artillery and barrages may soon be a thing of the past.

4. *Tank armor.* Shaped-charge warheads will no longer be so effective, and the new lightweight antitank weapons may be ineffective—except that the Russians now have 40,000 tanks with the old armor and would be hard-pressed to replace them.

5. *Remotely piloted vehicles.* These are cheaper than manned aircraft, can fly higher and longer, and maneuver more tightly—all in a smaller package, which makes them harder to detect and shoot down. Next, they will be able to see better than a man, and by the end of the century they will replace most manned aircraft.

6. *Small submarines.* Minisubmarines will soon be far enough advanced for small countries to possess, their size making them hard to detect, yet able to carry one or two weapons—such as cruise missiles—that could have remarkable accuracy and telling effect.

By including this summary I do not mean to endorse *The Economist's* views without reservation. I think they have overestimated the rapidity with which some of these ideas will be at hand, but their listing calls attention to three points:

- Professional military journals and official program documents are usually deficient in pointing out the extent of the changes that technology may bring and their implications.
- These developments do not require little-known technology; rather they involve engineering applications of known techniques.
- The developments in precision-guided munitions and remotely piloted vehicles are only part of a larger set of ideas that have a potential for changing military tactics and changing the dominant trend toward bigger and more expensive penetrating weapon systems.

Nonetheless, much more thought needs to be given to the implications of precision-guided munitions (PGMs) and remotely piloted vehicles (RPVs).

A PGM can be defined as a guided munition whose probability of making a direct hit on its target at full range (when unopposed) is greater than half. According to the type of PGM, the target may be a tank, ship, radar, bridge, airplane, or other concentration of military value.[2] This definition includes a wide variety of weapons, with the term "munitions" indicating that they are designed to impact on their target. Thus the increasingly important category of cruise missiles is included.

PGMs overlap with RPVs, many of which are designed to be recoverable and are used primarily to carry reconnaissance equipment or devices such as laser designators. Others, designed to impact at the target, qualify as PGMs. An RPV may be defined as a vehicle that is piloted from a remote location by a person who has available much of the same piloting information he would have if he were on board. Some people are considering RPV techniques for tanks, submarines, or other vehicles, but in its most common use the term refers to aircraft.

technical bases of PGMs

Three technological advances have greatly facilitated the development of the new precision-guided munitions:

- The capability to produce transmitters and receivers that use much higher frequencies than those used in the past. These high frequencies have made it possible to obtain angular accuracies approaching those obtained with visual telescopic sights.
- Progress in microelectric circuit designs that permit quite complex signal processing and storage to be handled in small, reliable, relatively rugged devices.
- Progress in the design of nonnuclear warheads. These new designs permit much smaller weapons to have the capability of destroying targets that formerly required much heavier warheads.

Perhaps the main thing to say about PGMs—if they are used under the conditions for which they were designed—is contained in the following statement:

> Accuracy is no longer a strong function of range; if a target can be acquired and followed during the required aiming process, it can usually be hit. For many targets, hitting is equivalent to destroying.[3]

drawbacks of near-future PGMs

This statement also gives some clues as to what might go wrong. For example, actual experience in the 1973 war in the Middle East showed that acquiring targets and then recognizing which were hostile and important was a very difficult job. That war also showed that it was possible to evade relatively slow PGMs, like the Soviet-supplied Sagger antitank missile, during their 15 to 25 seconds of flight. Israeli defenders learned quickly to take Sagger crews under fire during the time they were guiding their missiles. Sometimes, relatively simple measures will serve to conceal the targets. Finally, it can be noted that there are a number of ways of interfering with the seeing process. For some of the earlier missiles that use visual sighting, darkness, battlefield smoke, or ground fog may prevent sighting. (Later systems using long-wave infrared will expand considerably the conditions where seeing will be possible.)

Thus, the benefits of increasingly using PGMs and RPVs will be treated here as *potential* values, not as statements about a weapon revolution that is already here.

potential benefits of PGMs

First, it appears that PGMs and RPVs could substantially increase their users' tactical capabilities. Under best operating conditions, this is probably true. However, as mentioned, there are a number of ways to counter the new guidance systems, though many of these problems can be overcome by resorting to nonvisual-spectrum guidance systems. Now the United States seems to have the advantage over the Soviets in long-wave infrared systems and millimeter-wave systems, for example, and we seem far ahead in air-launched PGMs. However, the Soviets apparently have exploited the visually guided ground-based PGMs more efficiently, and they have been especially adept in exploiting antitank weapons.

The second point is that PGMs can be concealed in small units with great firepower potential. U.S. doctrine often runs directly counter to realizing this potential. The Army puts highest priority on developing the Big Five, all large, expensive systems.[4] The Air Force has put high priority on large, multipurpose penetrating aircraft as well as an airborne warning system that concentrates great value in a single aircraft. And the Navy is building expensive, nuclear-powered aircraft carriers and strike cruisers, both extremely high-value targets. The Soviets, however, are typically building large numbers of smaller vehicles. (One resulting problem is the difficulty of coordinating these dispersed units in a combat situation; the Soviets compensate by using standing procedures to a greater extent than we do.)

The third potential value of PGMs is that the offense will particularly profit from future, longer-range PGMs. This capability will require the development of new and appropriate tactics. Unfortunately, the United States, which has made greater technical progress, is not matching this potential capability with the necessary improvements in its reconnaissance capabilities, particularly over the ocean. At the same time, the American services seem reluctant to design appropriate tactics, especially for the projection of air and naval power, to utilize this emerging capability.

Fourth, PGMs are light and mobile, so they can be moved laterally or from a reserve and brought to bear in areas of greatest defensive need. In other words, they can reduce the requirement for static defense emplacements. Again, U.S. doctrine has not yet reflected this PGM capability with respect to land warfare and tactics for lateral deployment. Neither are there adequate command-control networks available to exercise this capability. If it is assumed that the Soviets will be on the offensive, this type of exploitation is less relevant from their perspective.

Fifth, since most PGMs and RPVs are both mobile and the units easily divisible, this facilitates a greater centralization of resources before combat use. This is especially important because it is essential that the United States be able to call on all its assets in any confrontation with the Soviets. At present, the United States is probably quite far from having a suitable coordinated plan under which all three services would work together in a deployed mobile force. Potentially, though, the U.S. advantage in data processing systems would be most beneficial in monitoring, deploying, and controlling forces that consist of many independently mobile small units. This is one area that the United States should exploit to the fullest.

Sixth, PGMs and RPVs can be used most effectively if the tables of organization and equipment (TO&Es) are redesigned to exploit the new capabilities. PGMs are somewhat indifferent to the kind of platform that fires them, and their full exploitation might suggest changes in the traditional service role and mission assignments. It will not necessarily be best to use sea-based platforms to launch antiship missiles or air-launched missiles to attack airfields. To date, United States TO&Es have not reflected the new possibilities with any substantial degree of change. The Soviets, however, have made a major change in their tactical doctrine in the employment of missile-armed BMPs;[5] this implies a significant alteration in combat tactics to emphasize the use of PGMs. To the American advantage, Soviet military practices have traditionally discouraged tactical flexibility whereas U.S. doctrine encourages substantial tactical independence (within broad guidelines) for its junior commanders.

Seventh, PGMs and RPVs can be inexpensive to produce and maintain. (This need not be universally true; Condor is an example of a high-performance but expensive system.) This potential might not be realized unless priority efforts are directed toward keeping PGM costs as low as possible so that large numbers of them can be procured.

Eighth, more and more, weapon systems can be designed independently of weapon platforms, enabling each to be modernized separately, with consequent savings. Currently, most funds for U.S. weapon systems are going into tightly integrated penetrating weapon systems. Modularity has been a goal of design engineers for many years, but it is honored more in theory than in practice.

Modern U.S. technology increasingly facilitates modular design, a trend that would do much to improve performance and cost goals.

THE FULL exploitation of PGMs must rely on a supporting structure, from improved reconnaissance and target acquisition capabilities to command structures to lateral transport to a logistics network for replenishment, if they are going to operate in their most effective mode. They should be embedded in combined arms tactics. Although some of these supporting components appear to be well suited to U.S. capabilities, we have yet to integrate them into a planned battle system.

Moreover, exploitation of precision weaponry requires more than technological excellence: political factors are important, too. From the political viewpoint, perhaps the most important new capability is that precision weaponry offers great precision in the physical damage inflicted on the enemy, thus permitting a more exact convergence between political decision-making and military action. This makes for a better chance of securing political objectives without the danger of escalation due to misunderstood military actions. Other political issues may be raised by the great mobility possible with PGMs.

PGM technology raises a number of arms control issues, also. Their small size and potential for concealment undermine "national technical means of verification." (Consider, for example, the frequently discussed problem of seeing and estimating the properties of cruise missiles.) Furthermore, since their performance is not particularly range-dependent, they blur the distinction between "strategic" and "tactical" forces as well as between "forward-based systems" and home-based forces. Finally, their effect on arms transfers warrants careful examination.[6]

I have mentioned enough potential changes—many of them of great importance to the two superpowers—to indicate that exploiting these potentials may make much difference both in the long-term military competition between the U.S. and the Soviet Union and in the ability of small powers to possess effective military forces. Many of the weapons mentioned earlier, as well as PGMs, are well adapted to being used in small packets. Some writers have compared them to the Colt revolver, the equalizer of the old West. The small power would need to be able to deal with relatively advanced technical systems, though. As to the Russians, they now seem to be adapting more flexibly than we are, with large production runs of small missile boats, mobile air defense systems, and the well-armed BMP mechanized fighting vehicle. But their great numbers of tanks with old-style armor and reliance on massive artillery barrages might be made obsolete. For the past forty years we have counted on superior technology to outweigh sheer numbers. While we clearly need numbers as well as technique, it seems that we are in a period of both peril—if we are stodgy—and opportunity—if we are nimble.

Rand Corporation

Notes

1. *The Economist*, December 4, 1974, pp. 100–101. The points made here are summarized, not quoted directly.

2. This definition is slightly modified from the one I give in Adelphi Paper No. 118, *Precision-Guided Weapons*, The International Institute for Strategic Studies (London), Summer 1975.

3. Slightly modified from my previously cited monograph, *Precision-Guided Weapons*, p. 4.

4. The Big Five include the Patriot antiaircraft missile, the XM-1 tank, the AAH armed helicopter, the MICV armored fighting vehicle, and the UTTAS transport helicopter.

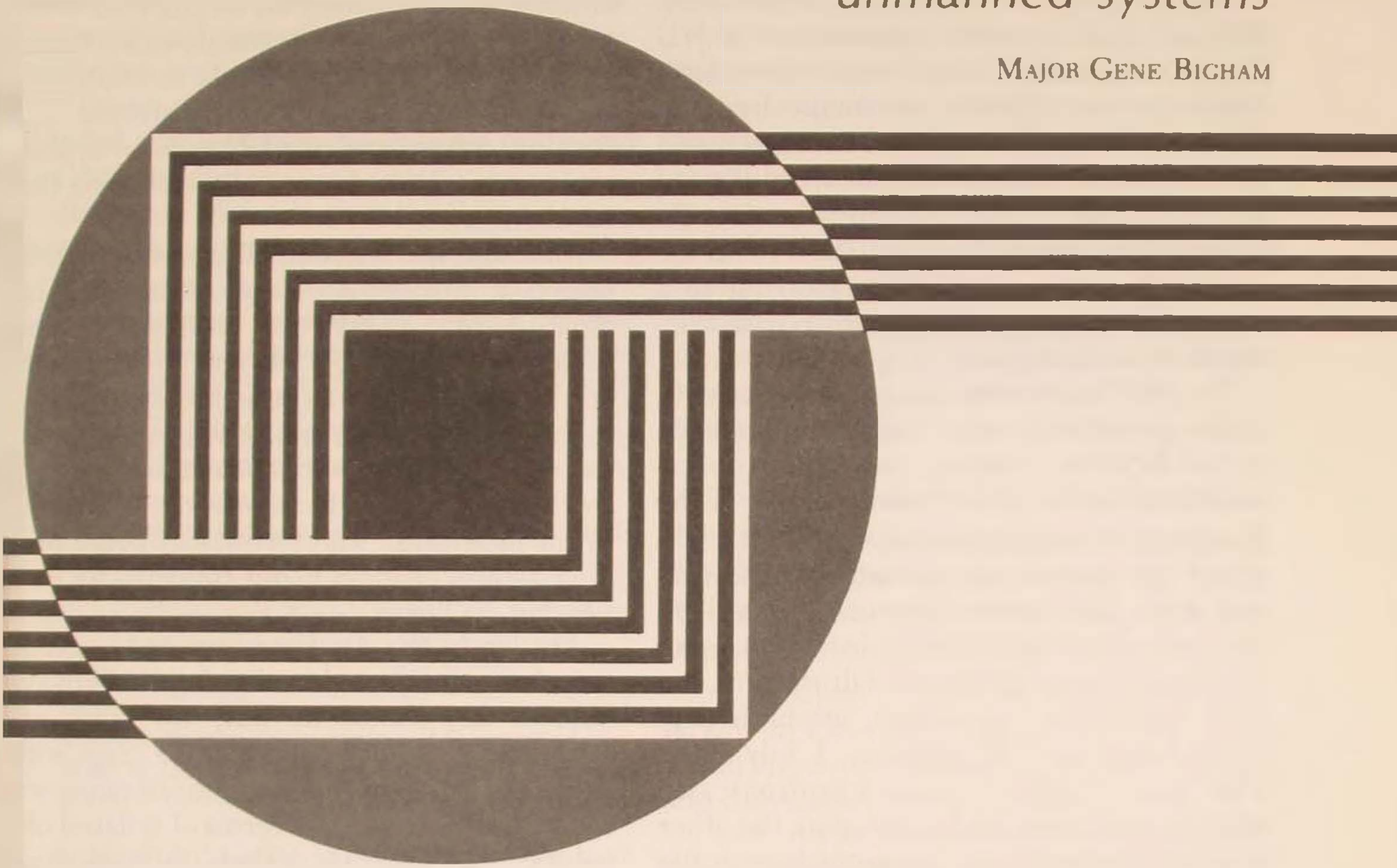
5. The BMP is a modern, heavily armed mechanized fighting vehicle. Its employment in special regiments is described by John Erickson in "Trends in the Soviet Combined-Arms Concept," *Strategic Review*, Winter 1977, pp. 38–53.

6. For more on these topics see "New Technology and Control of Conventional Arms: Some Common Ground," by S. J. Dudzinsky, Jr., and James Digby, in *International Security*, vol. 1, no. 4, Spring 1977.

THE FUTURE OF DRONES

a force of manned and unmanned systems

Major Gene Bigham



CHARLIE FLIGHT, a flight of four strike aircraft, was joined by the remainder of the strike force over Western Europe and began the ingress to the initial point (IP) for run-in to the target. After the IP and approximately two minutes from target, "Charlie" rolled in to the right and released bombs on a heavy concentration of antiaircraft artillery (AAA) and surface-to-air missile (SAM) defenses. The remainder of the strike flight did a separation maneuver and then struck the primary target, a mass armor staging area. Charlie lost one aircraft, but the defenses were sufficiently suppressed to allow the remainder of the strike flight to complete the strike unscathed. The strike flights departed the area and returned to their bases.

"Not an unusual mission," one might say. However, suppose these flights had been controlled by men located not in the cockpits but rather in the basement of the Pentagon, each of them controlling multiple drones through the use of a satellite link. Although this mission is not possible today, given our present technology and development efforts, it could become a future operational reality.

Before proceeding we need to establish common points of reference. The word "drone" is used within the context of JCS Pub. 1 definition: "A land, sea, or air vehicle which is remotely or automatically controlled." Within the Air Force research and development community, this word is used to encompass our unmanned aircraft. "Remotely piloted vehicle" (RPV) will be used only when specifically referring to a drone that will be controlled by a man during its time of flight.

The Air Force presently employs drones in three operational roles. Target drones, such as the BQM-34, Firebee, have been operational for several years. Modifications of the Firebee were employed in low-altitude,high-speed reconnaissance operations in Southeast Asia.[1] These recce drones have evolved into our other operational drones that are employed by our only tactical drone unit, the 432d Tactical Drone Group, established at Davis-Monthan AFB, Arizona, 1 July 1976. This group consists of two squadrons: one with an electronic warfare mission, the other a recce mission. Both squadrons launch the drones from DC-130 aircraft and recover them with CH-3 helicopters. A production decision for a follow-on model of these drones, the BGM-34, is due in mid-1977. This drone provides a modular concept for photo recce as well as electronic warfare missions. This multipurpose drone is based on existing technology.

The Air Force has successfully tested an experimental 55-pound mini-RPV in the role of a harassment-type vehicle, including tests in which it homed in on a ground-based radio emitter. Examination in this area is continuing with funding support from the West German government.[2]

An evaluation has also been made of the air-to-air combat application of an RPV. In 1971, a derivation of the Firebee was flown against a Navy F-4. During the engagement, the Firebee averted two air-to-air missiles fired by the F-4, closed to a firing position, and scored a simulated hit on the F-4.[3] Currently, no operational capability exists for an RPV to track or fire at another aircraft. This engagement, however, demonstrated the turning advantage available with drones since man's limited *g* tolerance is not a factor.

Although this is not an all-inclusive examination of ongoing Air Force efforts, it is indicative of a very real interest in the technology. Other services and governments are also investigating drone technology.

Future drone development and subsequent employment appear to be limited only by the resources and *imagination* applied to drone programs.[4] This technology could produce radical changes in our concepts for employing air forces.

Are we in the Air Force ready to accept this change? Although technology has always been a key factor in war, we have experienced difficulty in coming to grips with changes in military technology because we tend to address them in terms of isolated objectives. We must view these technological changes as integral aspects of a much larger military system.[5]

The use of drones to complement our manned systems is an area of technological change that we must now seriously consider. As former Secretary of the Air Force John L. McLucas has written:

> I believe we are entering an era when RPVs will play an increasingly important role in helping airpower to serve the nation. However, we need to check out our missions to make sure that we are preserving the best mix of different types of aircraft, RPVs, and other systems.[6]

The Air Force must continue to maintain the proper mix of weapon systems to perform its missions in severe defense environments. This is necessitated by the large Soviet inventory of advanced aircraft and sophisticated missiles and their willingness to provide nations under their influence with these weapons. Also, it increases the probability that formidable air defense could be encountered even in future limited wars.

Yet we are faced with a very real dilemma: we must counter this increasingly sophisticated threat within the confines of limited military budgets.

Secretary McLucas gave the following reasons for his interest in drones:

> I would like to review why we in the military are interested in remotely piloted vehicles (RPVs). I see three basic reasons and I think we should constantly keep these in mind when we talk about the future.
>
> First, RPVs can be used to reduce manned aircraft attrition in the very high threat environments . . .
>
> The second reason is to provide an acceptable way to accomplish certain tasks when the mission or area of operation is politically sensitive, and we just don't want an aircraft flight crew exposed . . .
>
> The third reason, and by far the most important for the future, is to achieve a significant cost advantage over comparable manned aircraft systems. Here lies the key to greatly expanded use of RPVs.[7]

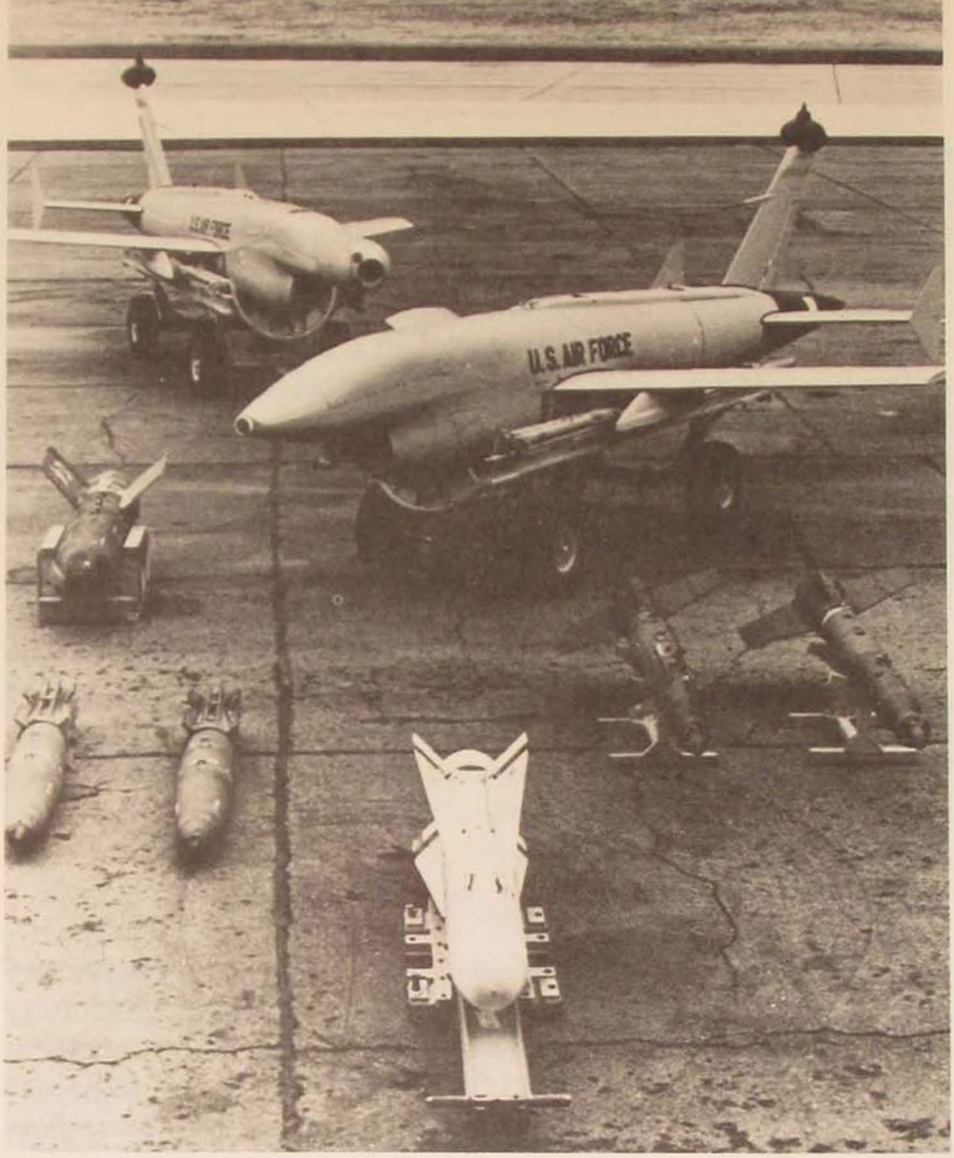
Cost advantage is the key. Yet, the fact that drones cost less than manned aircraft is not difficult to comprehend. They can be smaller, thus use less material. They do not require sophisticated life support or pilot escape systems, and they use less fuel. Since energy conservation is a topic of great concern today, this area will be examined further.

A recent Rand study attempted to estimate the peacetime annual fuel savings realized in the operation of an RPV compared to operation of an F-4 and A-7.[8] They considered an RVP using two engines comparable to that in the T-37 and capable of delivering munitions comparable to that carried by the F-4 and A-7. Rand determined the estimated annual fuel consumptions to be: F-4, 460,000 gallons; A-7, 148,000 gallons; RPV, 2280 gallons. These dramatic savings require some explanation. Fighter pilots require approximately 250 flying hours/year to maintain proficiency while it is estimated that an RPV operator would require only six flying hours/year to maintain proficiency. Thus the 2280 gallons consumed by the RPV in the study is the fuel required to maintain one operator's proficiency. If technology advances sufficiently and it becomes commonplace for one operator to control several RPVs simultaneously, the illustrated fuel savings could be readily realized. In the case of preprogrammed drones, the savings would be even greater since no operator proficiency would be required.

Drones and Tactical Air Forces

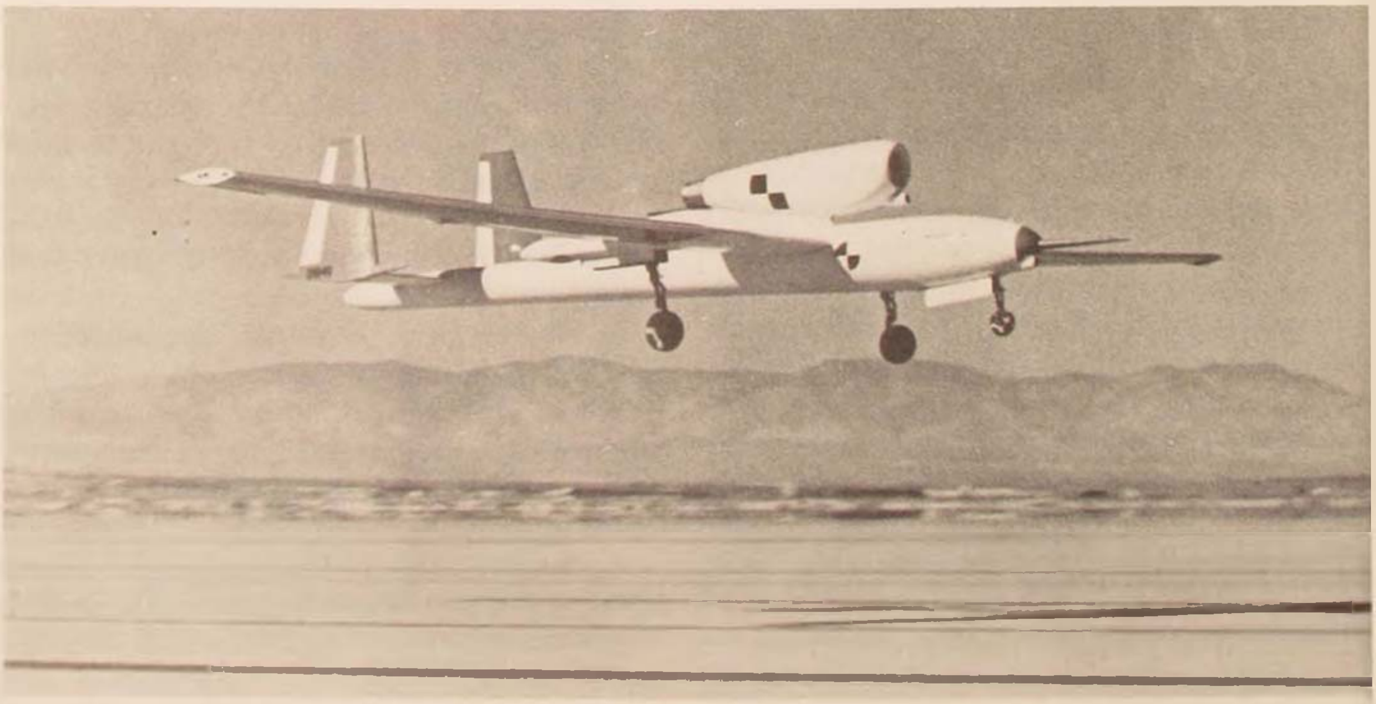
To facilitate determining how drones can complement our manned tactical air forces, the basic tasks that these forces perform must be understood. Briefly these tasks are:

- Close air support—Attacks against targets in close proximity to friendly forces requiring detailed integration with the fire and movement of ground forces.
- Air interdiction—Conducted to destroy, neutralize, or delay the enemy's military potential before it is brought to bear against friendly forces.
- Counterair—Destruction or neutralization of the enemy's air offensive and defensive systems.
- Tactical reconnaissance—Collection of information concerning terrain, weather, and the disposition, composition, movement, installations, lines of communications, and electronic emissions of enemy forces.
- Special air warfare—Includes air aspects of counterinsurgency (COIN), unconventional warfare (UW), and psychological operations (PSYOPS).



Remotely Piloted Vehicles

The BGM-34Bs (left) are prototype strike remotely piloted vehicles (RPV), designed to carry various weapon loads. Delivery is directed by a remote control operator in a DC-130 or at a ground control site. . . . The prototype Boeing high-altitude, long-endurance RPV (below) makes an automatic approach for landing.



These forces also perform tasks that are integral to the primary tasks of their employment. These additional capabilities are electronic warfare (EW), search and rescue, aerial refueling, and defense suppression.

The tactical forces that accomplish these varied missions must, by necessity, possess the employment characteristics of flexibility, range, mobility, responsiveness, and versatility. Possessing these characteristics, our tactical forces can then be orchestrated to fit the tactical situation. AFM 2-1, *Tactical Air Operations—Counter Air, Close Air Support, and Air Interdiction,* states:

> The composition of tactical air forces is influenced by the air environment and the nature of air targets, whether associated with a pure air campaign or operations in conjunction with a land battle. The quality and number of opposing air forces and surface defenses will determine the number and types of weapon systems needed to gain control of the air and conduct air strikes. The nature of the land battle and the types of air interdiction and close air support targets, their location and composition, will influence the force mix required for optimum support of the area objectives. In any area of operations, the wide range of available firepower and support capabilities permits discriminate application of force to achieve specific objectives.

Both industry and government have, in recent years, directed extensive resources to the study, development, and demonstration of drone equipment and concepts. Also, the Air Force has accumulated considerable experience with drones through acquisition processes and operational employment. It is within the reasoned framework provided by these efforts that the possible uses of drones for tactical tasks will be examined. These possible uses will be categorized under the tasks performed by our manned tactical air forces.

close air support

A vital element of the close air support (CAS) task is the forward air controller (FAC). He may be employed from the ground or an aircraft. Of course, his perspective of the land battle and his ability to see and direct strike aircraft are improved when he is airborne. However, a high-threat environment may make it impossible for him to be within visual range of his target area. It is in this situation that an RPV could be used to provide the "visual" capability.

The RPV in this instance would be a small or mini-RPV. It would weigh less than 200 pounds and be as "invisible" as possible. Design and construction would be optimized to ensure that the mini-RPV was very difficult to detect by radar, that it has a very low infrared signature, produces very little engine noise, and is difficult to acquire visually. The RPV would possess a low-speed capability and would contain a TV monitor (perhaps a forward-looking infrared sensor) and a laser designation capability. It would be ground launched, capable of being guided both from the ground and the FAC aircraft, and be recoverable.

This mini-RPV could possibly be used by the forward air controller in the following manner. Suppose the FAC has been informed that the Army unit he is supporting will be receiving a CAS strike. He discusses the strike with the ground forces over his FM radio and discovers that the situation is tense. Enemy tanks have been spotted by forward observers and are expected to be engaged shortly. The FAC proceeds to the area only to find that the defense umbrella supporting the enemy is making the area too hot for visual recce and control of the CAS strike from the target area.

He backs off to a safe standoff distance and calls the operations center at his Tactical Air Support Squadron (TASS) to request launch of a mini-RPV. The alert RPV is launched and flown to a hand-off point by the TASS RPV control center. At the hand-off point the FAC assumes control of the RPV and flies it into the target area. Because of the RPV's survivability, the FAC is able to observe the situation by monitoring the TV coverage relayed from the RPV. He locates the friendly positions and has them transmit with a coded beacon to ensure that the fighters will also be able to confirm the location quickly. Then the FAC guides the RPV over the enemy tanks and evaluates the target array. After formulating his plan of attack, he moves the RPV into an orbit on the friendly side of the forward edge of the battle area (FEBA) and begins to brief the strike flight that has just checked in. The fighters have Mavericks, so the FAC elects to have them stand off during their deliveries. He then utilizes the RPV to relocate the targets and designates a target with the RPV's laser designator, while he has the Army forces transmit their position by coded beacon. The fighters confirm the friendlies' position, the laser designation, and are cleared to expend. They do so from a standoff position, and the mission is a success. Once the target has been hit and, in effect, marked, the fighters could proceed at low level, pop-up, and attack associated targets with guns or other "close-in" munitions. The FAC then flies the RPV to the hand-off point for the TASS RPV control center. The RPV is recovered and prepared for its next mission.

air interdiction

The many facets of this tactical task provide several possibilities for drone employment. Because the interdiction effort is usually directed against substantial targets, the strike drone envisioned for this mission would have to be a rather large vehicle. It would have to be capable of carrying a 2000-to-3000-pound payload in order to carry a practical amount of ordnance for striking interdiction targets. The vehicle should have sufficient navigation systems to provide reasonable accuracy for typical long-range interdiction missions. It should contain a TV capability and a laser ranging/designation feature. The altitude and airspeed capabilities should be similar to those of manned interdiction aircraft as should its radar return signature. It should also have the capability to carry electronic countermeasure (ECM) pods.

As mentioned earlier, drones could be used to reduce the need for manned aircraft to attack heavily defended targets. This benefit of drones could be exploited by utilizing them to attack targets such as airfields, SAM sites, and AAA sites. There are varied employment concepts available for an interdiction drone.

This vehicle could be a drone or an RPV, or it could combine drone and RPV capabilities. If a drone, it would most likely be a "one-way" expendable drone. It should contain a navigational system, such as inertial, with sufficient accuracy to be programmed, before launch, with the route to the target. It could be programmed to arm its weapons automatically after passing a given inertial point. The drone would then fly itself into the target by attacking the programmed latitude/longitude coordinates. This drone could fly at the lowest practical altitude from takeoff to attack.

A variation of this configuration could be a drone with the capability to release its weapons and return to a general recovery area. At this point the drone would decrease its speed, deploy a recovery chute, inflate a "cushion bag," and float to earth for later pickup.

A more versatile and perhaps cost-effective configuration would be an RPV with a modular payload capability, which would employ easily changed packages to provide strike, recce, or electronic warfare capability. Here we shall address only the strike capability.

Presumably a vehicle that can be preprogrammed as well as remotely controlled would provide optimum employment flexibility. One possible use for these vehicles would be as part of a strike force. Four of these vehicles could be launched, joined up, and released to fly a preset route to the target. A force of manned strike aircraft could then join with the drones to use the drone strike capability in addition to their own. If this is not feasible, perhaps the drones could fly at a higher altitude and the manned force to the rear and lower.

An RPV controller would assume command of the drones as they neared the target. In the target area the drones could attack the heavily defended portion of the target while the manned aircraft struck a less defended portion. For a smaller but heavily defended target, perhaps the drones would attack first followed by the manned aircraft. If the target were very heavily defended, perhaps no manned aircraft would be committed; only a large drone strike force would be utilized.

With the combined preplanned and remotely controlled capability, this drone offers maximum flexibility in targeting. A modular capability would enable use of one of the drones as a photo recce system. Flying at the rear of the strike force, it could provide immediate battle damage assessment in its pass or passes over the target.

A Rand study has concluded that RPVs can be more cost effective than manned systems in terms of cost per kill for one of the most demanding strike tasks, attacking SAM sites.[9]

Another interdiction task that has been costly to manned aircraft operations in the past has been implanting target activated munitions (TAMs). The use of drones, either singly or in flights, may provide a more cost-effective method. In addition, if the drones have a TV capability, the RPV operator could do recce simultaneously over an area that is of obvious interest since we had decided to implant TAMs in the area.

A discussion of how the strike drone can accomplish its weapons delivery is appropriate. Will it be able to do the most vital chore— *hit the target* —as effectively as our fighter pilots? That is a good question, and one that will have to remain unanswered now. However, there are some aspects of the weapon delivery problem that should be addressed in order to speculate on the answer to that question.

The problem is somewhat lessened when we consider laser-guided weapons. The greatest accuracy problem for either manned or unmanned vehicles will be how accurately the target is designated. It appears that an RPV controller safely detached from the target area may be capable of more concentration on the designation problem. This potential advantage could apply to manned systems as well, since an RPV could be utilized to designate for them as well as for other drones.

The problem does crystallize somewhat when we consider accuracy in delivery of unguided bombs. Manned aircraft for interdiction strikes will have either a computer-controlled or manual-delivery capability. Meeting the parameters for accurate delivery of either mode may be difficult for the pilot. If he plans to bomb by computer, he faces two primary problems, both caused by a single factor, the enemy threat. Because of the high threat envisioned for the hypothetical interdiction mission, he is forced to use a higher-release altitude. Therefore, if he has a good system and can expect 15-mil accuracy in this combat condition, releasing at 8000 feet above ground level he can expect to hit within approximately 120 feet of the target. This expected miss distance is compounded by the fact that he has used a higher-release altitude, which means he has less tracking time and a less detailed view of the target before release, resulting in a less accurate positioning of his aiming symbol.

Another factor in considering release distances is that a pilot must pull out using only 4 to 5 *g*'s applied in 2 seconds. This requires substantial altitude and extends the manned vehicle deeper into the dense air defense environment. If RPVs are utilized in this type of mission, certain advantages may be accrued. An RPV would not be restricted to an 8000-feet release altitude because loss of life is not a consideration. Also, the RPV controller may be better able to align the aiming symbol with the target since he would have fewer outside distractions. Further, the RPV may be capable of releasing from very low altitudes due to its ability to sustain many more *g*'s in the pullout. An RPV may be capable of using as much as 10 *g*'s in the pullout with a resultant reduction in altitude lost.

These advantages lead to another spin-off. Considering the same 15-mil system in the manned aircraft: If an RPV could release at 1000 feet instead of 8000 feet, the expected miss distance would be reduced from approximately 120 feet to approximately 15 feet. This means the computer capability utilized by the RPV could be reduced to only a 30-mil system (less accurate by a factor of 2), and the RPV could still expect only a 30-foot miss distance. The RPV operator, when bombing manually, would be faced with the same problems of the fighter pilot. But again, he would be out of the threat environment and could release from much lower altitudes. Problems of one RPV operator's employing multiple RPVs in a target area would be one of the demanding technological developments required.

Another application of drones to the interdiction task offers a stark contrast to the strike vehicle. That is the use of a mini-RPV, similar to that discussed for use by the forward air controller in the close air support role, as a recce/designator for interdiction strike aircraft.

If the mini-RPV is designed to be capable of air launch from a strike aircraft, it would afford this interesting interdiction capability. The mini-RPV could be carried by the strike flight to a convenient holding point for the fighters, perhaps to a prestrike refueling point. Then the mini-RPV could be launched and flown toward the target area. Control after launch could be by the strike aircraft or by data link from an RPV operator through a relay drone.

In either case the TV capability of the RPV would be utilized to find the assigned target. The RPV could then be used to laser designate the target for the strike flight. If laser designation is not required, then weather information, threat information, or changes in target disposition could be relayed from the RPV to the strike leader. Most likely, this RPV would be expendable and not be returned for recovery.

counterair

Any discussion concerning possible use of RPVs for counterair operations will have to be very conceptual. However, there are some roles which seem applicable, given the technology to bring them to fruition. For example, consider such roles as augmenting the theater air defense force and protecting the Airborne Warning and Control System (AWACS).

This counterair vehicle could take either or both of two forms. First, it could be a vehicle capable of employing both long-range and short-range air-to-air missiles. Second, it could be a vehicle that is flown into the target in a manner similar to a missile.

Either type of vehicle could be used to augment theater air defense forces. These vehicles could be based with interceptor units and guided to a hand-off point after launch by a controller located at the unit command center. The RPV could be handed off to an RPV controller located at the Control and Reporting Center (CRC) for employment in the counterair effort.

Protection of AWACS by RPVs could take different forms. Perhaps the same vehicles that are based with interceptors could remain on call near AWACS. During this orbit they will be controlled by an RPV controller located on the ground. If they are required for AWACS defense, control of the necessary RPVs could be transferred to AWACS for employment. Perhaps AWACS could carry its own RPVs aloft, then employ them if the need arises.

tactical reconnaissance

This is the one primary tactical task for which the Air Force has established an operational unit. Our tactical recce drone, the AQM-34, evolved from the use of modified versions of the BQM-34 target drone for recce operations in Southeast Asia. This experience demonstrated the applicability of drones to the recce task. A recent study of the capabilities of manned and unmanned recce vehicles likely to be available by the 1980s revealed that both types would be needed for a recce force.[10]

The drones that would complement our 1980 recce force must provide better capabilities than today's unmanned systems. The vehicles will have to provide high- and low-speed capabilities in addition to high- and low-altitude capabilities. Although one vehicle may not be able to provide all of these capabilities, each type of vehicle considered should provide the maximum possible flexibility. Our present recce drone is capable of air launch, air recovery only; our future force must provide for both air and ground launch.

Given the required flexibility and capability, a future drone force could participate in all levels of recce tasks. They could be employed in the immediate area of the FEBA against first and second echelon enemy targets. They could ease the need for manned aircraft to face the high-threat environment surrounding very-high-priority, lucrative targets behind enemy front lines. Employed as a portion of an interdiction strike flight, they could provide immediate TV battle-damage assessment along with a timely photo intelligence capability. They would also eliminate the need to expose a man to the very hazardous recce mission in politically sensitive areas.

special air warfare

The capabilities of drones are applicable to the special air warfare (SAW) task, especially in psychological operations. They could perform the leaflet drops and low-altitude public broadcasts required during psychological operations even within today's technology. This capability would be more flexible with the development of ground-launched or air-launched options.

Employment of Tactical Forces

Several tasks are critical to the successful accomplishment of most of the primary tasks performed by the tactical forces. These tasks are electronic warfare (EW), defense suppression, and search and rescue (SAR).

The electronic warfare and defense suppression areas are extremely complex. There are many systems for accomplishing these tasks, and many systems are in development. The entire task becomes even more complex when one realizes our technology must keep pace with the ever changing enemy threat.

electronic warfare

In the electronic warfare (EW) role, drones could be employed for jamming in an escort role and a standoff role, or a combination of both. The modular strike RPV discussed as an interdiction vehicle would be the vehicle envisioned for this task. It would be capable of flying at the altitude and airspeed of the strike vehicle and would possess the same radar return characteristics on enemy radar. Several of these drones could be employed with a strike force of manned or manned and unmanned aircraft. The ECM RPV would jam on command of the ground RPV controller by use of a relay aircraft or on command of the pilot leading the strike flight. It is noteworthy to recognize another advantage of combining ECM RPVs, strike RPVs, and manned aircraft into a strike force. Not only do the manned aircraft receive the jamming benefit of drones but their pure numerical chances of not getting hit by enemy fire are improved.

The effectiveness of the strike flight could be improved even more by utilizing either a preprogrammed drone or an RPV, in a standoff orbit, for additional ECM jamming support.

defense suppression

In the defense suppression role, drones could have several applications. Our present operational drones have demonstrated the capability to release chaff in support of strike aircraft. In addition to this support of strike flights, drones could also be used to attack enemy air defenses. They also could be utilized to seek out these defenses and data link target type/position information to the Combat Information Center (CIC) at the Tactical Air Control Center (TACC) for use in generating defense suppression strikes.

The attack RPVs for this mission should be similar to the type envisioned for the CAS mission, although it would not have to pos-

The Tactical Expendable Drone System (TEDS) is a decoy and jamming platform for use with strike aircraft.

Combat Angel, an electronic warfare support remotely piloted vehicle, carries chaff pods and nose-jamming transmitters. It is flown by a Tactical Air Command drone squadron.

A low-cost, expendable harassment test vehicle being flight tested at Nellis AFB, Nevada, in June 1976

sess a laser designator. The RPV envisioned here would be a flying bomb using a TV capability for the RPV operator to search for the target visually. Once the target is located, the RPV operator flies the RPV into the target. This RPV would be directed against "soft" portions of the target array. Troops, radar vans, trailers, etc., would be the types of targets applicable for this small weapon. The enhanced survivability of the vehicle—small size, high *g* capability, low radar return, reduced infrared signature, and, possibly, armor—would make it very suitable for this demanding mission.

We could also use a very small vehicle in a seeker function. This vehicle could be a preprogrammed drone or an RPV. It would be compatible with an accurate navigational system such as the Global Positioning System (GPS). Once in orbit the vehicle could use a number of sensors to search for emitting targets. This vehicle's position would be tracked very accurately by a ground or airborne station. From this known position, bearing and distance to any discovered targets could be measured very accurately by use of a laser ranging device. This target information could be data linked to the CIC at the TASS for target generation.

For a pure defense suppression strike role the strike RPV or a drone could be utilized. Use of this vehicle would reduce the number of manned aircraft employed against this high-threat type of target.

search and rescue

The search and rescue (SAR) role is a fertile area for drone employment. All of the possible uses for drones in a SAR context would require characteristics similar to those previously discussed.

The most basic employment would be a drone in a preplanned orbit with the capability to home in automatically on an emergency beeper. The ground operator would have the capability of obtaining a very accurate fix on the drone. This coupled with an accurate readout of range and bearing from the drone to the beeper location would provide immediate survivor location information.

A drone similar to that envisioned for use by the FAC could then be used to enter the survivor's area and feel out the enemy defenses. Current tactics call for this to be done by the fighter aircraft on the scene. This same drone may also be used to acquire the survivor visually.

Strike drones could aid in the suppression of enemy defenses, lay smoke screens for protection of rescue helicopters, or other support functions. Another possibility would be the use of a drone to drop supplies, etc., to a survivor in an area of high enemy threat.

THIS DISCUSSION has highlighted the ongoing interest in drones by the Air Force. There are several development and procurement programs being pursued. The Air Force is going to utilize drones to complement its manned aircraft. In fact, that is the situation today. There are two operational drone squadrons within the Tactical Air Command. It is obvious then that drones, within today's technology, can complement manned aircraft in accomplishing tactical tasks. With improvements in technology, their future use appears to be limited only by man's imagination. Several employment possibilities for all facets of tactical operations have been suggested.

As a separate entity, drones can perform tactical tasks. They can complement manned aircraft. But, can they be integrated, as an unmanned tactical force, into our manned tactical force? We cannot do this today. Yet it is only through this integration that the true capabilities and benefits of drones will be fully realized. The key to this integration lies in two areas: technology and operations.

With proper emphasis, it appears that

technology will enable us to employ drones in any imaginable way. However, the degree to which RPVs can effectively accomplish tactical tasks is directly related to their capabilities for large-scale coordinated operations that can be conducted in a timely and efficient manner. Without multiple drone control, the very attractive interdiction strike application of drones appears doomed. If each drone used in strike force employment must be individually controlled, the cost would be unreasonable for the limited operational capability. Work is being done in this area. However, the recent Program Management Directive for Automated Mission Planner (AMP), 1 February 1977, states:

> . . . development for a new RPV mission control system was initiated. . . . it was determined that the Joint Tactical Information Distribution System (JTIDS) should be used. . . . However, the scope and importance of JTIDS to the overall tactical air control complex has prevented RPVs from being afforded a high priority in the formulation of the program.

This management directive illustrates the need for the proper emphasis and direction for our drone development efforts if the Air Force is to be capable of integrating manned and unmanned systems. The most favorable impact from the use of drones is reduced cost, and it must be kept in mind through all aspects of the drone life cycle. It is a factor in the design, production, operation, and utilization of drones.

Low cost must be considered by industry and the military alike. Technologies for drones have been demonstrated except for the ability to provide low-cost vehicles. Yet industry says it is possible to achieve drone systems with remarkably low life-cycle costs.[11]

The military must realize that in dealing with drones we must develop unique techniques, not reduce manned aircraft techniques for drones. Our specifications, inspection requirements, and maintenance procedures must reflect low life-cycle cost efforts. We must realize that drones are not expected to fly for years as manned aircraft do. Yet there are many subsystems in a drone that must operate perfectly at all times. Even occasional failures of some subsystems may cause catastrophic loss of an entire drone mission. In other areas, we must establish practical yet minimal performance requirements. New and innovative construction materials such as compressed paper, plastics, or epoxy should be considered. High production rates through automated fabrication would also reduce cost. All these possibilities are applicable to thinking of all drones as expendable. We can then view those drones that are designed for recoverable operations as reusable expendables. Perhaps this would aid in meeting the required low-cost thinking.

DRONES present the Air Force with an interesting challenge: A chance to accomplish their mission in a more cost-effective manner but at the cost of a very solid tradition. That tradition is the one of Air Force fighter pilots in the cockpit of tactical aircraft. Now the Air Force must consider placing man in a different position in the control loop. His ability to make decisions, fly aircraft, and deliver ordnance will be maintained, but his physical limitations will be removed from the aircraft.[12] Acceptance of this concept for a portion of our tactical force requires not only development of new vehicles but other basic changes as well.

The Tactical Air Control System (TACS), which is the Air Force component commander's system for control of tactical force employment, must be reorganized to integrate drones. Provisions must be made for autonomous drone operations as well as integrated drone and manned aircraft operations. Drones cannot be simply plugged in to a control system. Removal of the pilot from the aircraft and perhaps remoting the drone system are going to require changes in airspace management, coordination, and vehicle control.[13]

The Air Force will be faced not only with force structure decisions but also decisions such as where drones should be based. Would it be practical to base interdiction type drones with an interdiction-capable fighter wing? Would it be better to disperse a drone unit? Also, who would fly drones? Is an officer required? Must the RPV operator be a pilot? Is the only requirement for a pilot during the attack phase of flight? How do we train? These and many more questions will have to be answered.

However, the most basic unanswered question is: What is the Air Force position on the roles and missions of drones? Perhaps a solid position on the roles and missions of drones is lacking to some extent because of the reluctance of pilots to have an interest in a system that could replace them. Unfortunately, development funds will probably not be increased until the Air Force develops a solid position on drones. Drones can accomplish tactical tasks. With improvements in technology they can be integrated, as a force, into our manned tactical air forces. They can complement manned tactical aircraft and be orchestrated as the optimum force for the tactical situation. Thus, the development of an Air Force position on drone roles and missions is not a future decision but one that must be made today. The Office of the Secretary of Defense has issued its preparation instructions for the FY 79–83 Program Objective Memorandum stating:

> RPV/DRONE
>
> The Services should specify levels and funding over the program period for their drone and remotely piloted vehicle programs. The specific mission intended for each drone and RPV program should be given and the impact that the drone/RPV program has on manned aircraft doing the same mission should be addressed.

Now the Air Force must answer the difficult questions concerning drones and decide if we are ready to accept the changes and challenges effected by drone technology.

Alexandria, Virginia

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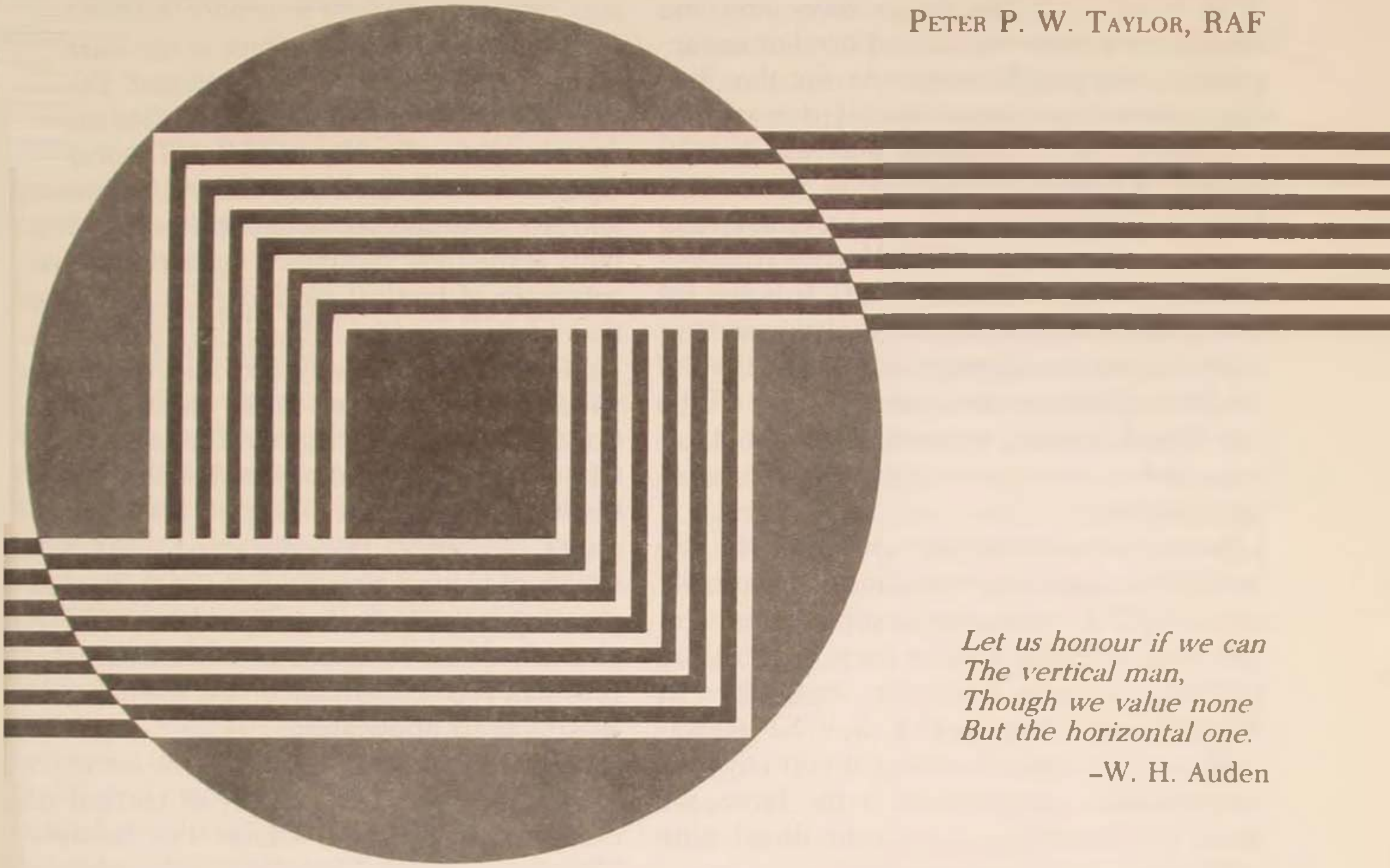
THE IMPACT OF V/STOL ON TACTICAL AIR WARFARE

Wing Commander
Peter P. W. Taylor, RAF



Let us honour if we can
The vertical man,
Though we value none
But the horizontal one.
–W. H. Auden

THE VERTICAL and short takeoff and landing (V/STOL) concept is not new, having fascinated air theorists with its possibilities for many years. French, American, German, Russian, and British designers are a few among many who have experimented either theoretically or practically over the last twenty or so years. And now, V/STOL is really with us. This article proposes that V/STOL is the future of tactical fighter aviation. Unfortunately, as Auden indicates in his pithy poem, complete agreement on the issue has so far eluded us. It will, therefore, be the purpose here to examine the impact that V/STOL technology has and might have in tactical air warfare; to present facts, interpretations, and views; and logical argument to convince a wide audience that V/STOL has much to offer—and that time is getting short for the West to exploit the advantage it currently enjoys in this field of technology.

The Hawker Siddeley Harrier has been in service with the Royal Air Force (RAF) and the United States Marine Corps (USMC) for eight years; and the Royal Navy and the Spanish Navy have either acquired or are acquiring seagoing Harriers. As for the Russians, their first experimental design, the Freehand, has developed into the Yak-36 Forger, currently embarked on the carrier *Kiev*. In the near future, we shall see an updated version of the USMC Harrier (the AV-8A), now designated the AV-8B. It is also inconceivable, as John W. R. Taylor asserts in *Jane's Aerospace Review 1976–1977* that "if the Soviet Navy was prepared to show off the Yak-36 so blatantly, we must assume that it is regarded as merely a first step towards something better."[1]

Some, then, are clearly convinced by the possibilities, and they are those who usually argue V/STOL with the most persuasive enthusiasm. But why, if the case is so good, has V/STOL not found greater acceptance in military aviation circles? If a V/STOL aircraft can show significant advantages over its conventional counterpart, why have we been so hesitant and tardy in developing both technology and concepts?

History provides many examples of new technology, both in industry and in the military, that have either been ignored, discarded too soon, or have been developed much later than they should have been. With the benefit of hindsight, we look back and marvel that anyone could have been so blind as not to have seen the advantages of, say, the bow, the machine gun, or the torpedo. Yet, they were only to have been proved wrong time and again. It will be proposed here that V/STOL is a technological advancement similar in significance to those just cited. We must hope, therefore, that we are not ignoring an innovation of such fundamental importance that we shall be similarly accused by our successors.

Characteristics, Functions, and Principles of Tactical Air Forces Employment

How would V/STOL adapt to the current concepts of tactical air operations? To answer this question, we shall look first at the doctrine prescribed by AFM 2–1, *Tactical Air Operations—Counter Air, Close Air Support, and Air Interdiction,* which states that flexibility is the most significant operational characteristic of tactical air forces. It continues that tactical air forces have the inherent capability to react rapidly and selectively to a wide range of missions under varying operational conditions throughout the entire spectrum of conflict.[2] And how is this flexibility to be derived? By capitalizing on the inherent range, mobility, responsiveness, and versatility of tactical aircraft. None of these characteristics is adversely affected by V/STOL aircraft; on the contrary, as we shall see later, they can replace, enhance, and even revolutionize their application.

AFM 2–1 has further pertinent advice to offer concerning the security of tactical aircraft on the ground. Under the headings "Dispersal" and "Security," the manual states:

> Since tactical air forces can operate at high speeds and over long distances, they should be dispersed for security.
>
> Technological advances should be exploited to minimize the force required and to reduce operational losses.
> Measures to maintain and strengthen the security of available forces against all actions which could reduce, neutralize or destroy capabilities are of paramount importance.[3]

Could there be a more effective way to provide dispersal and security than the V/STOL option? V/STOL allows dispersal and concealment, freedom from fixed bases and rigid concepts, and therefore contributes to a reduction of operational losses. And finally, could there be a more effective way to maintain and strengthen the security of available forces than the theoretical freedoms to hide and operate from almost any surface?

Sufficient evidence exists to propose that V/STOL could replace, enhance, and revolutionize the doctrine dictated by AFM 2–1 for tactical aircraft. For the first time, the oft-repeated ideal requirements that are espoused in the doctrinal manuals could be translated into an actual capability.

Deterrence Value of NATO's Conventional Air Forces

The present doctrine for deterring Soviet aggression in Western Europe is based on a defense triad consisting of strategic and tactical nuclear forces and conventional forces. Since tactical nuclear and conventional aircraft are often the same in NATO (possibly until the introduction of the cruise missile), no specific effort will be made to draw clear lines of distinction between tactical operations involving the two. The discussion will focus on the broad category "tactical aircraft" and encompass all the generally accepted roles in tactical operations.

It is axiomatic that the tactical air contribution to the deterrence equation must be credible or it may assume a negative value. That is to say: if NATO's tactical air forces are so structured and employed that they are either vulnerable to surprise attack or have a doubtful capacity to operate in war, then these forces invite rather than deter aggression. A closer look at the relative deterrence values of both the Warsaw Pact and NATO air forces is taken later in the article. For the moment, however, the deterrence value of tactical aircraft will be discussed more in the abstract than the subjective.

If we begin by proposing that the tactical part of the triad must be as invulnerable as we can make it, we must examine how this is currently achieved. Air Force doctrine stresses that the vulnerability of tactical aircraft can be reduced by applying the following principles:

Flexibility. Aircraft must be given as many operating options as possible.

Readiness. The highest state of readiness commensurate with peacetime and training requirements ensures some degree of security from surprise attack.

Training. A high state of training coupled with realistic exercises contributes to successful operations and reduces losses both on the ground and in the air.

Defenses. A combination of hardening and toning down key equipment and installations, plus improved antiaircraft artillery (AAA) and surface-to-air missiles (SAM), will reduce vulnerability.

Dispersal. Dispersal and concealment are ancient military principles whose validity has been proved in many campaigns.

In light of these principles, we pose the question: How applicable will the principles be in the face of advancing technology? To answer, we will assess the vulnerability of today's airfields against precision-guided munitions (PGM); and we begin with a few published statements on the subject:

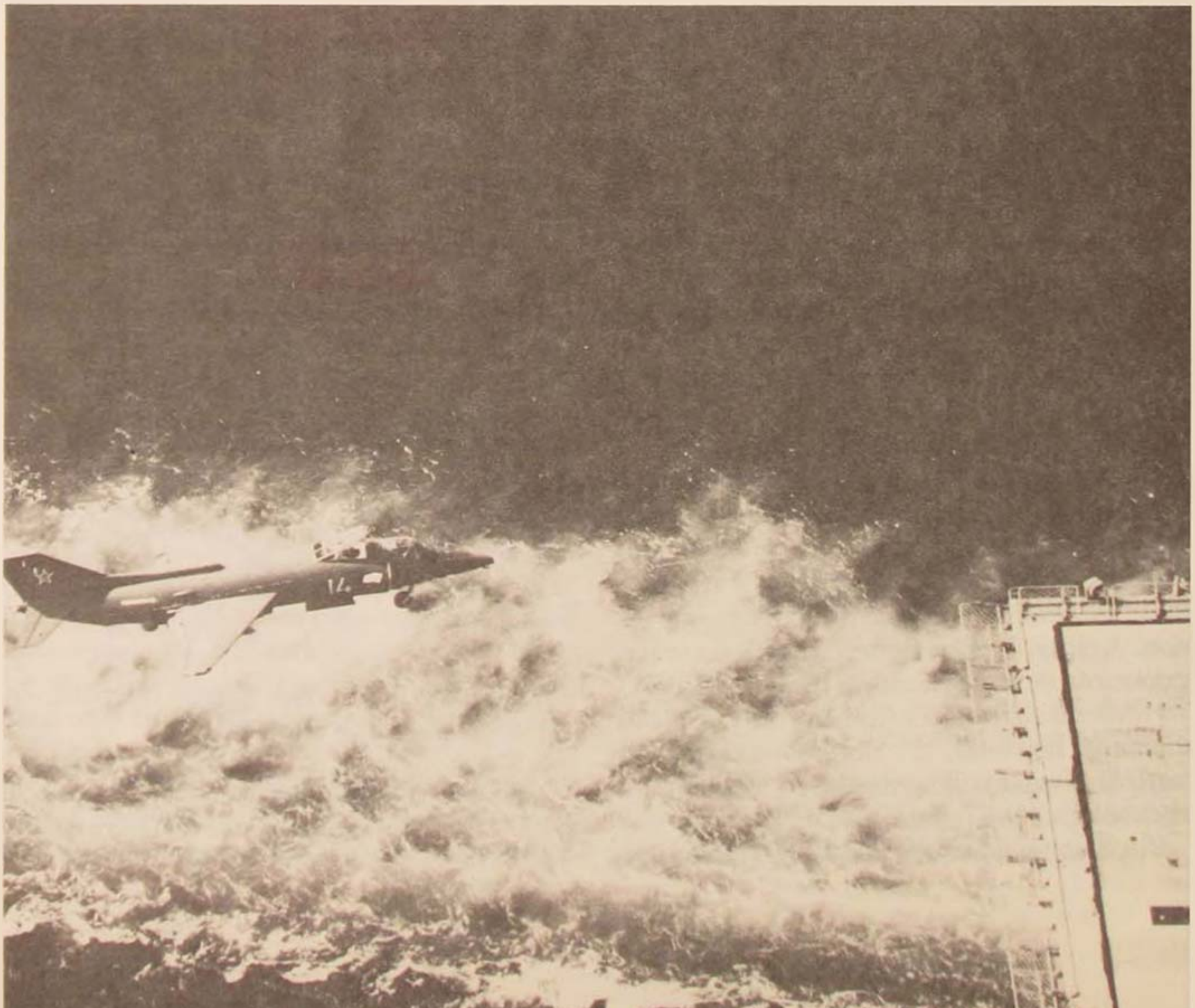
> Nor are all the tactical implications of even the current generation of PGM yet apparent. Thus far only two have been clearly identified. The first is that fixed installations seem to be particularly vulnerable to PGM. . . . This means that depots, *airfields* . . . are less secure than they have been in the past. . . . This tends to put a premium upon hiding, blending with the background, . . . [4]

James Digby of the Rand Corporation wrote on the same subject.

> It will become much less desirable to concentrate a great deal of military value in one place. . . . If the attacker has a finite number of PGM, any one of which has a high probability of de-

V/STOL Comes of Age

Long a subject of fascinating speculation to theorists, the V/STOL during the past two decades has progressed from theory to actuality. For eight years the Hawker Siddeley Harrier AV-8A has been part of both the Royal Air Force and U.S. Marine Corps inventory. The Marine Corps version (right) is armed with bombs and Sidewinder missiles. . . . That the V/STOL is well established in the Soviet arsenal is confirmed by the wide display made of the Yak-36 Forger, seen below landing on the first Soviet aircraft carrier Kiev *in the Mediterranean.*



> stroying its target, then it is better to force him to spread them over many targets which are individually of small value. . . . Smallness and mobility will make hiding easier. . . . However, one must also consider the degree to which concentrations can still be sheltered, or protected by active defenses . . . (but) there is no question of PGM not being used if fighting takes place, and no tactical planner can any longer afford to ignore their effect on his vulnerabilities.
>
> Even small units can be very powerful when equipped with PGM or with designators that can call in and guide remotely-launched PGM. . . .[5]

The significance of these extracts is clear: PGM among other weapons can probably defeat airfield defenses. Furthermore, the principles from which a degree of vulnerability had previously been derived now look less valid. How flexible can one be if either individual targets or the main runway are successfully attacked? All the readiness in the world cannot help if runways are destroyed in the first salvo. And finally, the security of the base can be overcome not only by air attack but also by ground attacks, if the threat from sabotage groups, for instance, is enhanced as much as Digby's last statement would lead us to believe.

Although the extracts about PGM predict a rather gloomy future for the fixed installation, they were chosen because they not only described the potency of the PGM but also how PGM effectiveness might be reduced if certain other principles were reapplied to the argument. The extracts all hinted that dispersal of forces into a number of smaller targets and mobility and concealment could still allow the flexibility, readiness, and security required for effective tactical operations.

Warsaw Pact and NATO Tactical Air Forces Compared

the Warsaw Pact

The threat from the Warsaw Pact tactical aircraft is today both quantitative and qualitative. Until quite recently this was not the case since although the pact enjoyed a considerable numerical superiority over NATO, their aircraft possessed little sophisticated equipment and a relatively poor offensive capability. The aircraft were, however, very rugged and designed to operate from a variety of natural and prepared surfaces. The apparent qualitative deficiency in Soviet designs has now been considerably reduced by the advent of a new generation of tactical combat aircraft. By almost any estimate, the Fencer, Flogger, and later series of Fitter and Fishbed are formidable aircraft giving the Warsaw Pact air forces an immensely improved offensive capability. Nor, seemingly, has this achievement been accomplished at the sacrifice of numerical strength. According to *Flight International* magazine, the Russian aircraft industries supply about 1000 new combat aircraft every year, not counting about 700 helicopters. In addition, improvement to some earlier models has meant that they are often being replaced roughly one-for-one, over and above being reinforced by new types.[6]

Soviet operations have traditionally stressed the need for surprise and security,[7] and nowhere has this been more clearly demonstrated than in their doctrine for the use of tactical air power. The Soviets have always clearly understood the need to safeguard their air assets either from a surprise attack or during operations, through a combination of strong static defenses and dispersal. Contemporary developments have not changed this perception. Descriptions of the formidable Soviet air defenses can be found in almost any aviation magazine today, stressing the numbers, complexity, and efficiency of the various systems.[8] Furthermore, the emphasis on dispersal, combined with hardened shelters, remains of fundamental importance to the Warsaw Pact:

> The operational readiness status of Soviet Frontal Aviation units is on a permanently high

> level, and is continually improved and checked on by practice alerts. As part of these practice alerts, units are redeployed from their bases to small auxiliary airfields, of which there are *several hundred in frontal areas.*[9]

It would, therefore, be fair to conclude that the Warsaw Pact is well equipped, well trained, enjoys the benefits of standard equipment, and maintains a high state of readiness. The continued emphasis on dispersal capability bestows the dual advantages of reducing aircraft vulnerability in the event of a pre-emptive attack by NATO, while at the same time allowing an unrivaled offensive capability to either pre-empt or conduct operations in war. Warsaw Pact tactical air power is thus credible in terms of deterrence and capable in terms of performance.

the North Atlantic Treaty Organization

NATO's approach is somewhat different, stemming in part from military, economic, and political perceptions. Colin Gray summarized the basic NATO approach:

> The NATO countries are essentially *status quo* powers, and so have generally adopted a mix of strategic and arms control policies that give the initiative to the other side. . . . [10]

This quotation suggests many of the policies and doctrines that NATO has adopted in the equipping and use of its forces. To deal with the specific case of tactical aircraft, we see that NATO intends to undertake all the traditional roles, such as interdiction, counterair, reconnaissance, and close air support. It is intended to pursue these roles irrespective of the Soviet air defense threat and the imbalance in numbers of aircraft between the Warsaw Pact and NATO. The current *Military Balance* estimates the imbalance in Central and Northern Europe to be 2085 for NATO and 3975 for the Pact.[11] Recent re-equipment programs have seen or will soon see a significant qualitative improvement in aircraft, provided by the F-16, F-15, the Tornado, and the A-10.

Unfortunately, NATO's aircraft are concentrated on a few, easily identified airfields whose position is precisely known. This presents NATO planners with three main problems: how to reduce the effectiveness of a pre-emptive attack; how to continue operations during war; and how to receive the planned reinforcements from the U.S. to offset the present numerical inferiority. In other words, apart from the Harrier, NATO does not have a dispersal capability and pays the price in the lack of flexibility inherent in its tactical air doctrine. Nor does the future look bright, for the main effort to reduce the vulnerability of NATO's airfields is being directed to such static measures as hardening, toning down, and improved air defenses. Worthy and necessary though these measures may be, they retain the essential weakness of being static, a point aptly summed up by Bill Bedford, a former Hawker Siddeley chief test pilot:

> In war certain basic principles apply of which flexibility, mobility and surprise with quick reaction are of the utmost importance. Is there not a tendency for these fundamentals to have been overlooked in latter years where air power is concerned? Have certain NATO and other countries not partially buried their heads in large, vulnerable concrete runways, protective shelters, SAM and Anti Aircraft defences? History points, time and time again, to the danger of STATIC inflexible defence whether it be a stone age cave, a castle, Maginot line, or an airfield. The Achilles Heel is that of being static —no matter how well protected and defended such bases may be.[12]

This, in essence, is what NATO has done. As a result, options are few, a high state of readiness is difficult to achieve, and fixed installations can be accurately targetted. The new-generation NATO aircraft are highly sophisticated and aggravate the problem further since their very sophistication argues against operations from anywhere other than a fixed installation with the necessary support.

Thus we see a NATO air force that although well equipped and trained possesses the fundamental operating weakness of being highly concentrated. Furthermore, there appears to be little enthusiasm for developing any kind of comprehensive dispersal capability, relying instead on improving static defenses. The deterrence posture gives little comfort or credibility, and the imbalance created mainly by the dispersal issue is or should be worrying. NATO has pursued an unequivocably defensive strategy that should have placed great stress on survivability of its forces. A parallel strategy can be found in the most expensive efforts which both the U.S. and the U.S.S.R. have undertaken to ensure the survival of their respective strategic weapons. Yet whereas NATO's tactical forces are grouped closely, the Warsaw Pact's, already enjoying the luxuries of superior numbers of aircraft and airfields, have a further marked superiority in dispersal capability.

What can be done to correct this imbalance? We have already found arguments which stress that technology is the West's strong point, but it seems that on the subject of dispersal, a proper course is not being pursued, despite such exhortations as

> The side which can maximize the effects of the new technology first is likely to be the better prepared for the next conflict.[13]

Current V/STOL aircraft and associated concepts of operations have shown how effectively they could free NATO's tactical aircraft from the dangerous constraint of operating from a handful of airfields. Unfortunately, only a few have seized the opportunities now offered.

The V/STOL Argument

The human race has seldom distinguished itself by the rapidity with which it has embraced new ideas, and military innovations fit only too neatly into this hypothesis. Admiral Alfred Thayer Mahan expressed this aptly in his classic study *The Influence of Sea Power on History, 1660–1783:*

> Changes in tactics have not only taken place after changes in weapons, which is necessarily the case, but the interval between such changes has been unduly long. This doubtless arises from the fact that an improvement in weapons is due to the energy of one or two men, while the changes in tactics have to overcome the inertia of a conservative class; but it is a great evil. It can be remedied only by a candid recognition of each change, by careful study of the powers and limitations of the new ship or weapon, and by a consequent adaptation of the method of using it to the qualities it possesses, which constitutes its tactics. History shows that it is a vain hope that military men generally will be at the pains to do this, but that the one who does will go into battle with a great advantage—a lesson in itself of no mean value.[14]

These are brave and prophetic words that apply to many technological advances, of which V/STOL is one of the latest. So let us examine "the powers and limitations" of this new technology and provide perhaps one example to history of military men who have adapted it, made capital from its properties, and produced new, even revolutionary tactics for jet fighter aircraft.

advantages of V/STOL

The advantages of V/STOL technology will be developed under three headings: operational flexibility, survivability, and combat agility.

Operational flexibility. V/STOL technology allows aircraft to disperse from fixed bases whenever a threat seems imminent, providing both a survival and a return strike capacity. Any attempt by the enemy to locate and destroy these dispersed forces (either close to or far from the main base) will compel him to dissipate a large proportion of his air power. This fact is emphasized when we consider the type of operating surface that may be available to V/STOL aircraft. The Harrier, for example, has already operated from meadows, parts of active or disused airfields, roads, playing fields, light aircraft strips, railway stations, woods, and has flown from 18 different types of ships;[15] there may be a future application for the security of oil rigs.

If the V/STOL aircraft is brought close to the area of operations, either on land or sea, there are possibilities for providing exceptionally rapid response to calls for ground support. There are other advantages to be gained from this. For example, rapid response can be provided whenever required without having to adopt an expensive airborne alert, and pilots can become very familiar with the operating area, thus reducing briefing times and navigation problems. Furthermore, in relative terms, more ordnance can be dropped per flying hour since so little time needs to be spent in transit. This factor also ameliorates the impact of being forced to jettison weapons in an air-to-air combat encounter. Finally, V/STOL aircraft can operate and recover in very low cloud base/visibility conditions and generally without regard to crosswinds. V/STOL allows the recovering aircraft to slow down, maneuver, and land if it is not aligned with a strip, or even to maneuver to undamaged areas of a main runway that has been attacked during its absence. V/STOL, therefore, offers unparalleled operating flexibility for a modern jet aircraft.

Survivability. As already mentioned, survivability is one of the aspects of operating flexibility that is derived from V/STOL, but it is of such fundamental importance that it should be amplified further. The ability to survive a pre-emptive attack and to operate during war are two essential prerequisites for any air force. V/STOL aircraft fulfill both these requirements; in the first instance dispersal greatly improves the chances of survival and, in the second, if they survive the initial attack on an airfield either by dispersal or by protection, it is unlikely that sufficient space could not be found for subsequent operations. Even in the worst case, where airfield logistics and runways were destroyed, whereas the conventional aircraft would be forced to wait for runway repairs, the V/STOL aircraft could depart in one of its various modes, fly to another source of fuel and weapons, and recommence operations. The flexibility that allows an aircraft not only to maneuver and fly to another airfield when its own is damaged but also to maneuver within its airfield perimeter to reach fuel and weapons is, without question, a unique capability.

Combat agility. Combat agility in V/STOL aircraft like the Harrier is an unusual capability derived from the design concept of vectored thrust. Startling maneuvers can be generated in flight during air combat through a combination of aerodynamic and jet reaction controls. Extremely rapid decelerations and instantaneous turns can be achieved in the vertical or horizontal planes that cause almost unmanageable overshoot problems for an attacker with guns. As an example of what can be achieved, it was stated recently in *Jane's Aerospace Review 1976–1977* that whereas the F-14 Tomcat had fought successful engagements against the Mirage F-1 and F-5Es, results against the Harrier flown by United States Marine Corps pilots were quite different:

> Using the full V/STOL aircraft's low-speed maneuver ability, and rapid acceleration and deceleration, the Marine pilots outfought F-14s in six of the sixteen engagements, losing only three, with the others indecisive. There could be no better incentive for ensuring the successful development of the McDonnell Douglas AV-8B advanced version of the Harrier; and the U.S. Navy must be relieved to know that the Kiev's Yak-36s do not share the Harrier's VIFF (thrust vectoring in forward flight) and STOL capability.[16]

It should be stressed that this capability is derived from the vectored thrust design for producing V/STOL aircraft.

V/STOL Versatility

The vertical and short takeoff and landing (V/STOL) concept has much to offer in theory, and in practice the RAF has found much in it to endorse. A vertical landing by the Hawker Siddeley Harrier is easily accomplished (top) on a 70-foot square pad. . . . V/STOL aircraft can be hidden in most unusual and innovative places (middle), and they can operate over extremely rough ground. . . . Also, the Harrier (bottom) can operate just within or outside the normal airfield boundaries.

In addition to advantages during combat maneuvering, there are other distinct operating gains that follow from the vectored thrust idea. For example, steep dive bombing or evasive descents are possible without speed fluctuations. Fuel consumption, a most important aspect of air combat, can also be kept to a surprisingly low level. In aircraft like the Harrier, vectored thrust allows the use of all the installed engine power when in conventional flight. The high thrust-to-weight ratio allows outstanding climb, accelerations and decelerations, and maneuver. Moreover, the Harrier engine has many of the characteristics of the reheated supersonic fighter without the accompanying complexity and massive fuel consumption of the latter. For example, at full power the Harrier burns only 220 lbs/min while the F-4 Phantom burns 1200 lbs/min.[17] The Harrier thus has a clear edge in staying power over the F-4 and many of her likely Soviet opponents. Even when the Harrier or any V/STOL aircraft is finally forced to retire from the fight, whereas the conventional aircraft *must* reach a base before running out of fuel, the V/STOL aircraft has virtually unlimited flexibility in finding somewhere to land.

disadvantages of V/STOL

When the relative merits of V/STOL and conventional aircraft are discussed (while the merits of V/STOL are generally conceded), opponents seize tenaciously on certain of the alleged disadvantages and, after a brief session of bloodletting, the victim is usually pronounced dead. Such judgments are often premature and do not stand up to dispassionate examination. Unfortunately, discussions of V/STOL are usually undertaken by people who are already convinced one way or the other, and a balance of views is seldom reached. We, therefore, shall look at the four most commonly cited disadvantages of V/STOL in an attempt to reach a balanced assessment of its contribution to tactical air warfare: logistics, security, command and control, and cost. While payload and range are also put forward as serious disadvantages, in general this accusation has been leveled specifically at the Harrier. Nevertheless, this change will be discussed under future developments.

Logistics. The problem of servicing and resupplying a dispersed force is the one most often raised as being the Achilles' heel of V/STOL concepts. It, therefore, deserves a close analysis. We shall consider two resupply problems: the first for V/STOL aircraft operating from a main base and the second for fully deployed operations.

1. *V/STOL at the main base.* V/STOL aircraft operating from main bases suffer no more logistics problems than conventional aircraft operating from the same base. In fact, the V/STOL aircraft may be slightly better off wherever an airfield is attacked and so badly damaged that aircraft and vehicle movement are severely curtailed. Under these circumstances the conventional aircraft has no option but to wait for repairs, whereas the V/STOL can either maneuver within the airfield perimeter or fly to another base for fuel and weapons.

2. *V/STOL in tactical deployment.* Although the problems of resupplying deployed aircraft are unusual today, they are not unique. World Wars I and II, helicopter operations, etc., offer many examples of resupplying deployed air forces. Moreover, it is self-evident that any military unit requires logistics support when deployed forward, and, of course, V/STOL aircraft are no different. However, whereas previous arguments about logistics were based mainly on theory, we now have eight years of practical experience to draw on from operating the Harrier. The Harrier logistics concept in Germany is based on a Royal Air Force resupply system from the Harrier main base to tactically deployed logistics parks. Each logistics park contains a comprehensive amount of fuel, weapons, and spares and serves its associated operational site. If the operational site moves, the logistics park continues to serve it, although the system has sufficient flexibility that almost any site could be served by almost any logistics park. In the near future, logistics parks will also have a greater degree of mobility. Operational sites are restocked at night with 24 hours of supplies so that these sites also constitute a limited source of logistics. If either the logistics park or the operational site were destroyed or damaged, aircraft already airborne may be recovered

to another site or return to the main base, or, with greater weapon standardization, go to any base where fuel and weapons are available. These are real solutions to the logistics problem that have been put to the test during Harrier exercises. In fact, so successful has the logistics plan been that the Harrier force in Germany has been awarded the highest NATO ratings during realistic evaluations for the past two years.[18] Despite the success of the Harrier, however, we must recognize that the resupply problem for the Harrier wing in Germany is on a relatively small scale. A bigger problem would require a different approach with perhaps a renewed emphasis on standardization of common-user items with the army, thus allowing greater operating flexibility. There is great scope for standardizing such items as trucks, wheels, fuels and oils, some weapons, and especially small arms for site security. In other words, given the requisite motivation, the army supply system could be adapted to provide a measure of support for tactically deployed aircraft. Therefore, while not minimizing the logistics problems, we can see that they are not insuperable for deployed operations.

Security. As with logistics, ensuring the security of any military installation or piece of equipment is not unique to V/STOL aircraft, although special problems do exist, as seen in on-base and off-base operations.

1. *Security on the main base.* Provided that V/STOL aircraft remain within the airfield perimeter, there are no special security problems. On the other hand, V/STOL offers such flexibility that concepts have been developed which envisage the dispersal of individual or small groups of aircraft either just within or just outside the airfield boundary to take advantage of natural cover and suitable roads or strips. For defense from air attacks, these aircraft must rely on a combination of dispersal and concealment and the normal AAA and SAM airfield defenses. For ground defense, an outer defensive ring of static ground troops and mobile patrols is supplemented by an inner ring of armed and trained aircraft technicians. Once more the problems of security do not seem to be insuperable, while the gains are in presenting the enemy with an unusual and difficult targeting problem.

2. *Security when deployed.* The security of V/STOL aircraft when deployed is undoubtedly one of the biggest headaches. For example, Harrier sites deployed behind forward army elements, say 50 kms from the forward edge of the battle area (FEBA), are extremely hard to find. No attempt has yet been made to provide the sites with active air defenses, but mobile SAM technology is advancing at such a pace that this may soon be feasible. It is generally argued that the greatest threat to Harrier sites will come from a ground or airborne assault. Under these circumstances, the first recourse would be to divert aircraft and move the site. Failing that, the outer and inner defense concept would attempt to stabilize the situation to allow evacuation or call for help. All Harrier site training includes operating in a nuclear, biological, and chemical warfare (NBC) environment. In summary, placing sites near army units, dispersal and concealment, active air defenses in the future, and a higher state of training provide the sites with viable security.

Command and control. The problems of command and control hinge on the ability of the tasking agencies to communicate with deployed units. On-base dispersal presents no difficulties since the tasking facilities already exist. Individually dispersed aircraft are reached by telebrief, mains radio, vehicle radio, or hand-held VHF radio. Off base, the use of secure army communications has allowed tasking to any or all sites. Sites may task each other and speak to logistics parks. In addition, the use of aircraft telebrief either on or off base allows cockpit tasking and associated high sortie rates and reduces the hazards of operating in NBC conditions.

Cost. To begin a discussion about cost by proposing that it is difficult to be definitive usually provokes a flood of skeptical comment. Nevertheless, although the statement is true since cost measured against effectiveness is bound to be inexact, we must grasp this nettle. As a rough estimate, it costs 10 to 15 percent more to operate a fully deployed Harrier squadron than its conventional counterpart at an airfield. This extra cost follows from the need to provide logistics support, communications facilities, protection of sites, etc., according to the distance of the sites from the main base and according to what is already available.[19] The return for this extra cost is, however, a highly flexible, invulnerable, and responsive force. We can also say that operations from a main base involve no extra cost at all: in fact, unless the individual aircraft are destroyed, operational capability can be practically guaranteed. And we are talking about a formidable capability here. It has been said that the Harrier devours six to seven times the fuel and weapons of a modern tank, yet she can deliver up to 20 times the weight of ordnance over 30 times the distance and can assume many more roles.[20] We can, therefore, sum up by saying that there are no extra costs for operating V/STOL aircraft from a main base, but an increase in the order of 10 to 15 percent can be expected for deployed operations. Cost effectiveness on the other hand is practically immeasurable since operations by a V/STOL aircraft can be guaranteed to a higher level than its conventional counterpart.

Battle damage. A final disadvantage that is sometimes raised concerns the problem of battle damage; e.g., a bullet in the wrong place may preclude the V/STOL option. While this is undoubtedly true, a similar argument could be applied to carrier operations, and this has not yet caused the carrier option to be abandoned. Battle damage will occasionally prevent a V/STOL aircraft from operating in all its modes, in which case it becomes a conventional aircraft facing similar problems of conventional recovery.

Dramatic improvements in both aircraft and concept have been achieved in eight years, and the signposts for future improvements no less dramatic are clear. Most important, however, is that having overcome the real or imagined disadvantages of V/STOL operations, V/STOL design allows tactical aircraft to take advantage to the maximum extent of the characteristics, functions, and principles of employment.

V/STOL Concepts

The Royal Air Force has devised two basic V/STOL concepts with the Harrier, and the United States Marine Corps has developed one. Meanwhile, outline concepts for naval use are emerging, also.

concept for RAF Germany Harriers

The main concept of operations that has been developed for the three RAF Harrier squadrons in Germany envisages full tactical deployment. Aircraft are dispersed to a number of preselected sites where maximum use can be made of concealment and existing facilities, such as buildings, barns, woods, and where some sort of operating surface is available; logistics parks provide fuel, weapons, spares, etc. Secure communications allow tasking and link each site with a forward wing operations center (FWOC). Sites may also communicate with each other. The essence of the concept is its mobility, since each site is virtually self-contained and retains most of its equipment on wheels to facilitate rapid site moves. Such moves could be generated by a deteriorating ground situation, air or ground attack, or contamination from nuclear or chemical sources. While every site maintains a rudimentary decontamination capability and all field exercises include contamination training, the first recourse is to effect a site move. Security of the sites is achieved by the outer ring/inner ring principle. The outer ring is provided by specially trained RAF regiment squadrons and the inner ring by the site personnel themselves. Every technician receives extensive tactical training and can fight as a soldier if he must. This capability is also regularly exercised in a nuclear, biological, and chemical environment. Sites contain enough fuel and weapons for 24 hours' operations and are restocked at night. Sufficient flexibility also exists to accept aircraft from other sites either during site moves or for emergency reasons.

Operations are normally conducted from dawn to dusk and in visual meteorological conditions, although the unique characteristics of the Harrier allow operations in very poor weather. Tasking is originated through the usual channels, normally through the FWOC, although sites may be tasked directly if necessary. Within the sites, each aircraft is connected to the site headquarters by telebrief, thus allowing cockpit tasking. This scheme permits great responsiveness to tasking, high sortie rates, and a degree of immunity to the aircrew during contamination.

The concept has proved to be very successful. It is not unusual for the Harrier wing to fly about 240 sorties per day for extended periods, achieve a response time of 10 to 15 minutes, and avoid detection. The daily number of sorties could be exceeded but for peacetime constraints of safety and consumption of weapons. Most pilots fly six consecutive sorties before relief, and this schedule has been found perfectly sustainable over a period of many days.

concept for United Kingdom Harriers

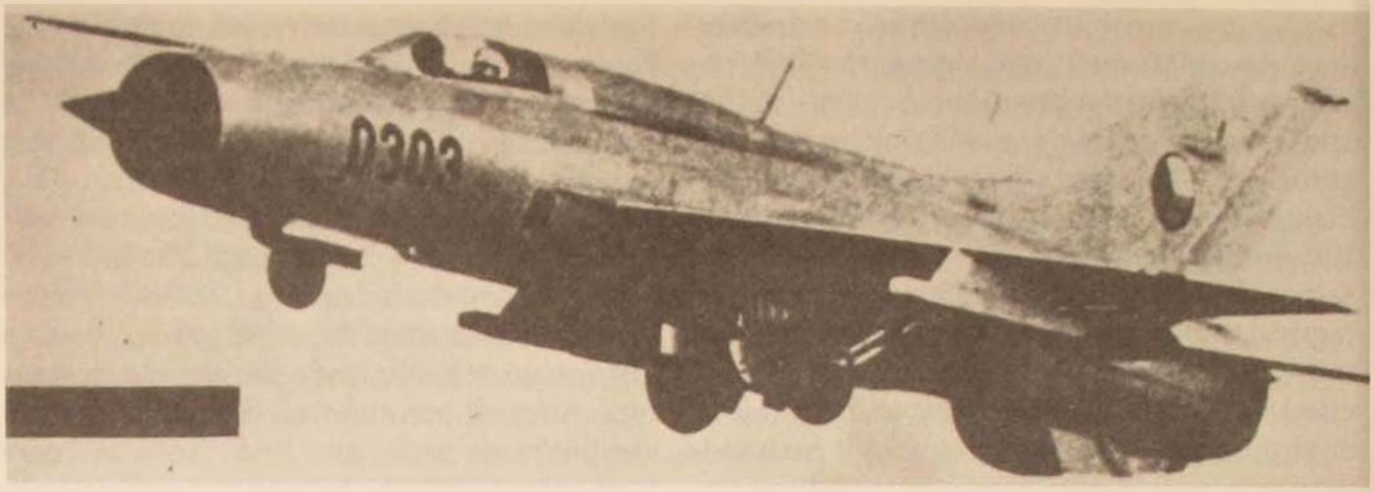
The concept for the one Harrier squadron in the United Kingdom has been developed to cope with its specific commitment. The squadron is assigned to NATO, mainly to the flanks, but it also has a worldwide role outside Europe in support of national interests. A concept has therefore been developed that envisages an air mobile deployment of the entire squadron, including manpower and logistics support, to an airhead. The individual aircraft are then dispersed, sometimes singly and sometimes in small groups, either just within or just outside the airfield perimeters. Aircraft are concealed, and operations are the same as for the RAF Germany concept except that any part of the airfield or its environs are used for dispatch and recovery.

This concept has also proved to be very effective during operational deployments overseas and exercises at home. As an example, a recent exercise in the United Kingdom simulated a Harrier squadron of 12 aircraft in direct support of a brigade under heavy attack from the ground. In response to requests for air support, 12 aircraft generated 364 sorties in three days. One aircraft flew 45 consecutive sorties without major servicing, and serviceability in general was outstanding, demonstrating that flying this type of aircraft in a tactical setting presented no insuperable engineering problems. Although critics of the Harrier have denigrated her weapon load, the potential amount of ordnance that could have been dropped in the brigade area is worth noting:

72,000 30-mm high-explosive shells
1500 cluster dispensers
or 900 × 1000-lb bombs + 600 SNEB rocket canisters
or 300 × 1000-lb bombs + 1800 SNEB rocket canisters.[21]

A formidable load by any standard.

The concept for the U.K. Harriers, while not the best of the two RAF concepts, nevertheless has been successful and is clearly applicable in principle to operations by other V/STOL aircraft operating from airfields in Europe. Experience has shown that while an attacker may know the precise location of an



The Soviet Mikoyan MiG-21 "Fisbed-G," the STOL version of the MiG-21, was first demonstrated at the air display at Domodedovo on 9 July 1967.

airfield, individual targets that are dispersed and concealed are hard to find and engage. Furthermore, if these aircraft possess V/STOL characteristics, it is virtually impossible to stop operations completely, and the use of several strips simultaneously allows extremely rapid takeoff and landing, and exposure time is accordingly small.

United States Marine Corps concept

The United States Marine Corps has been most enthusiastic about the possibilities of V/STOL aircraft and is currently carrying the banner for future development with vigor. The marines are operating about 100 Harriers (designated AV-8A), mainly in support of amphibious assault but also in a limited air defense role. The USMC concept envisages three phases: (1) operations from ships, (2) operations from a temporary site on or near the beach, and (3) operations from a main base or shore. In the initial stages of a landing, fully loaded AV-8As operate either in the air defense or close support roles. When the beach is secure, the ground commander can call for the AV-8As to fly to the beach site on ground alert (cab rank) and return to the ship for refuel and rearm. The temporary beach site can provide basic turnaround servicing, but the aircraft still depends on its sea base for major support until the main base is established on shore.[22]

Convinced of the possibilities of V/STOL, the USMC has been most active in the development of the AV-8A. The marines have proposed an improved version of the AV-8A, designated AV-8B, which includes specific modifications to make it more suitable for USMC duties. If the development programmed is successful, the marines envisage a force of 342 AV-8Bs by the 1980s.[23] Lieutenant General T. Miller, USMC, has stated:

> The advantages of V/STOL are so important that we have stated a requirement for an all-V/Stol light-attack force to begin to phase in during the 1980s . . . [24]

Navy concepts

To introduce the subject of the uses of V/STOL for naval purposes, it is appropriate to quote John Fozard, the Harrier's chief designer: "The Harrier is the only aircraft that Nelson could have used at Trafalgar!" Not surprisingly, then, many navies of the world have seized on the possibilities that V/STOL offers. Already we see both Western and Soviet navies beginning to develop V/STOL aircraft, and various applications are emerging.

As carriers become ever more costly with their complex arrester gears and catapults, the validity of the carrier concept as a future weapon system is in the melting pot. Yet, there is an increasing need for long-range maritime patrol aircraft to be complemented by high-performance combat aircraft integrated and based with the fleet. These aircraft must combine the virtues of fleet protection and quick reaction. It is well known that ships are highly vulnerable without air cover, even with good antiaircraft (AA) defense, and this problem has become more acute with improvements in antishipping weapons. The sinking of the *Eilat* by Styx missiles provides a striking example. However, if the carrier concept becomes too expensive to support in the future, the requirements for responsive high-performance aircraft can still be met by using V/STOL aircraft. Seaborne V/STOL aircraft can undertake any of the traditional fixed-wing roles, including antisubmarine warfare, from a variety of deck surfaces without the complexity of the carrier. In fact, V/STOL aircraft once more open up the possibilities of pursuing the classic naval roles of projecting power and control of the sea quite inexpensively.

The Future

No study of this kind would be complete without a brief look to the future, since it seems evident that V/STOL indeed has a future in tactical aviation. What are the signs and portents? Unfortunately, some are not good. Until the arrival of the Harrier and now the Forger, discussion of the merits of V/STOL aircraft was mainly theoretical. Events have changed this, and we now have much practical experience about operations, logistics, costs, and so on, and concepts have been developed, modified, and proved to be effective. Skepticism, however, remains very strong despite 18 years of V/STOL flying, eight of which have been operational. Brigadier General Atkeson made some pertinent points when he wrote that:

> . . . conventional defense of Europe is not only possible, but that its feasibility and facility are improving steadily. Inasmuch as the new technology very definitely favors the defense, and is only beginning to have its weight felt in the tactical balance, we can look forward to an era of positive improvement and increased confidence in Western security. Technology is the strong suit among the Allies (particularly the United States) and the rapid expansion of known and shortly-to-become known physical and engineering principles is a task for which Western society and industry is naturally geared. . . . weapons revolutions have become routine and are really held in check *only by the imagination limitations of those who contemplate their meaning.*[25]

The invention and development of V/STOL aircraft relate directly and significantly to these statements. It has been argued here that the development of a tactical air force with a viable V/STOL element could enhance the deterrence value of the conventional leg of the NATO triad of forces. V/STOL would enable NATO to develop a dispersal strategy that is clearly lacking today. Moreover, despite the length of time that V/STOL has been on the scene and the achievements of the Harrier forces, development of the idea seems to be being hindered, even blocked by ". . . imagination limitations of some of those who contemplate their meaning." While one can perhaps understand from the practical aspect that there is a limit to the number of systems that can be developed simultaneously, it is more difficult to understand downright skepticism. Nevertheless, we must take heart from present achievements and continue sanguine regarding developments on the horizon.

On the Soviet side, as we have seen, the Forger is in service now with every expectation of seeing a more sophisticated V/STOL aircraft in the near future. The USMC plans to develop the AV-8A into the AV-8B and buy them in considerable numbers. The U.S. Navy is showing interest in V/STOL aircraft using a different design to the vectored thrust idea,[26] while the Royal Navy has ordered a naval derivative of the RAF Harrier, to be named Sea Harrier. Other navies of the world are watching the development of these aircraft very carefully, and already the Spanish Navy has purchased a version of the Harrier, now named the Matador. But so far the development of the V/STOL idea is being developed more stongly by naval than land-based air power, although the application for the latter seems clear.

One of the few possibilities that presently exist is to be found in the RAF's plan to build a single replacement for the roles currently filled by the Harrier and Jaguars. The requirement has been designated Air Staff Target (AST) No. 403. This could be one of the most significant aircraft of the future and is worth a short digression. The RAF plans to identify and build the Harrier/Jaguar replacement by about the end of the 1980s. At present it has not been decided whether this aircraft will be V/STOL or not, or whether it will develop into an aircraft similar to the F-16. A further factor in the development of AST 403 is that other European countries (France, Belgium, Netherlands, Germany) have identified a need for a versatile follow-on battlefield support aircraft. These four nations, plus Britain, have formed a five-nation working group to discuss their possible mutual requirements for a future tactical combat aircraft (FTCA).

While there are obvious political and economic overtones to discussions surrounding this aircraft, combining these with the military advantages produces a strong case for its development. An aircraft with the inherent flexibility derived from V/STOL technology that was also equipped for all-weather operations, was supersonic, and could carry a wide range of stores over a long distance would be a potent weapon. And, as John W. R. Taylor adds in *Jane's Aerospace Review 1976—1977:*

> Add thrust vectoring in forward flight, and the resulting aircraft begins to sound expensive, but is anything else practical to preserve balanced forces in a period when the Soviet Union is producing 1000 tactical aircraft every year?[27]

It is not yet clear whether the differing requirements of the AST 403 and the FTCA can be reconciled, but in the light of NATO's clear requirement to develop a dispersal strategy and enhance the credibility of its conventional deterrence, a golden opportunity appears to be open. The first step, therefore, ought to be to include V/STOL technology in the AST 403.

Before leaving future aspects of V/STOL, we should perhaps glance briefly at the prospects for the development of payload and range, since this has been an area where the critics have been most active, and we refer here specifically to engine development. Hopefully, the story of the development of the Harrier's engine, the Rolls-Royce Pegasus, might allay the fears.

The present payload and range of the Harrier are largely functions of engine power, so that an increase in engine power would allow the V/STOL idea to be applied to many other roles than the present close support. For example, air defense, reconnaissance, and interdiction are roles that would be highly compatible with a V/STOL aircraft. In fact, a V/STOL aircraft with tactical nuclear weapons would provide a most potent deterrent and war-fighting force. Although V/STOL technology can be provided by means other than vectored thrust, the simplicity of the idea and its proven reliability remain an attractive proposition. Can vectored-thrust engines meet future requirements? History answers yes. The Rolls-Royce Pegasus entered RAF service in 1969 at 8680 kg thrust. In three years this had grown by 12 percent for an increase of only 2 percent in the weight of the complete weapon system. The net gain in thrust minus weight represents a 44 percent increase in the payload carried from vertical takeoff (VTO) and a somewhat smaller proportional increase in the (larger) STO payload.[28] It could be argued that thrust growth benefits the V/STOL aircraft more than it does its conventional counterpart. Any future thrust increases should therefore enhance the already highly competitive capabilities of today's V/STOL aircraft.

The future is clouded by uncertainties. V/STOL aircraft exist today and have demonstrated their possibilities for both land and sea warfare. Further developments are clearly possible, and some avenues of approach for the future have been identified. We must not enable history to point to us and say that even with the examples of the machine gun and the torpedo less than 50 years old, another technological advance took years to be fulfilled.

Hq Tactical Air Command

Notes

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23. Ibid.
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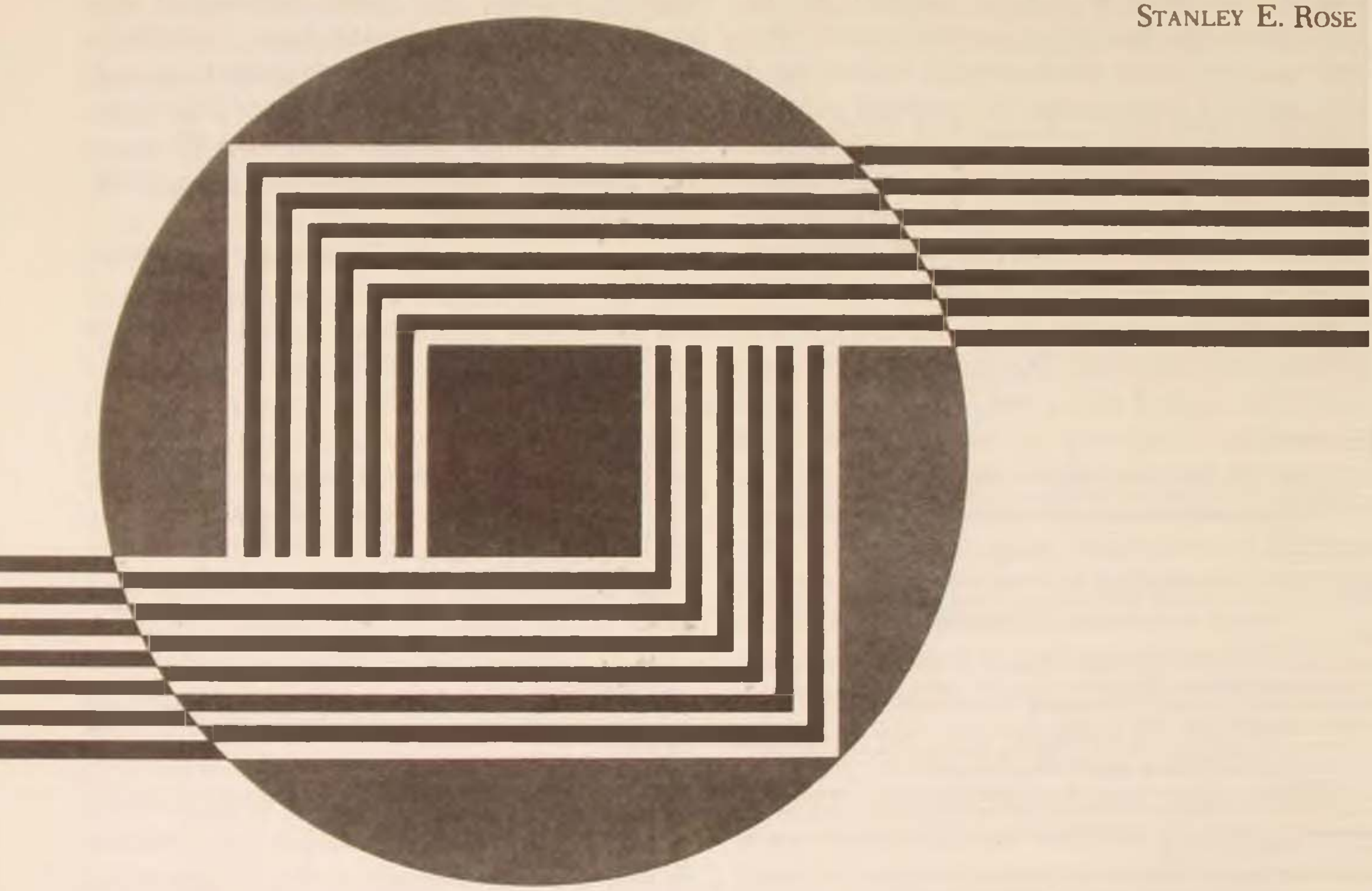
Our age of anxiety is, in great part, the result of trying to do today's job with yesterday's tools—with yesterday's concepts.

MARSHALL MC LUHAN

THE IMPACT OF COMMAND, CONTROL, AND COMMUNICATIONS TECHNOLOGY ON AIR WARFARE

CHARLES A. ZRAKET
STANLEY E. ROSE



THE TECHNOLOGIES of aerodynamics, propulsion, and structures have produced a marvel in terms of the aircraft that have resulted; however, the technology that has produced the ability to command and control and to communicate with these aircraft has given us air power. This C³ technology has recently enjoyed an explosive growth in capability and reduction in cost that promise an even greater impact on air warfare than we have witnessed to date. The short history of the development of C³ technology for air defense is illustrative of the roots of command/control capabilities for air power.

Following World War I, while air power advocates struggled to gain acceptance of their weapon, all nations disarmed rapidly. Airmen could do little toward improving air defenses. Yet, for the future of air defense, by

1935 the British had made a most important technological development, radar. Radar revolutionized the art of air defense.[1]

After the outbreak of war in Europe in 1939, all nations had begun the construction of air defense systems. But only Great Britain had built a radar early-warning network capable of alerting and controlling the air defense system. When World War II began, Great Britain had a network of 20 radar stations. This radar network allowed the few Royal Air Force fighter squadrons to remain on the ground until the last possible moment before taking off to intercept the bombers. Largely because of the British early-warning network and other radar developments such as ground-controlled interception (GCI), airborne interception (AI), and identification, friend or foe (IFF), the Battle of Britain of 1940–41 was won by a numerically inferior fighter force.

The operation of the early radar systems was difficult since people had to interpret manually some hundreds of plots every minute, all subject to variable delays and to the personal errors of the observers. Quite trivial difficulties proved surprisingly hard to overcome. It was difficult to find room for all the plotters around the table, and they could not plot fast enough. They might disturb one set of plots when they leaned over to plot another aircraft. Such rather simple difficulties could be, and often were, the limiting factors on the use that could be made of the radar plots, and an intensive study of all the stages in plotting and filtering was made throughout the early years of the war.

In the U.S., a first step toward coordination of air defense was taken early in 1940 when the War Department created the Air Defense Command and sited about 95 radar sets —65 on the Pacific Coast. By early 1943, the danger of enemy air attack had passed, and in the following year the continental air defense system was dismantled.

During the early years of peace that followed the defeat of Germany and Japan, air defense seemed unnecessary. The victorious Western allies quickly demobilized and scrapped or stored most of their air defense weapons. However, by 1948, the cold war had begun, and as the split between the free world and the Communist nations widened, most governments began to rearm. With the world's two strongest powers armed with nuclear weapons, defense against air attack assumed new importance. Nations on both sides of the Iron Curtain felt compelled to erect the most effective air defense system possible.

By the mid-1950s, the free world, under the leadership of the United States, had made substantial progress in constructing an early-warning radar network around the periphery of the Soviet Union and its satellites. Inside the Iron Curtain another radar network was poised to alert the Communist air defense system. Into these air defense systems went a substantial part of the defense budget of each nation.

In late 1950, the United States Air Force recognized the shortcomings of the continental air defense system in being at that time. As a result, the Air Defense Systems Engineering Committee (ADSEC)* combined air defense data-handling work at the Massachusetts Institute of Technology (M.I.T.) Digital Computer Laboratory with radar data-transmission equipment from Air Force Cambridge Research Laboratories. The results were favorable, and the Air Force then suggested the establishment of a laboratory to continue this program. In the spring of 1951, negotiations were carried out which first led to a five-month study (Project CHARLES) and, second, to the establishment of the Lincoln Laboratory in August 1951.

It was during this study period that the use

*ADSEC, a group formed in 1950 by the Scientific Advisory Board at the request of the Air Staff to study the overall problems of air defense.

of a high-speed digital computer gained full momentum for application to air defense. Project CHARLES recommended the testing of such a computer in the ground environment by use of the Whirlwind I computer then in being at the Digital Computer Laboratory, M.I.T. This test was to provide information to the Air Force on the capability of such equipment to solve the ever growing air defense problem. The Cape Cod system, which was established as the experimental system, led to the development and deployment of an operational system for air defense.

The air defense art developed during the Battle of Britain is remarkably well preserved but automated in the Air Force's semiautomatic ground environment (SAGE) system, as it was called. This automation overcame many of the problems the British system experienced when it was saturated with a high traffic density.

At an FPS-3 radar station, for instance, the signals from the radar were processed so that they could be transmitted within the bandwidth capability of a telephone line. This was done by equipment at the radar station that integrated the video signal over one radar beam width and transmitted on the telephone line one range sweep during that interval. A number of radars were netted and sent their data to a SAGE direction center. The mapping station at the direction center consisted of a plan-position indicator (PPI) scope display of incoming radar data from a particular radar set. From this data, information displays were generated so that operators could make decisions and guide weapons to the target.

Charles Babbage's computer designs were limited by mechanical devices, and the engineers of the early 1950s were limited by vacuum tubes, which by today's standards would be impossibly bulky and unreliable. The first engineering model of SAGE's AN/FSQ-7 computer contained almost 60,000 vacuum tubes. Its memory, however, was small by today's standards—8192 words of 32-bit length, though that was later expanded to 69,632 words. The memory cycle time was six microseconds. Processing speed was a mere 75,000 instructions per second. And, though the drive to snatch new developments from the forefront of technology and press them into service has been a continuing thesis throughout computer history, the fact is that prudence governed the choice of tubes, rather than transistors, for the FSQ-7 digital computer. Transistors were close, but they were not quite there; and the fate of the system could not be staked on them. So SAGE rode into the future on a technology that was swiftly being overtaken by a new generation.

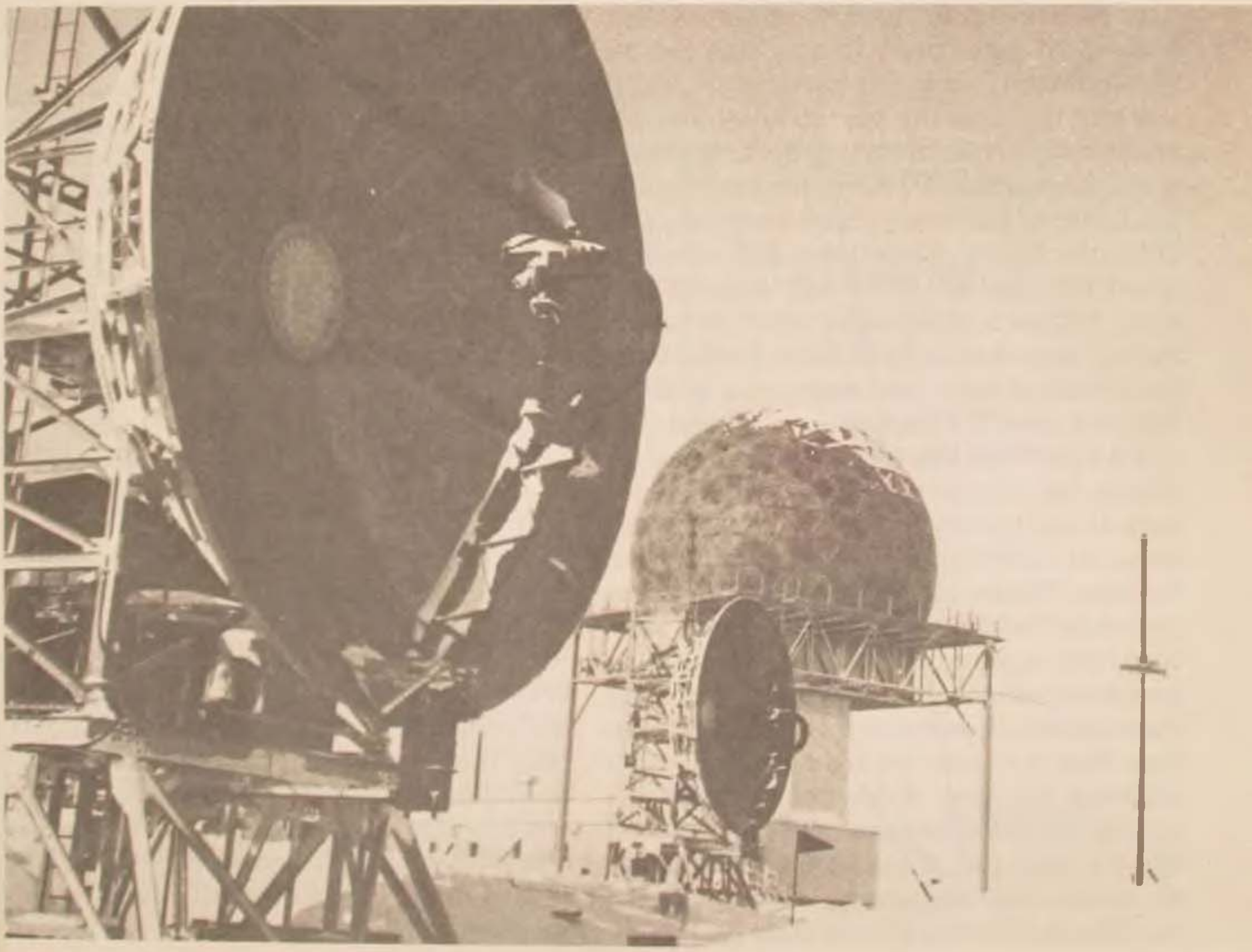
But the SAGE computer was able to generate about 200 different kinds of displays, requiring up to 20,000 characters, 18,000 points, and 5000 lines every two and a half seconds. By time-sharing the central computer, each air defense routine could be operated at least once every 15 seconds. The 22 SAGE centers that eventually dotted across the U.S. and Canada were netted together with digital data communications and went into operation in the late 1950s and early '60s.[2]

From this point, advances in computer technology followed one of two distinct directions. There were the "number-crunchers"—large, powerful devices that manipulated enormous amounts of data and performed complex calculations at ever higher speeds. These were in essence the logical descendents of the systems gone before. And there were the representatives of a newer breed: the smaller, lighter, more reliable processors that were faster and more capable than their predecessors and which were being called on to do more diverse sorts of operations.

The technology of miniaturization put digital computers into the air. Before the

Cold War Vigilance

In the decade following World War II, the Western nations constructed early-warning radar networks to "observe" the Iron Curtain nations. Texas Tower 3 (left) stood in the Atlantic some 30 miles south of Nantucket, Massachusetts, on the alert for incoming enemy aircraft. . . . The Distant Early Warning (DEW) Line, completed in 1957, was a 5000-mile chain of radar stations (like the one below) stretching along the Arctic Circle from the Aleutians to Greenland. Its mission: to spot enemy manned bombers attempting raids on North America over the polar approaches and warn the North American Air Defense Command (NORAD).



days of transistors, digital computers were much too heavy and bulky to be airborne.

At MITRE, we recently defined one measure of progress in computer circuitry. As the basis for developing a figure of merit, we used an element about a centimeter on a side—that is, an element that would have been a fraction of a vacuum tube 20 years ago, a single transistor 10 years ago, an integrated circuit today. This turns out to be a useful volume because the cost and reliability of these elements have been roughly the same over the past 25 years, but the computing power has grown. If you take as a measure of computer power—that is, *the figure of merit*—the *product of speed* (operations per second) and *complexity* (equivalent number of gates per package) that can be accomplished in our centimeter cube, and if you plot this over the past 25 years, you get an amazingly smooth curve with an improvement *three orders of magnitude each decade*—a factor of ten every three years or so. In 1950, the figure of merit was 10^5; now it is about 10^{12}, and in 1980 it will be about 10^{13} or 10^{14}—that is, about eight orders of magnitude greater than in 1950. Costs for the same performance have been decreasing at about half that rate, not including peripherals.

We know that this trend will continue for at least five more years because of the experimental and prototype equipments that exist today in laboratories and pilot production facilities. We are almost sure it will continue for ten to fifteen more years since many ideas are being explored and tested with radically new materials, new ways of interconnecting these materials, and new methods of fabrication. Also, we know we are a long way from violating the laws of physics. In these advanced projected systems, in order to store a bit or a logic-gate, it takes tens of thousands of atoms. In comparison, living material stores each bit of the genetic code pretty reliably with less than a hundred atoms.

Three orders of magnitude in performance per decade is a significant increase. When a technology is improving by several orders of magnitude and can be reasonably expected to continue at the same rate, so that perhaps another eight or nine orders of magnitude will be available for exploitation by the end of this century, then that can, in fact, have revolutionary as opposed to evolutionary implications. Similar improvements are taking place in high-speed and secondary storage and in analog techniques, such as surface-wave devices and charged-coupled devices.[3]

Although it is difficult to predict the effects of improvements of many orders of magnitude, there are some things that seem likely to us at MITRE. For example, the statement that computer scarcity will be replaced by computer plenty may seem odd because apparently computers are everywhere you turn. The very phrase "computational scarcity" sounds strange applied to computers. However, even though there are lots of computers, we still treat them as a scarce resource, try to ensure that they are used efficiently and that we not buy a larger one than is necessary. The situation is going to change, though, and we are going to be in the position where we can really get all the computation that is needed. Efficient use of hardware will, therefore, become less important, and other things will become the driving forces in C^3 technology—e.g., software, sensors, and communications.

The application of command and control to other military uses multiplied after the development of SAGE. As would be expected, the availability of data processing to accomplish them has grown to accommodate the need. This phenomenon is illustrated in Figure 1, where command and control requirements have been plotted over the years. The capabilities of computers that have been responsive to these requirements are plotted

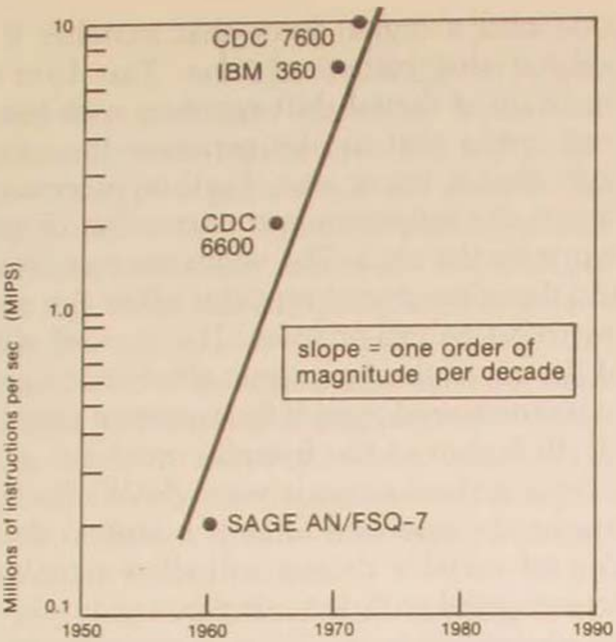


Figure 1. Trends in command and control requirements

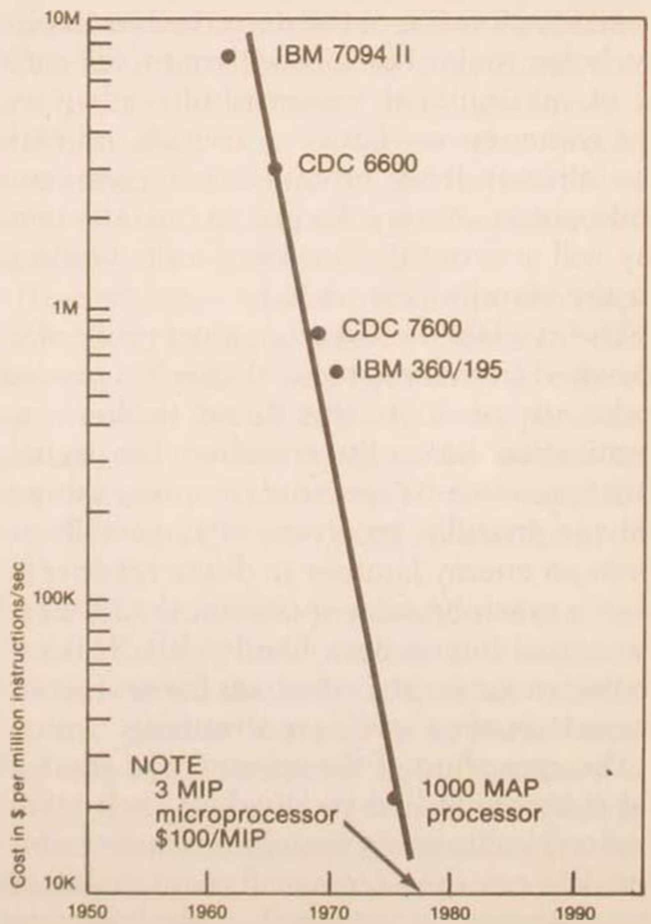
on the figure. Machines of these capabilities have become possible because of the miniaturization of high-performance computer circuitry already mentioned.[4]

Figure 2 further illustrates the effect of this technology on the practicability of acquiring this capability in terms of the dramatic decrease in cost per instruction over the last two decades. Note the order of magnitude cheaper capability available with a million instructions per second microprocessor.[5]

The resulting technology of miniaturization not only allowed us to put computation capability into the air but also made it possible for an aircraft to sense its environment and communicate securely with friendly forces. By sheer dint of computational force in an airborne radar, we are able to process returns of thousands of unwanted echoes per second from the terrain below, eliminate them all, and leave only the desired returned signal of a low-flying enemy aircraft. We can pick out targets that are reflecting radar power that is 60 dB below the signal reflected from the ground clutter. By means of this processing capability, small in size but powerful in concept, we can overcome the shortcomings of earlier radars that dealt with the clutter problem by ignoring (as the British filter officer did) signals from this region. Now we can purposefully look down from a moving radar platform into an ever changing overland clutter background, ignore the clutter, and extract the signal all automatically. This capability had a far-reaching effect on the way that air warfare will be conducted. Its implications are only now being appreciated and embodied in such systems as the F-15 and E-3A Airborne Warning and Control System (AWACS).

Similarly, this same processing capability allows us to eliminate the familiar mechani-

Figure 2. Trends in cost per instruction



cally scanning antenna that often is the bane of the aerodynamicist looking for a clean profile. It is possible to process signals from a thin array of transceiving elements by inserting computed delays among them to form simultaneous beams in space that are equivalent to many equivalent rotating antennas. We can even adjust the antenna pattern to place nulls in the directions of unwanted signals.

Other sensors that the technology will support are the following:

- Receivers that sense enemy-emitted signals and by means of adaptive processing form matched filters to these signals. This ability enables the perception of distant threats before they can be effective.
- Devices that continuously sense many simultaneously arriving signals from threat emitters and adapt the best combination of barrage jamming, spot jamming, and chaff to optimize the penetration of the air defense.

Although much of the described technology helps make the aircraft more self-sufficient, maximum air power results only if we can communicate between aircraft and with the aircraft from ground-based command and control centers. Realizing this, the enemy will attempt to jam, spoof, or eavesdrop on the communication links.

The availability of digital signal processing spawned from these technologies has proved to be an answer to this threat to the communication links. By encoding the signal, thus spreading its spectrum in a way known only to friendly receivers, it is possible to force an enemy jammer to dilute his energy over a much broader spectrum than that of the actual information bandwidth. This encoding process also is the basis for protection against spoofing and eavesdropping.

The spreading of the spectrum of the signal is accomplished by dividing each information bit into many pseudorandomly coded bits. We can then recover these data bits at the other end by passing the pseudorandom code into a digital filter that matches the code at that instant of time. This filter is made up of digital shift registers with feedback paths that locally generate the same code that is being sent. Further processing allows the detection and correction of any errors in the data. The codes are very long and therefore do not repeat to allow the enemy to eavesdrop or spoof. The present state of the art in this technique allows the signal to be recovered even if the jamming signal is 20 dB higher at the friendly receiver.

New surface acoustic wave (SAW) devices where the matched filter is a tapped delay line (of variable delays) will allow signals to be extracted with jamming power levels 40 dB above the signal. Digital communication systems like this also lend themselves to a time division multiple access (TDMA) mode of use where many subscribers can use the communication link almost simultaneously. For instance, in the Joint Tactical Information Distribution System (JTIDS) now being developed by the Air Force, a net of users contains 128 transmission time slots per second. Each time slot consists of a synchronization preamble so that the receiver's filter can synchronize its pseudorandom sequence to the correct position. Following this preamble, the information is transmitted in up to 233 error-coded bits, each in a spread spectrum and frequency hopping format.

This is a receiver-oriented system in which all participants have connectivity with all others and where, therefore, no central, vulnerable mode exists. The messages are encoded so that each receiver may select only that information of interest to it. This feature provides a circulating bus architecture for the net's information base.

By means of such a net, many aircraft can be connected to each other and to control centers, thus achieving a force multiplying effect through the use of C^3. Similar techniques could be used to provide more jam-proof tactical voice systems.

THE POWER of digital computers and their associated sensor and communication equipments has led us to a new concept of piloted aircraft control. You might call it the "digital airplane," a nickname that indicates one of the more important aspects of such an integrated system: it uses the comparatively fast, highly condensed kind of information processing made possible by the use of digital instead of analog data. Such an avionics system controls the aircraft's on-board systems and makes flight a vastly different affair—with new freedoms and new responsibilities.

An example of the digital airplane is the B-1 bomber, whose future at this time is at best uncertain. About two-thirds the size of the B-52, it can carry almost twice the payload—75,000 pounds. This aircraft is essentially run, managed, flown, maintained, and controlled by its computers, integrated and under the command and control of a small crew of four men.

The design of the instrumentation and controls is influenced by the availability of digital computers. This is manifested by the profusion of dedicated processors which deal with such functions as rotation, go around, angle of attack, and air vehicle limits—one processor—and engine instrument system, signal conditioning and distribution—another processor. There is a processor to manage the fuel center of gravity and one for a vertical situation display. Separate processors control the flight instrument signal converter, the gyro-stabilization system, central air data storage and manipulation, and the electrical multiplex subsystem.

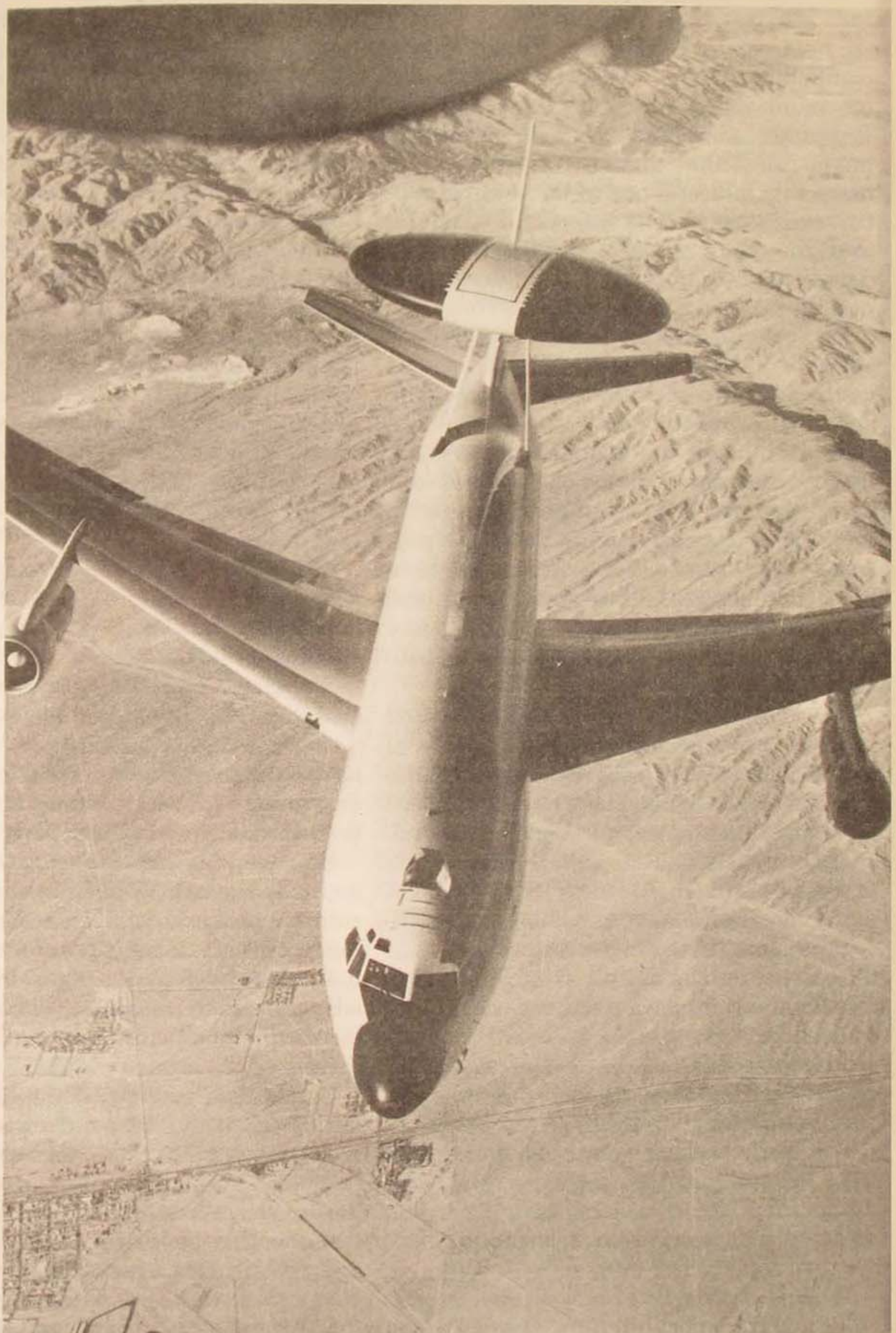
The B-1's weapon systems involve five large general purpose computers: a general navigation avionics control unit, a weapon delivery avionics control unit, and a defensive avionics control unit; all use computers with 32-bit words. Two more computers control radio frequency surveillance, electronic countermeasures, and an integrated test subsystem that check out everything onboard. In addition, there are multiplex systems that interconnect all the on-board processing systems.

The important part about this aircraft is that it is an integrated system—an aggregation of subsystems under the control of higher-level systems that are themselves under the general direction of the pilot. He can make the aircraft do what he needs it to do, by executive control. What we have, then, is not an airborne assemblage of a dozen or two dozen discrete systems but rather something like an organism—all of whose parts are functioning toward a common purpose under centrally coordinated control. And, that control is a mixture of machine organization and human judgment.[6]

Over recent years, the development of air defense systems had reduced the effectiveness of bombers. The improvements in radar, computational capabilities, and the augmentation of interceptors with supersonic surface-to-air missiles might have produced a strategic air power stalemate that would have continued except for the impact of the development and acquisition of the intercontinental ballistic missile (ICBM).

However, the maturing of the developments that made air defense command and control possible are now providing an opposing force that is making possible the penetration of air defense systems by means of adaptive countermeasures. The B-1 capability with its small crew is an embodiment of this trend.

In addition, recent maturation of a number of relatively independent technologies, such as composite materials, small turbine engines, smaller and more powerful warheads, compact and accurate navigation systems, and, most important, solid-state microelectronics, have made possible the development of an air-launched cruise missile that promises to enhance significantly the



strategic bomber force. The highly accurate cruise missile provides the potential for additional attack modes, for suppressing and saturating defenses as a standoff weapon, and for increasing the number of strategic targets at threat by both widening and extending the effective flight path of the penetrating bomber. This conclusion is based on three factors: the cruise missile's small size and relatively long-range flight at low altitude; its potential for low cost; and the consequences of exploiting in C^3 systems the major technological asymmetry enjoyed by the U.S. in microelectronics and large-scale integrated (LSI) circuitry.

Now the technology has enabled us to come full circle. Where the invention and development of the radar and digital computer have yielded a ground environment whereby the effect of defensive high-speed interceptors could be multiplied through command and control, the ability to place this command and control in airborne vehicles has also given the offensive aircraft more viability.

We are entering the age where bombers

The E-3A AWACS (Airborne Warning and Control System) can "look down . . . into an ever changing overland clutter background, ignore the clutter, and extract the signal all automatically." . . . The distinguishing feature of the E-3A is its 30-foot rotodome, which contains much of the equipment that makes the aircraft a survivable command and control center for identification, surveillance, and tracking of airborne forces. The E-3A (opposite) approaches a KC-135 tanker for aerial refueling over Edwards AFB, California. The operators (below) are at two of the four multipurpose consoles on each E-3A AWACS aircraft.

will not only have self-contained adaptive penetration systems but could also act as "airborne command posts" to fleets of accompanying pilotless vehicles. We will probably see a restoration, through this feature, of the balance between offensive and defensive air power that has for many years been tilted toward the defense.

The principal virtue of the manned bomber leg of the strategic Triad is the many ways in which the intellect and the versatility of the crew can be applied to a rapidly changing situation. At present, one of the ways that this flexibility is manifested is in dynamic selection of penetration aids where enemy defenses appear or by the choice of less hazardous routes or alternate targets. Therefore, built-in "smarts" or adaptability of the cruise missile—the role of command and control—can preserve this characteristic of the Triad by allowing aircraft crews executive control over a large, sophisticated penetrating force.

The open-loop operation, where each bomber launches its magazine of cruise missiles toward predestined targets, along paths determined by prehostility knowledge of defense positions, need not be tolerated with smart cruise missiles under the executive control of the bomber crew.

A smart cruise missile, which flies from about one to three hours and which operates semiautonomously and adaptively after launch under the overall control of the carrier, should have the self-contained capability of two-way communication with the carrier, the ability to sense electronically the environment through which it is flying, the ability to store and process this information for evasive maneuvers, and the ability to report this information and its status to the carrier. Based on this information, subsequent missiles that may have already been launched can be reprogrammed via a data link to attack alternate targets still within the missile's footprint. Also, missiles may be redirected so that their simultaneous time of arrival at a defended target can help to saturate the defense.

These capabilities will amplify the effectiveness of the carriers manyfold, permitting new tactics to be employed and thereby exploit the U.S. advantage in electronics by providing a combined weapon system with high performance at relatively low cost.

To exploit fully this potential, the integrated command and control system should have the following capabilities:

- The ability to net the ground control centers with the carrier aircraft acting as airborne command posts to perform strike planning and dynamic battle management.
- The ability to achieve high nuclear safety for exercises and alerts and provide positive launch control of missiles from the carriers.
- The ability to control critical functions during and after the launching of the cruise missile, which contains self-adaptive electronic threat sensors for evasive maneuvers and countermeasures as well as self-contained navigation and homing modes.
- The ability to communicate, without enemy interference, among all elements of the system.

SO FAR, we have mostly discussed the impact that C^3 technology could have on strategic air power. Air power has had and will continue to have a profound impact on land/air battles where air cover, close air support, and air interdiction can provide precision firepower in tactical situations. Recently, we have seen the acquisition and build-up of mobile surface-to-air missile (SAM) capability to attempt to offset this tactical advantage of air power. As a matter of fact, the proliferation of shoulder-fired SAMs (e.g., Redeye) among our own troops has increased the fratricide problem to further inhibit the application of air power near the battle area. In addition to the SAM threat to air power, a direct measure against today's relatively unsophisticated tactical C^3 is appearing in the form of electronic warfare (EW).

It is the application of new C^3 technology for the secure, jam-proof control of tactical strike aircraft that will allow us once again to utilize air power to help friendly air/land forces move the forward edge of the battle area (FEBA) toward the enemy-held territory.

It is feasible with C^3 technology now in research and development to gather a myriad of information from battlefield surveillance and target acquisition sensors and use these data in real time to arrange for and direct air strikes against ground targets. A ground target strike control center could assemble a strike force consisting of manned and smart unmanned aircraft, electronic warfare and defense suppression assets and in real time orchestrate such a force against time-critical ground targets.

It is conceivable that the manned aircraft operating beyond the FEBA could be directly augmented with accompanying smart cruise missiles under the executive control of the manned aircraft crews themselves. Cruise missile costs in quantity can probably be brought down to a small fraction of the cost of a manned aircraft. If they can be used in a way that increases the per sortie survivability of the manned aircraft, we can probably afford to make them expendable (nonrecoverable), even using large cruise missile/manned aircraft ratios per mission. These augmenting cruise missiles could be used in the following potential applications:

- Additional platforms for air-to-air or air-to-surface missiles with launch decision and terminal guidance under control of the manned aircraft crews.
- Carriers for additional standoff jamming transmitters under control of the electronic warfare members of the manned aircraft crews.
- Chaff and expendable jammer dispensers propitiously released under control of the EW officers.
- Electronic support measure sensor platforms to locate and identify enemy emitters to be displayed to appropriate penetrating aircraft and thus help perceive the extent of the enemy defense system as it applies to each aircraft in the mission.
- Platforms moving ahead of strike aircraft to help detect moving ground targets so that the strike aircraft can maneuver into best position.
- Platforms carrying look-down radars which can be netted to provide an air surveillance picture to Combat Air Patrol (CAP) aircraft crews.
- Platforms for communications relays.

A tactical strike force, then, could consist of manned strike aircraft, CAP aircraft, and specialized cruise missiles, each capable of performing one or more of these tasks. In addition, the cruise missiles could perform decoy duties, and since they need not be recovered, they could carry a warhead to be delivered after the cruise missile performed its support function.

The key to achieving these capabilities is an overall tactical command, control, and communications structure that allows supporting cruise missiles to be controlled with a minimum of attention from busy aircrews and a ground-based distributed air-control facility to command and control this mixed force. To exploit the C^3 capability which technologically exists, we must mount a development program concomitant with the cruise missile development to evolve systems like the tactical air control system (485L) into this capability.

In the twenty-five years since the beginning of SAGE, we have seen an explosion in C^3 technology that multiplied the computing

At the forefront of USAF involvement with C^3 technology is the E-4 Advanced Airborne Command Post, a Boeing 747 adapted to accommodate our most sophisticated command, control, and communications equipment. The presently projected program will be complete in 1983, with six fully equipped E-4Bs. The operations team area is shown at the bottom and the communications area (data section) on the opposite page.

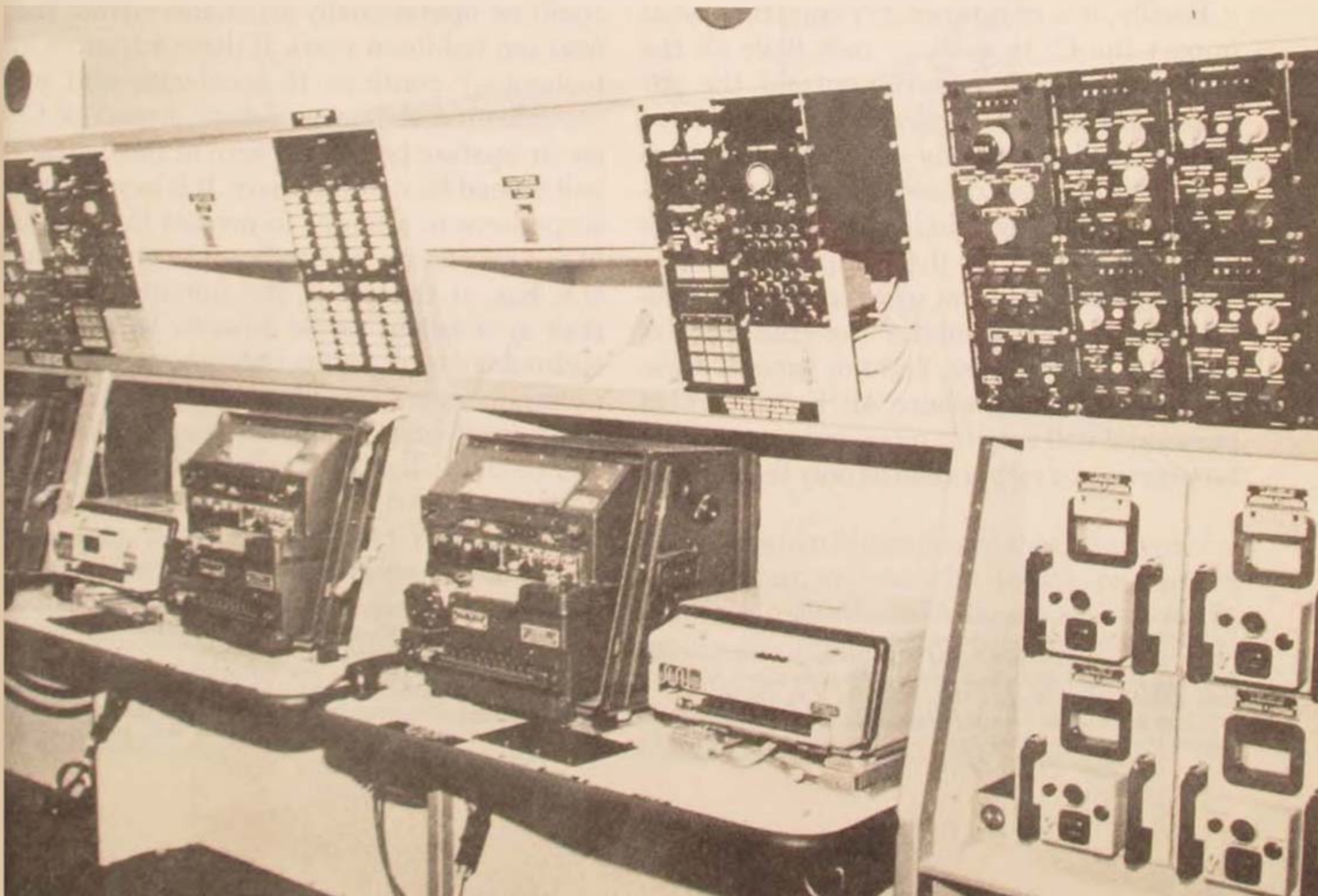
power of the SAGE FSQ-7 machine and shrank it in size to microscopic chips. Where the technology of C^3 made defensive air power awesome, the miniaturization of the circuitry has now reaped the same benefit to offensive air power. Aircraft can now carry sophisticated sensors and computers that can exchange data with other computers by means of a secure antijam, digital data link.

We are now on the brink of another revolutionary change in air warfare. Manned aircraft can now command and control an accompanying armada of pilotless but smart cruise missiles. This combination has the potential of regaining from the defense some of the same command and control advantages.

In both strategic and tactical applications, a command, control, and communication capability is achievable which will:

- Provide strike planning and dynamic battle management from ground-based command and control centers with manned aircraft, in addition to their primary role of acting as airborne command posts.
- Allow the manned aircraft to utilize the pilotless vehicles in supportive roles to suppress, overwhelm, and confuse the enemy defensive command and control.
- Augment the manned aircraft offensive capabilities by providing additional firepower to the pilotless aircraft, which can be directed to targets under the command and control of the flight crews.
- Modernize our own tactical and strategic air defense systems to keep pace with the virulence that C^3 technology will also and inevitably bring to enemy offensive systems.

To achieve this C^3 capability, the following



developmental activities must be pursued aggressively:

- Acquisition of a narrowband, secure, jam-proof, multiple-access data link system to ensure that the required communication connectivity is available to all elements.
- Acquisition of ground-based, survivable command and control centers (especially for tactical applications), which can handle the data in real time to accomplish dynamic battle management that capitalizes on the availability of real-time sensing data and retargetable weapon assets.
- Exploitation of the availability of new airborne sensor and navigation technology for the new cruise missile technology to produce a smart cruise missile, which would result in an adaptive autonomous craft requiring the minimum of control from the C^3 system.
- Acquisition of ground-based and air-based sensors to gather data on air and ground data.

Finally, it is of interest to conjecture what impact the C^3 technology may have on the future personnel requirements of the Air Force and the cost of new systems. We have been visualizing highly automated air warfare. The classical duties of the air officer—flying, navigating, flight engineering—are being taken over by the computer.

Automation will put more and more vehicles and firepower under the command of each Air Force officer, flight or ground crew. The era is coming where Air Force combat personnel will require more training as military tacticians rather than as only technicians or pilots. One impact of C^3 technology on air warfare, then, may have the potential of allowing more emphasis on the development of air warfare tactics and tacticians.

The impact of C^3 technology on the cost of air weapon systems shows up in two ways. First, we can put into the inventory effective air weapons that need not be man rated and thus trade off the cost and weight of a life support payload with a C^3 payload. We can then attempt to produce unmanned air weapons at less than 10 percent to 20 percent of the cost of manned air weapons, but retaining the same firepower. Second, the recent trend toward higher life-cycle costs due to skilled labor-intensive maintenance and operations expenditures can be reversed with automatic checkout, redundancy, and throwaway modularity features available in the same technology that yielded C^3 itself.

WITH A rigorous development and deployment program, the conjectures in this article could be operationally attainable within the next ten to fifteen years. If these advances in technology continue to accelerate and we capitalize on them, the future impact of C^3 on air warfare before the turn of the century will indeed be revolutionary. It is beyond our scope here to attempt to predict the details of this revolution. But suffice it to say that the U.S. has, at this point, the initiative in this area as a fallout of its superior electronics technology and production know-how. Let us hope that we recognize the availability of this initiative and proceed to exploit it.

The MITRE Corporation

Notes

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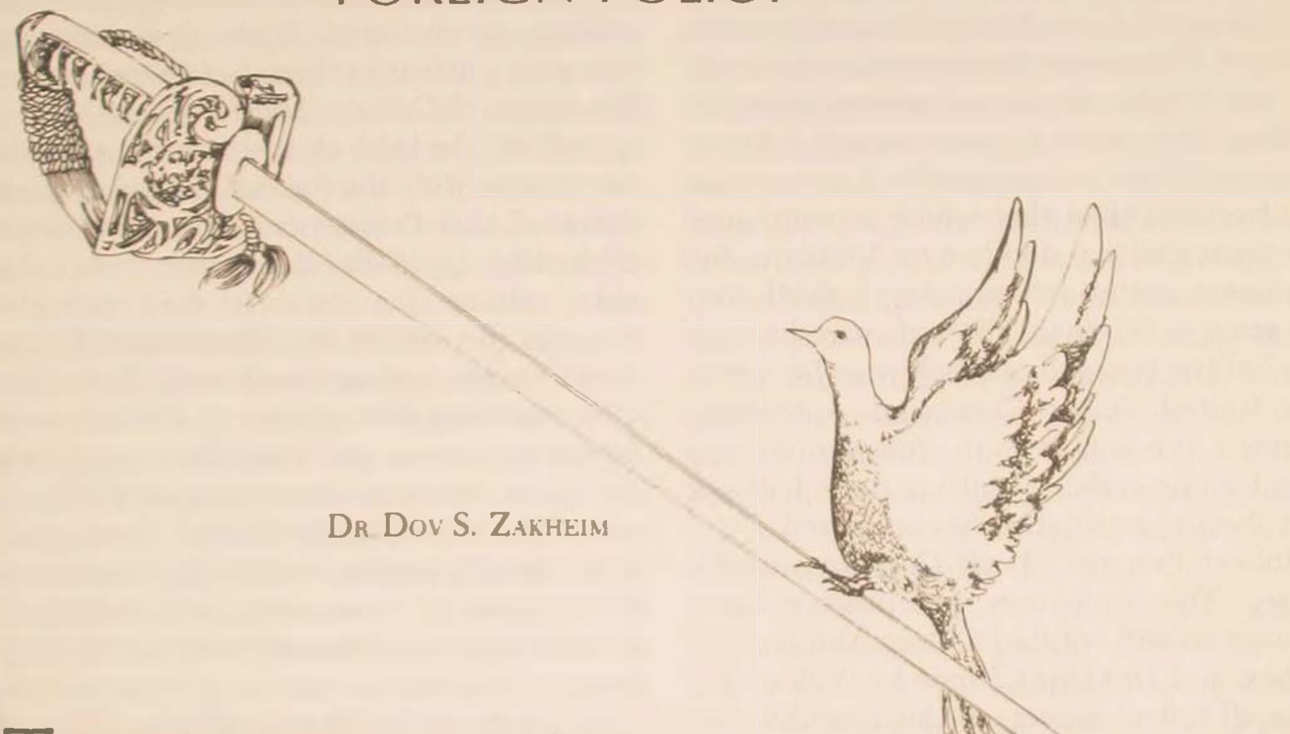
books and ideas

DÉTENTE, DEFENSE, AND THE FUTURE COURSE OF AMERICAN FOREIGN POLICY



DR DOV S. ZAKHEIM

THE FINAL YEARS of America's Vietnam experience, coupled with the tragedy of Watergate, witnessed an ever more bitter debate about the role of the United States in world affairs as well as about the place of the executive branch in formulating that role. Both Vietnam and Watergate are now historical events, although vestiges of both are likely to affect American thinking and behavior for some time to come. Although America is now fundamentally at peace with the world and herself, the debate continues.

It is singularly significant that after years of focusing national security debates on matters relating to Southeast Asia, we now virtually ignore the region. Our major concerns, according to the Department of Defense, are Europe and Northeast Asia as well as a minor contingency "elsewhere"—probably the

Middle East. We have thus shed much of our interest in that region which for a decade absorbed our major systems, our stocks of ammunition, and our thinking. Instead, we have returned to contemplate developments in those regions that have been the focus of intensive Soviet activity for that same decade, and we are now debating the significance and consequences of that activity. What are the intentions of the Soviets and their allies? What is the meaning of the Soviet strategic and conventional buildups? What is the role of our allies? Who, for what, and where, if anywhere, should we be prepared to fight next? Is our focus to be solely on the Soviets? What about their surrogates, or others who might obtain nuclear weaponry?

Thankfully, these questions and the debate in general are being posed in a manner far less frenzied than that which accompanied the great national divide over Vietnam. But the issues are no less pressing; indeed, they are more so. Vietnam, after all, was the "half war" of the two-and-one-half wars for which the United States Command Authorities planned. It is with both the full war (we now plan for one-and-one-half[1]) and the half war that the present debate is concerned.

Robert Pranger's book *Détente and Defense,* The Brookings Institution's latest volume on and entitled *Setting National Priorities,* and *The Last Chance* by William Epstein all reflect aspects of this new debate.† Each highlights different views of the evolving world order and different priorities for coping with it.

Pranger's reader is not meant to be a formal position paper. Nevertheless, its focus on the U.S.–U.S.S.R. competition, notably in the strategic arms arena, dominates its contents. Other areas of concern—the role of allies on both sides, the Chinese–U.S.–Soviet triptych, mutual balanced force reduction, Helsinki, and stresses in Africa and the Mideast—receive far less attention, often only passing reference. Nevertheless, all clearly impact on the prospects for détente and requirements for U.S. defense. The contrast with the Brookings volume could not be more marked. The latter stresses the dangers inherent in a Mideast conflict, which it posits may be the next immediate focus for U.S. military involvement. Epstein's preoccupation with nuclear proliferation seems lost on the editor of *Détente and Defense.*

In short, the book clearly does not provide the reader with the "global perspective on détente" that Pranger advertises in his introduction. (pp. 5–6) All the same, it is a valuable volume for what it does provide, namely, the setting for the present debate over détente and an insight into three specific aspects of that debate: (1) the nature of Soviet intentions and what these imply for the future course of American policy; (2) the value of détente to the United States, particularly with respect to strategic arms competition; and (3) the nature and significance of comparisons of U.S. and Soviet-related defense expenditures.

Of the three subject areas, the book's treatment of the first theme is both the most interesting and, together with the source documents on détente, probably of the greatest value. It includes a restatement by Richard Nixon of the foreign policy initia-

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† **Robert J. Pranger, editor, *Détente and Defense: A Reader* (Washington, D.C.: American Enterprise Institute for Public Policy Research, 1976, $4.50), 445 pages.**

Henry Owen and Charles L. Schultze, editors, *Setting National Priorities: The Next Ten Years* (Washington, D.C.: The Brookings Institution, 1976, $6.95), xvii and 618 pages.

William Epstein, *The Last Chance: Nuclear Proliferation and Arms Control* (New York: The Free Press, 1976, $14.95), xxiv and 341 pages.

tives of his first administration as well as a contribution by Melvin R. Laird, written especially for the volume, which reassesses the foreign policy accomplishments and failings of the Nixon–Ford years. Additionally, and following the Nixon selection, the book juxtaposes a neo-cold war view of Soviet intentions with a more benign assessment of East–West relationships by placing side by side selections by Charles Burton Marshall and J. William Fulbright, respectively. These pieces are most useful because it must constantly be remembered that relatively recent disagreements about Soviet motives and U.S. responses, which stem from disillusionment with recent U.S. policy in Southeast Asia, nevertheless, have been projected backward into time to address U.S. foreign policy from Yalta onward. A historical perspective that goes beyond the mere evaluation of current trends, which are affected by the base year from which their data points are plotted, is critical to clear comprehension of both sides of the present debate. Motives are, however, unquantifiable; subjective themselves, they can only be judged subjectively. The quantitative overlay cannot and should not obscure that fact.

Immediately following the Marshall–Fulbright "exchange" is a selection from the writings of Zbigniew Brzezinski. It provides the reader with a good taste of the panoply of the new National Security Adviser's views on the proper course for American foreign policy to follow and on the shortcomings of that policy in the Nixon years. Brzezinski catalogues these shortcomings: insensitivity to the concerns of our allies; indifference to the needs and problems of Third World states; and the "historical irrelevance" of the balance of power approach to world affairs. (pp. 65–67) Brzezinski's own focus is primarily on the question of alliance relationships and how they should be improved. He sets forth his well-known "trilateralist" conception of intensive cooperation between the three pillars of the developed Western world: the U.S.A., Europe, and Japan.

Brzezinski's prescription in turn is subjected to Stanley Hoffmann's incisive criticism in the following selection. Trilateralism, according to Hoffmann, implicitly seeks to maintain American supremacy in a world characterized by hostility between the Western and Communist camps. It is noteworthy, however, that Hoffmann does not produce his own foreign policy blueprint *contra* Brzezinski or, for that matter, Kissinger. He suggests that the U.S. orient herself to "North–South" questions, a perspective that Brzezinski, among others, has incorporated into his own foreign policy world view. But Hoffmann does not say very much about *how* one goes about doing so. Likewise, he does not point to the optimum "synthesis" (his term) between what he describes as a role of American "primacy" in world affairs and one of American "modesty." One leaves the Hoffmann piece with that familiar feeling that it is far more difficult to construct a foreign policy framework than to criticize one. Nevertheless, Hoffmann's points are telling; taken in tandem with the Brzezinski contribution, Hoffmann's paper comprises the book's most valuable analytical unit.

As already noted, there is less to be gained from the book's treatment of its other two major themes: the value of détente to the United States, particularly in the strategic weapons realm, and comparisons of U.S. and Soviet expenditures on armaments. The latter may be more of a fad than an issue. It is the product of debates that took place primarily in 1975–76, when the Pentagon sought to reinforce its demands for additional resources to counter a very real Soviet arms buildup, and Pentagon critics sought to minimize the appropriation of those resources to the extent that one responsibly could in the face of that buildup. Expenditure comparisons are input comparisons. They say little about what types of war-fighting capabilities are being added to a given force; instead they indicate *how much* is being expended to acquire some degree of additional capability. Of necessity, these measures understate inefficiency, regardless of the monetary unit (dollars or rubles) employed to express the comparisons. They can only be one rough guide of many, and the degree of their roughness depends on the accuracy with which they are tabulated.

The debate on optimum defense budget levels has recently begun to move away from expenditure comparisons, precisely because it is clear that these measures cannot substitute for true output measures and have been accorded too much significance as input indicators. Their accuracy, as noted, is moot and discounts inefficiency; their inaccuracy does not disprove the existence or likelihood of a Soviet buildup. The value of Pranger's focus on this subject—other than to provide the reader with a picture of the quirks of recent debates on the defense budget—therefore, is somewhat problematical.

The section on the strategic competition is a useful primer for the new student of strategic policy issues but easily could have fulfilled this function with fewer pages and selections. The Nitze-Lodal-Nitze debate need not have been played out in full (Why was Mr. Nitze given the last word?), partly because it is still going on (Nitze-Warnke-Nitze-Warnke . . .). Additionally, it conveys the impression that, within the panoply of U.S.–U.S.S.R. competition/détente, strategic issues are the most critical factor today and in the future. Yet no need to subscribe to one recent appointee's belief that "nuclear weapons mean crap,"[2] or to Henry Kissinger's more subtle but similar views, in order to cast doubt on the perspective that Pranger fosters. As Henry Owen states, in his contribution to the Brookings volume, "Soviet leaders can be expected to proceed with caution, constrained by the fear that large scale war would destroy everything they have built up since the revolution." (p. 45) Such caution is likely to result in Soviet probings of the American will in the nonstrategic arena, with possible conflict likewise limited to that arena. The strategic balance remains important, indeed vital, but the areas of greatest concern may lie elsewhere.

Regarding the choice of source material, in general it is a useful complement to the analytical matter. Nevertheless, one would have expected more than a single document—the Shanghai communiqué—focusing on U.S.–Chinese relations. Also, inclusion of a statement setting out Chinese objectives, in the manner of the Kissinger and Brezhnev statements appearing in the text, would have been appropriate. And the Helsinki agreements would seem to be "Basic Documents on Détente" and deserve inclusion in the chapter of that name. Or are they to be completely discounted?

IF THE focus of the Pranger American Enterprise Institute reader is somewhat narrower than might have been anticipated, the framework of the Brookings volume, *Setting National Priorities,* is as broad as its title implies. Indeed, its focus in the national security chapters is significantly broader than that of previous volumes in the series. The 1977 version, in fact, is far different from its six predecessors in many respects. Previous volumes were a key source of budget alternatives to those of the Nixon–Ford administrations. They employed a five-year framework, issuing counterprojections to those officially put forward. Their emphasis seemed to highlight programs and postures that were likely to find more favor with Democrats than with Republicans: more caution in approaches to cuts in domestic programs, relatively greater willingness to find economies in defense expenditures.

The creation of the Congressional Budget

Office (CBO) by the 1974 Congressional Budget Act may have prompted the change in the format of the Brooking volumes. The CBO, as its first annual report to the Congress (1976) made clear,[3] promised to be the key source of budget alternatives to those presented by the executive. Its status as an agency of Congress placed it in a position to analyze and produce budget options in greater detail and depth than could Brookings.

In order to maintain the impact of its previous contributions to official Washington thinking, given the new role of CBO *Setting National Priorities* has moved from a five-year projection format (which CBO employs) to a ten-year one. This longer-term framework is particularly welcome and useful. Insofar as policy debates tend to look past the horizon of the current year, they merely fall in line with the administration's five-year structure. Yet five years is not necessarily the ideal format for prognostication, certainly not in the national defense/foreign policy area. For example, new weapon systems in particular take a decade, or even longer, from initial development to entry into service.

Similarly, while international crises inevitably have the air of suddenness about them, they tend to be the product of many—often more than five—years' gestation. Developments in Southern Africa, for example, are the result of more than a decade's insurrection by the Rhodesian government, equally long internal strife in Angola under Portuguese rule, and the steady growth of Soviet and Chinese influence in that part of the continent for at least the same time period. A longer-term view might help to assess the likelihood and significance of these and similar developments. It might, therefore, help to point to likely trouble spots and forestall the use of improper frames of reference drawn from other scenarios. Such misapplied frames of reference were, in fact, in evidence during the debates over Angola. That situation was termed "another Vietnam" by both proponents and opponents of U.S. involvement there. Yet this phrase obscured a multitude of factors indigenous to the Angolan civil war, of which race and the participation of a variety of actors, including Chinese, Soviets, Cubans, South Africans, Zairians, represented only the most prominent differences from the Southeast Asia situation.

In adopting a broad-brush, longer-term view, *Setting National Priorities* provides a useful perspective for an approach to re-evaluating the needs and requirements of American foreign policy. Consistent with this approach, the volume generally and sensibly avoids the budget-oriented approach of its predecessors, which is more difficult to apply to a ten-year span and is in any event best left to CBO. Nowhere is this change in approach more marked than in the national security affairs chapters. Gone are line-item cost comparisons as well as five-year costs compared to administration "base lines." Rather, the emphasis, particularly in the chapters by Henry Owen and Barry Blechman, is on the changing nature of the world-wide military balance, the importance of different regional balances to U.S. global interests, and the ways to improve U.S. posture in those regions.

The Owen chapter provides a most useful overview of the likely structure of U.S. foreign policy in the later seventies and eighties. Owen argues that the Mideast, Persian Gulf, and perhaps Yugoslavia are likely to be the next flashpoints that could elicit U.S. military involvement in hostilities. As previously noted, he feels that the Soviet Union will move cautiously but always to its own advantage. He considers further normalization of relations with China unlikely without movement regarding Taiwan, and he posits that there is little the United States can do in Africa because a consensus on this racially oriented question will not be found domestically. These conclusions are unobjectionable, but they do not add much to the present fund of knowledge about U.S. foreign policy. They reflect a crisis-avoidance approach, which is certainly healthy, but offer little that is positive. With the exception of a fifth policy line, a phased withdrawal of the U.S. presence from Korea, they are also cautious to a fault.

Owen's message—and it is an important one—is that the United States cannot withdraw from the world, which will continue to be a dangerous place and which we will not be fully able to control. But surely there might be innovative ways for the United States to exert its influence by capitalizing on new situations and untapped resources. Owen says little about the promise that the outcome of the Lebanese war might hold for Mideast peace. Even if the war had not reached cease fire by the time of writing, some speculation might have been in order. He says nothing at all about the positive role U.S. blacks could play in stabilizing relations with Africa and working toward a settlement. Yet, are Cuba's blacks indeed to be the only active North American participants in the developing African situation? Owen also avoids the South African question almost entirely. Will we really stand by and watch a racial war take place? Risk avoidance is but the beginning of a new, more balanced foreign policy.

Blechman's lucid and thoughtful essay addresses a quite different problem: the nature and consequences of the Soviet buildup. He argues, quite persuasively, that the evolving threat requires a reassessment of United States posture in Europe and elsewhere that might lead to reductions in some geographic areas (Korea) as well as improvements in others (Europe and its surrounding seas). His chapter also addresses manpower efficiency questions, drawing attention once again to that most costly element of the U.S. defense budget. In general, his message is that spending patterns should be neither uniformly higher nor lower but geared to changing needs. That point cannot be reiterated too often. Many arguments on both sides of the defense spending issue continue to be framed in doctrinaire terms. As Blechman concludes: " . . . the process of reducing the share of U.S. resources devoted to defense has more or less run its course. . . . This outlook may be disheartening to some Americans, but the alternative is worse." (pp. 127–28)

Philip Farley's section on nuclear proliferation provides a brief but useful overview of the history of nonproliferation efforts, the evolution of U.S. policy in this area, the shortcomings of that policy, and possible remedies as well as prospects for a regime on nonproliferation. His focus is virtually identical to that of William Epstein's considerably longer (341 pages of small print) study, *The Last Chance,* discussed later. Farley seeks to limit proliferation and feels that the nonproliferation effort may yet succeed. To be sure, he carefully distinguishes between nuclear *potential* and the inevitability of proliferation. He argues that the potential is there and that formal restraints on proliferation are quite weak. Nevertheless, Farley argues that the momentum for proliferation may not be as great as some observers imply.[4] He reasons that states rationally and realistically appraise the costs and benefits of acquiring nuclear weaponry in light of their position in both regional and global balances. They are aware of the great costs of acquisition, of the vagueness of benefits, and the clear risks of further destabilizing regional balances and alienating great power protectors who provide valuable—and often critical—military and economic assistance.

Clearly, Farley's premise about the rational behavior of states with regard to acquiring a nuclear force capability may not always hold true. Some Third World governments betray attributes that are far from rational in the accepted Western sense and have sufficient resources clandestinely to acquire nuclear weapons, if not technology, to support what they might perceive as their "interests."[5] Additionally, his premise fails adequately to address the probability of a chain-reaction effect—if one state "went nuclear" and thereby altered the "rational" perceptions and calculations of its neighbors —and how that probability could be lowered.[6]

Nevertheless, Farley accurately observes that the nuclear club hardly has grown in the past decade, China and India (if one counts membership in terms of explosions, "peaceful" or otherwise) being the only new members. That the club has not expanded more rapidly is the product of choices made by individual states rather than their lack of nuclear potential. Thus, there is some hope that the pace of proliferation can be maintained at its present slow pace, if not entirely arrested.

Farley appreciates the need for major superpower SALT agreements, without which, in the long term, the Nuclear Proliferation Treaty (NPT) regime cannot survive. However, he does not feel that present SALT agreements damage that regime. Indeed, as long as the superpowers evince good faith in their negotiations, the agreements will have little impact on NPT for good or ill, whose fate "will be decided on other grounds." (p. 152)

Farley's presciptions, like his assessment of SALT, are not dramatic, but they are realistic and, hopefully, attainable. They focus less on the NPT per se than on cooperation generally. They do include support for formal instruments of the nonproliferation regime. Additionally, they call for cooperation with non-NPT states on terms similar to those prescribed by the NPT; coordination among suppliers to ensure that safeguards are not undercut; support for international measures to prevent terrorist and other subnational access to nuclear facilities and materials; and support for cooperative approaches to key stages of the nuclear fuel cycle. The latter would include expansion of U.S. uranium enrichment capacity to permit a resumption of American supplies to slightly enriched uranium to the international market. Underlying all these recommendations, and itself a proposal, is the need to foster a sense of security among smaller and more vulnerable states, by means of guarantees and cooperation that will lower the value of the nuclear option in their eyes.

Farley's chapter completes the series of chapters of *Setting National Priorities* that directly address national security issues. However, a word is in order on Graham Allison and Peter Sztanton's chapter on reorganizing government to manage the national security policy. If problems such as nuclear proliferation or indeed the overall future course of U.S. foreign policy are to be addressed coherently, some shift away from the present governmental structure that focuses on the Executive Office Building to the downgrading of certain cabinet departments and Congress clearly is desirable. Whether the complete diagnosis of governmental ills that the authors put forward, and the suggestions they propose based on that diagnosis indeed are correct, is, however, another matter.

For example, Congress may not need a new special committee on Interdependence —with unclear jurisdiction and no grip on the purse strings—in order to foster improved executive legislative relations. It is noteworthy that the authors hardly explore the limits on congressional participation in foreign policy formulation or their effect on the viability of their proposal for a new committee. Yet these limits may be such that a genuine informal network of contacts between President and congressional leaders, in addition to the reams of paper already available as reports, testimony, and studies may suffice to keep Congress a well-informed contributor to the foreign policy process.

Similarly, the authors' proposed abolition of the NSC and creation of an executive cabinet committee, seemingly following the model of the British cabinet, may go further than necessary for efficient organization. Cabinet officers will continue to lobby on behalf of their departments; the President will continue to need an independent analytical staff, responsible only to him. If the cabinet is properly utilized and the NSC cut down to more manageable size, as Mr. Brzezinski has ordered, there may be no need for an "ExCab" that might itself become a new NSC with an inflated staff of its own.

ExCab and the congressional committee are but two of the more innovative suggestions that Allison and Sztanton put forward. Others are equally timely and deserving of consideration. These include the proposals that cabinet officers remain longer in office and that the Department of State, if it is to function effectively, elevate the level of its focus on politico-military affairs and hire more economists. Whether any or all of these suggestions are adopted, the authors will have performed a useful service in pointing to the need for a reassessment of government mechanisms for promoting foreign and security policies in addition to that of evaluating the policies themselves.

WILLIAM EPSTEIN'S agenda in *The Last Chance* resembles that of Philip Farley's contribution to *Setting National Priorities.* It, too, traces the history of efforts to contain nuclear weapon proliferation and examines ways to enhance and sustain those efforts further. Like Farley, Epstein adopts the premise that states act rationally in their own self-interest. However, whereas Farley's presumption of rationality and his optimistic prescriptions based on that presumption are touched by a realistic view of world affairs, Epstein allows his optimism to run wild.

A member of the United Nations staff, Epstein attaches great faith in the chapter and verse of international agreements. He carefully documents those relating to nonproliferation to show where they have not been followed and chastises the major developed countries—notably the United States and U.S.S.R.—to honor both their spirit and letter. Unlike Farley, Epstein is particularly critical of the SALT agreements, which in his view foster a qualitative strategic arms competition and have become "blueprints for the continuation of the nuclear arms race by the two superpowers under agreed terms and conditions." (p. 190)

Epstein contends that the superpowers must go further than SALT to ensure the integrity of the NPT. Such an effort also would prevent small power feelings of "discrimination" that could serve as an excuse for nonadherence to NPT, as well as for nuclear tests such as India's "peaceful" blast. To that end, Epstein puts forward his own list of twelve "proposals for the future" that he feels will put a definitive end to the nuclear arms race. These include (in order of descending realism): cessation of underground tests; the phasing out of ICBMs and strategic bomber forces; a ban on new tactical nuclear weapons and a pullback of those already in existence or use; the convening of a world disarmament conference; new draft treaties for complete disarmament; and the reduction of general purpose force levels, unilaterally by the United States, if necessary. (pp. 200–05) Epstein himself admits that these proposals are unlikely to be achieved within the foreseeable future. But that observation leads him to urge scientists (presumably Americans) to stop all further work on the research and development of weapon and delivery systems. (p. 206) This suggestion is one which can in fact be implemented. It is all the more dangerous for that reason. Indeed, like the proposal for a world disarmament conference—a long-standing Soviet ploy—or for American unilateral reduction of its conventional forces, in the face of a Soviet buildup and/or improvement in quality in most weapon system categories—the "call to scientists" seems to focus more on the imagined sins of the United States than on the motives or misdeeds of others. In doing so, it vitiates the author's credibility as an objective analyst.[7]

Despite its legalism, its frequently shrill tone ("Man Is an Endangered Species" is the title of the final chapter), and the air of unreality, and bias, that pervades its "proposals for the future," the Epstein volume does have much to offer. It provides the student of nonproliferation issues with a useful, detailed history of the development of the NPT regime. Additionally, it does contain an articulate description of the problems that continue to plague the effort to limit the spread of nuclear weapons.

Clearly, further steps must be taken to promote that effort. These steps perhaps need not be as radical as Epstein proposes. Nevertheless, as Farley illustrates, they do require a greater degree of cooperation among the world's leading powers. It should not be forgotten that the 1963 Partial Test Ban Treaty, perhaps the first real breakthrough in easing the Cold War, was also a key milestone in the effort to foster a regime that limited the spread of nuclear weapons. Similarly, the achievement of future milestones in furthering that regime will in fact also serve as critical indicators of the expansion and resilience of the policies of détente which both superpowers profess to pursue.

Washington, D.C.

Notes

1. See Melvin R. Laird, *Annual Defense Department Report for Fiscal Year 1971*, February 1970, especially pp. 1–20.

2. Quoted in C. Robert Zelnick, "M-X and the Next Arms Debate," *The Washington Post*, February 27, 1977, p. C2.

3. See preface by Alice M. Rivlin in Congressional Budget Office, *Budget Options for Fiscal Year 1977: A Report to the Senate and House Committees on the Budget* (Washington, D.C.: Government Printing Office, 1976).

4. See, for example, the arguments of Lewis A. Dunn and William H. Overholt, "The Next Phase of Nuclear Proliferation Research," *Orbis*, XX (Summer 1976).

5. See Lewis A. Dunn, "Nuclear 'Grey Marketeering,'" *International Security*, I (Winter 1977), pp. 109–12.

6. Ibid., pp. 111–12, 114–15; and Dunn and Overholt, especially pp. 505–7, 509–16.

7. A more balanced presentation of many of these proposals may be found in Richard Falk, "Nuclear Weapons Proliferation as a World Order Problem," *International Security*, I (Winter 1977), especially pp. 85–93.

Views represented herein are entirely those of the author. The Congressional Budget Office, where he is employed, bears no responsibility for the contents of this article or the opinions of the author.

The Soviets have been developing satellite destroyer systems for five years, and there is no guarantee they will not use them when it appears to suit their purpose.

Aviation Week & Space Technology
10 May 1976

POTPOURRI

Seaford House Papers, 1975 edited by Philip Panton. London: The Royal College of Defence Studies, Her Majesty's Stationery Office, 1976, 127 pages.

The Royal College of Defence Studies (RCDS) is the senior service staff college of the British armed forces, equating with the National War College. Its students are drawn from the three armed services and diplomatic services of Britain, the Commonwealth, and Europe, thus ensuring an extremely broad mix of backgrounds and interests. This volume, the sixth to be published of Seaford House Papers, contains nine contributions by RCDS students from Britain, Australia, Germany and Sweden and representing seven separate services. As expected, the subject matter clearly illustrates the diversity of a cosmopolitan student body, for it ranges from NATO to Cambodia, from Japan to the Persian Gulf, from current problems of youth and race in Britain to the role of Sweden in Europe.

Such a collection, however, does have some relevance for the American military reader at the staff college and academy faculty level if nowhere else. Within the context of professional military education, it is useful to know and appreciate the subjects of concern to students of such a prestigious institution as RCDS. In this connection Air Commodore Knight's plea that greater progress could be made in NATO's air arm—in common tactical doctrine, command and control, and, of course, standardization—by a commitment to "think NATO" is far from new. Indeed, some Americans see this as the most outworn of all "European arguments," yet, if it is still very much an issue for the Royal Air Force's future top commanders, it should surely be of continuing concern for their opposite members in the United States Air Force.

Of more specific interest, however, will be the two Australian contributions on the future role of Japan and the inside view of the war in Cambodia by the then head of the German Diplomatic Mission in Phnom Penh. Brigadier Morrison argues that the historic hostility between China and Japan ignores the equally historical adaptability of the Japanese and that both countries have much to gain by developing closer economic relations. Air Commodore Trebilco believes that Japan is content to exert influence through diplomatic and economic channels and sees no possibility of a revival of Japanese militarism. Both authors are convinced that American resolve to honour her defence commitments in the Far East are as firm as ever. Neither, of course, was in a position to consider post-Mao China.

Dr. Walther Baron von Marschall of the German Diplomatic Service has most lucidly analysed the military and political events in Cambodia between 1970 and 1975 that led to the downfall of the Khmer Republic and victory for the Khmer Rouge. His compassion for the ordinary people, who suffered so much at the hands of the devious Sihanouk, the stupid Lon Nol, the ruthless Vietnamese Communists, and continued to suffer under the Khmer Rouge, dominates his account of the Cambodian tragedy. His view of the American involvement is tinged with some bitterness:

> American aid, well intentioned though it might be, was always given half-heartedly. It was always enough to continue the war but never enough to win it. It served only to prolong the agony and increase the suffering but it did not provide the means to end the war and restore peace in the country.

I know many Americans who, while wishing the author had specified what was "enough," would not disagree too much with that general verdict. To have it restated by an impartial eyewitness to the events will not be wasted.

However unpromising at a first glance this short volume of Seaford House Papers, with its dull presentation and potential remoteness, may appear, I recommend it to the American military officer who aspires to a deeper understanding of the attitudes of his Allies and friends.

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The Sorting Machine: National Educational Policy since 1945 by Joel Spring. New York: David McKay Co., Inc., 1976, index, notes, 309 pages, $4.95.

"How far does one move to the horizontal and retain the right to remain vertical?" is an old philosophical question that expresses the dilemma of government intervention into local school systems. How far does our national government move in the direction of control and still remain able to say it represents a free society? Joel Spring has written a sound book, rich in history and varied in interpretation, that delineates this problem. At times, it reads like a novel. A well-written account of events and persons caught up in the significant decision-making that established our educational priorities from 1945 until the present, it shapes succinctly the making of a national educational policy, which focused increasingly on manpower needs in relation to military security, unemployment, and civil rights. In a phrase, the author explains how our school system became "a social-sorting instrument in terms of national needs."

This reviewer, who as a professional educator was a part of some of these developments, finds Joel Spring's account accurate and his judgments well formed, especially in his references to the "Titles" programs of the 1960s. Through it all, some interesting philosophical ideas are well articulated, and key questions are raised effectively. For instance, there is a probing insight into the control of curriculum by publishers and special-interest curriculum-developers through their textbooks.

Also, some explicit as well as implicit notions concerning human nature and society parallel the panoramic description and lead to deeper considerations. Classic conflicts are defined and described: manipulation versus understanding, craft versus thought, skill versus intellect, aids versus ideas. The greatest conflict deals with the school as a democratizing process of the social system versus the school as an agency for nurturing intellectual excellence.

One fascinating conclusion reached regarding all these programs and concerns is that people respond positively to special treatment, no matter what the nature of the specialized project: Treat someone—a student or a teacher, a class or a school—as if important for any reason, and the response invariably will be supportive and productive. For instance, serious consideration is given to the "American dilemma," the struggle of the American black for equality of educational opportunity, and in every case, no matter what the program, the black responds positively.

All these developments are depicted against a background of the awful events that crowd our memory: when, for example, local attempts to avoid desegregation caused the vast liberation movement to thrust itself into the streets and back alleys and along the country roads. There are painful recollections as we read of a lack of administrative initiative during those postwar years to implement the Supreme Court's findings. We are reminded that it was only after consideration of the potential damage to our cold war foreign policy that the President was moved to executive action. In other words, the nation's educational policy was motivated by its foreign considerations, reflecting deep irony on a profound sociological level.

The government as adversary—to goals which in former times received only words, not actions—was thus created. The power of Washington had to be and was increased in defense of civil rights. The overriding issue which we have come to face is that students are citizens and fall under the equal protection of the Fourteenth Amendment, and, because of this ruling, the power of the federal government to influence educational policy is now a given. The movement of the last thirty years has been one away from local control (which, by its very being—"local," that is—was unequal) to state and national control.

The book is most assuredly one of Spring's best, yet it is hard to know how to react to it in a culminative way. I keep wanting to ask, after he has thoroughly briefed us on these historical events, "Now what?"

Dr. Porter J. Crow
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Born on the Fourth of July by Ron Kovic. New York: McGraw-Hill, 208 pages, $7.95.

Born on Independence Day, Ron Kovic grew up in the Dr. Spock-Sputnik-Mickey Mouse Club era. In Vietnam he learned that the real article bore little resemblance to the war games he had played with Mattell toys or to such movie epics as *The Sands of Iwo Jima* and *To Hell and Back*.

Born on the Fourth of July relates Kovic's unsuccessful effort to adjust to reality after an enemy bullet had left him permanently crippled. The story, though poignant at times, is all too trite. Indeed, practically every cliché one can associate with the Vietnam debacle can be found in this book. A typical, sheltered, immature all-American boy, the son of devout working-class parents, enlists in the marines in a fit of romantic idealism;

seeking glory, he accidentally shoots a comrade and slaughters Vietnamese civilians. A cruelly disabling wound earns him not honor but merely a disgustingly pro forma award of the Purple Heart.

Returning home, Kovic is assigned to a Veterans' Administration hospital, which resembles a chamber of horrors; his family fails to comprehend the agony he is suffering; hometown American Legion hawks exploit him shamelessly; and the "Great American" public could not care less. Finally, the Kent State riot restored a sense of purpose to his life—speaking and demonstrating against the war. Kovic became obsessed with the desire "to make people remember, to make people as angry as he is, every day of his life, every moment of his existence. . . . " Presumably, this is also the aim of his book, but, sad to relate, he fails. Others have long since beaten him to the punch; even horror can become tiresome.

This is not to say that *Born on the Fourth of July* is totally without merit. Although his syntax is occasionally bizarre, the author has a sure ear for authentic GI dialogue and an uncanny ability to recreate the feel of Vietnam. Moreover, he has a flair for black humor and a sharp eye for the absurd: witness his sketches of the pompous, insensitive general pinning a decoration on a babbling human vegetable while a photographer takes snapshots for the folks back home and the VA hospital orderlies playing poker on toilet seats while helpless patients' urine bags overflow onto the floors of the ward. Aside from these and other novel literary devices, however, the book has little to commend it to the military professional. Principally, Kovic rehashes a hackneyed tale. The exercise may have provided a catharsis for him, but it adds nothing to our knowledge of the war.

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Soviet Strategy in Europe edited by Richard Pipes. New York: Crane, Russak, 1976, 303 pages, $14.50/$7.50 paper.

"Russia must be regarded as a serious imperial power with a sense of mission and an inflexible will to fulfill it . . . . " In this era of détente and "adversary relationships," which has replaced the cold war, *Soviet Strategy in Europe* comes across like a dash of cold water. Nor is this shock accidental. Clearly, editor John Pipes's purpose is to warn us of what he sees as an unwarranted relaxation of Western vigilance against an enemy whose goal continues to be "to detach Western Europe from its dependence on the United States . . . and to make it dependent on the U.S.S.R."

Reflecting the current trend of considering "strategy" within a broader framework than the traditional employment of military forces, Pipes defines Soviet strategy as "the coordination of political, military, economic, and ideological instrumentalities toward predetermined long-term objectives." In analyzing this multifaceted approach, he has brought together eight essays by distinguished Sovietologists. Four of the essays focus on political dimensions, two grapple with military considerations, and two deal with Soviet economic policies.

As could be expected in any such compilation, the authors do not agree completely on the exact nature of the Soviet threat to Western Europe. None of them, in fact, adopts quite the strident tone of the editor's opening essay. On the other hand, they all tend to view the Soviet Union as an aggressive power which seeks through a variety of means—probably short of the actual employment of military forces—to gain greater leverage over Western Europe.

Soviet Strategy in Europe is not a comfortable book to read. The information it presents and the conclusions it suggests (however tentatively the individual analysts couch them) are disquieting. All the more is this true since the contributors are not half-baked reactionaries who see Communists hiding in every dark corner. Even those who do not accept fully the warning contained within—that "as now defined and practiced, détente primarily benefits the Soviet Union"—should consider carefully the sober and judicious analysis contained in *Soviet Strategy*. Unfortunately, the gnawing feeling remains that this is the type of study read only by those who already accept its conclusions, a condition that may make the book little more than an exercise in "preaching to the choir."

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The Road to Yorktown by John Selby. New York: St. Martin's Press, 1976, index, x + 214 pages, $10.00.

The Road to Yorktown is a survey of George Washington and the Continental Army during the

American Revolutionary War. John Selby writes a clear, concise analysis of major events and includes, as well, stories of human interest.

The book is recommended for someone not familiar with the war. Military heritage classes and history readers will appreciate the book's uncluttered maps. However, specialists will quickly recognize the book's inaccurate uniform illustrations reflecting the Napoleonic era. Other specialists will notice incomplete names and false legends; the famous myth of Mrs. Murry detaining General Sir William Howe's British army in New York City is perpetuated in this book. Readers who like miscellaneous details—such as the names of Washington's horses or that whores were sometimes used as nurses—will be occasionally amused.

Selby presents an overview and sometimes allows contemporary writers to describe details. The book includes an appendix of the orders of battle of the armies at Yorktown, and a select bibliography is also included. On the whole, this book is useful only as popularized short history.

Alan Conrad Aimone
U.S. Military Academy

Battles Lost and Won: Essays from Civil War History edited by John T. Hubbell. Westport, Connecticut: Greenwood Press, Contributions in American History #45, 1975, 289 pages, $13.95.

This addition to the Contributions in American History series is a collection of articles previously published in *Civil War History*. Some of the articles are of interest only to serious students of the Civil War, but others raise points of interest to any serious student of the military art.

A number of selections concern firepower—broadly interpreted as the ability to inflict damage to the enemy on the battlefield—and its relationship to tactics. Two selections that nicely complement each other concern "cold steel": the cavalry saber and the bayonet. Both were weapons to which ante-bellum military leaders assigned great importance but which events proved to be seldom used and even less frequently effective. As any student of the war knows, the advances in firepower made in the decades preceding the war resulted in the superiority of the tactical defensive over the tactical offensive, a fact amply demonstrated by shattered attacks on countless Civil War battlefields. This lesson was learned slowly, however, and only at the cost of much blood and thousands of lives. Some commanders, like Confederate General John Hood at the Battle of Franklin, never learned this lesson. The point is brought out repeatedly in articles on trench warfare and on the causes of Confederate defeat. The inference in all four selections is that the successful commander must constantly assess the impact of changing technology on his art and make whatever adjustments are necessary.

The most interesting set of articles are the two by Thomas Connelly and Albert Castel. Connelly's selection originated the furious debate over Robert E. Lee that still rages among Civil War historians. Connelly assigns to Lee a significant portion of the blame for the South's defeat, stating that Lee's emphasis on the war in the East to the exclusion of the West, the Confederacy's heartland, cost the Confederacy more men and resources than it could afford. Connelly's attack on Lee, and Castel's defense of "Marse Robert," published in response to Connelly's selection, are easily the highlights of the book.

This is not meant to denigrate any of the other selections. Topics such as military preparedness, civil-military relations, intelligence-gathering operations, guerrilla warfare, and the measurement of officer effectiveness (they had OER troubles then, too!) are the subjects of very interesting articles. The book could have benefited from the inclusion of a selection on a naval subject, such as the blockade, but this is a minor criticism. It is an excellent anthology that anyone with an interest in military or American history will enjoy reading.

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Jeppesen Sanderson Aviation Yearbook 1977 edited by Ed Mack Miller. Denver, Colorado: Jeppesen Sanderson, Inc., 1977, 442 pages, $14.95.

If a browser can overcome his initial resistance to open a book with the formidable title of *Jeppesen Sanderson Aviation Yearbook 1977* and disguised as a training manual in a plain blue cover, he is almost certain to become a reader. Ed Mack Miller, well established as an old pro in the aviation writing fraternity, has compiled a 442-page anthology of some of the most entertaining and informative aviation articles published in 1976.

Whether your interest runs to military aviation, parachuting, the airlines, wing walking, ballooning, women, Ag flying, FAA, air traffic control, aerobatics, hang gliding, air safety, B-1s to BD-5s, antiques, foreign developments, space, history, aerodynamics, helicopters, or the first man-powered flight in the Western Hemisphere, this yearbook has something for you. As in any gathering of articles, there is considerable variation in the writing, but in general the pieces are short, amusing, and, as might be expected, resemble the breezy style of the editor.

If you, like this reviewer, have the backward reading habit of an Oriental and tend to read from back to front, this book is perfectly suited to this regression. In fact, you can open the *Aviation Yearbook* almost anywhere and begin reading for fun and profit.

Colonel Glenn Wasson, USAF
Air University Review

Spaceborne systems will certainly constitute an increasingly important part of military capability. They are absolutely essential, for example, to our communications, command, control and surveillance functions. This will increase in the future. With the advent of the space shuttle in the early 1980s, I personally feel our capabilities in space will increase very perceptively. Our reliance on space will also increase. Systems such as the NAVSTAR Global Positioning System will, in my view, not only revolutionize navigation per se worldwide, but will revolutionize weapons delivery against a variety of targets. Of course, this increased dependence upon space raises questions of the vulnerability of our space systems. The question is, will space eventually no longer be a sanctuary, and will one have to worry about the increasing vulnerability of space systems? I believe this will require a great deal of attention in the next few years.

Dr. Malcolm R. Currie
Director of Defense Research and Engineering
Countermeasures, *December 1976*

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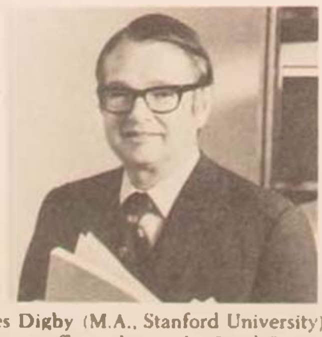

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AWARD

The Air University Review Awards Committee has selected "Industrial Democracy and the Future Management of the United States Armed Forces" by Dr. Laurie A. Broedling, Navy Personnel Research and Development Center, San Diego, as the outstanding article in the September-October 1977 issue of the *Review*.

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