AIR UNIVERSITY review

JULY-AUGUST 1971

environmental
perturbations

UNITED
STATES
AIR FORCE
AIR UNIVERSITY
REVIEW

AIR UNIVERSITY review

THE PROFESSIONAL JOURNAL OF THE UNITED STATES AIR FORCE

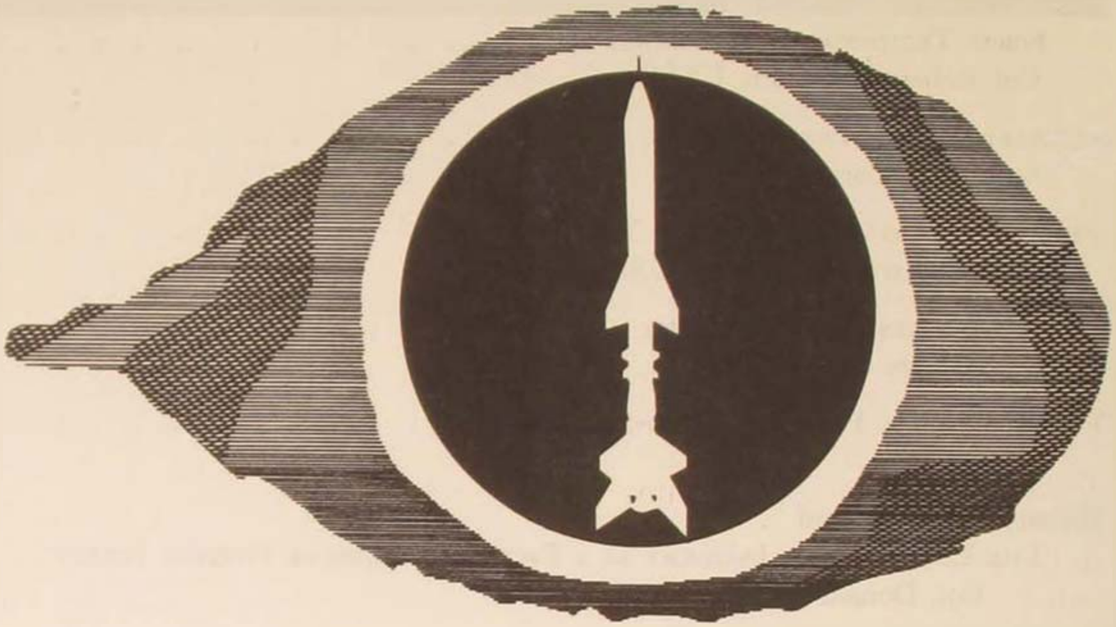
Address manuscripts to Editor, Air University Review Division, Bldg 1211, Maxwell AFB, AL 36112. Printed by Government Printing Office. Address subscriptions to Superintendent of Documents, GPO, Washington DC 20402: yearly $4.50 domestic, $5.75 foreign; single copy 75¢. For back issues, mail check or money order to Book Department, DMSB, Bldg 1450, Maxwell AFB, AL 36112: domestic 75¢, foreign 90¢.

Vol. XXII No. 5 July-August 1971

the cover

Planet earth has been here several billions of years, Dr. William Pollard reminds us, but man's accurate knowledge of it and its evolution is largely a product of the past century or so. While the tools and skills of scientific investigation grow increasingly sophisticated, so, too, the complex products of technological advancement sometimes pose threats to man and his environment: e.g., the sonic boom and aircraft wake turbulence. Several of our authors are concerned with aspects of technology and the environment.

AIR FORCE TECHNICAL INTELLIGENCE



COLONEL ROBERT B. KALISCH

ADMIRAL THOMAS H. MOORER prior to becoming Chairman of the Joint Chiefs of Staff said, "I believe that the greatest military danger facing our country lies in the possibility of a major technical surprise."[1] As this nation reduces its investment in military technology and development, the need to prevent technological surprise becomes even more important.[2] When U.S. technology is foremost, the chance of an unbalancing breakthrough from a nation of lesser technological strength is not so great. Now with the steadily burgeoning Soviet investment in science and technology, the chance of a new development that could break the nuclear stalemate is increasing.[3] This article traces the early Air Corps commitment to the prevention of technological surprise down to the present problems of technical intelligence. The period up to 1945 differed greatly from the later developments, 1945 to the present. Organizational unity within the Air Force during much of this latter period had a major influence on the attitudes of the current technical intelligence community. Technical intelligence growth has been a direct response to the technological military threat. The increasing complexity of modern weapon systems has created new aspects of technical intelligence. In this article I shall outline and discuss such aspects as technical intelligence priorities, the significance of warfare systems, the growing importance of science to technical intelligence, and the complexities of net assessments.

early air technical intelligence

Military requirements for technical intelligence were minimal prior to World War II. A few farsighted Air Corps leaders such as Major William (Billy) Mitchell, Chief of European Intelligence Section of the War Department (1912), and Major Raynal C. Bolling (1917) foresaw the need for air technical intelligence.[4] Despite their efforts, only a modest capability existed in 1941. Realization of the importance of air technical intelligence was slow because of the attitude that technological surprise would not be a decisive factor in a major war. In earlier wars between industrial nations, technical advances were not crucial.

World War II changed these attitudes. New technology dominated events. Radar, antisubmarine warfare, sonar, fighter aircraft design, ballistic missiles, aerodynamic missiles, and atomic weapons created major technological imbalances. These technological asymmetries gave rise to the first real opportunities for technical intelligence.

During World War II one approach to the introduction of a significant new technology was to counter with simple, unsophisticated direct action. One such example was the German V-1 launcher deployment. V-1 launch sites had been identified as "ski sites" by the British from aerial photography.[5] "Operation Crossbow" was designed to destroy these sites by aerial bombardment. A high priority was given to their destruction. Yet, during much of this period the Allies were not sure of the purpose or the operational characteristics of the V-1 sites.[6] This was a "knee-jerk" response to new technology: if the enemy valued certain facilities, destroy them. The enemy's enthusiasm in repairing facilities served as a guide for the bombing priority.

Few of the technical intelligence opportunities of World War II were elegantly exploited. Those that were exploited at all usually followed the pattern of capturing enemy equipment (airplanes, guns, torpedoes, or mines) and analyzing it.[7] While this technique led to the birth of practical technical intelligence, it was ill suited to counter certain types of the new World War II military hardware, such as radar or atomic weapons. These problems required a more sophisticated approach.

One hint of the potential of technical intelligence analysis was given by the V-2 incident. Some months before the Germans launched the V-2 missiles against London, the Soviets observed a number of large blast craters on the Polish front. An Army Air Corps team went to Poland, retrieved some fragments, and returned to England. By assembling these fragments, a joint British-American team was able to identify the new weapon as a ballistic missile. Once the weapon had been identified, efforts were made to establish suitable countermeasures.[8]

the cold war

In the twenty-five years following World War II, the need for subtle technical intelligence methodology steadily increased. Nonhostile techniques for obtaining technical data on major enemy weapon systems had to be developed. Each weapon system had to be assessed from the viewpoint of its possible effect in altering the cold war balance of power.

Radar, aircraft, missiles, space vehicles, and nuclear weapons dominated the intelligence efforts of this period. Each new radar posed a challenge from the viewpoint of the Strategic Air Command penetration capability and the possibility of effective electronic countermeasures. New Soviet interceptor aircraft raised questions of air defense doctrine, aircraft intercept capability, air-to-air armament, and effective counter actions. Soviet missiles and satellites established a new increased dependence on the technical intelligence analyst. Technical intelligence required not only new collection techniques but also identification of the parameters to define the threat. Public statements by national leaders are evidence of the apparent success of this aspect of technical intelligence.[9]

major areas of technical intelligence

Four major areas characterize technical intelligence activity to date:

1. Preventing technological surprise.
2. Advancing U.S. technology by use of foreign technology.
3. Identifying weaknesses in foreign weapon systems.
4. Using certain design traits of foreign weapon systems as indicators of strategic intent.

Each area has a "success story" to tell, but much of it cannot be told now for security reasons. Characteristic unclassified achievements can be cited to give the reader an indication of the progress that has been achieved.

Major Raynal Cawthorne Bolling (1877–1918)
Seeing the approaching involvement of the U.S. in World War I, and sensing the potential of aviation, Bolling learned to fly. He was a colonel and Assistant Chief of Air Service when killed in action.

Technological surprise. Two interesting examples of prevention of technological surprise are the forewarning of the Soviet ICBM threat and the warning of the Soviet fractional orbital bombardment system (FOBS). Dr. Harold Brown has described the importance of intelligence evaluations in the former case:

> A good example of the two-edged nature of lead time and intelligence estimates is the intercontinental ballistic missile, which the Soviets were working on in the early 1950s. Knowledge that they were developing an I.C.B.M. was a major factor in the initiation of our own program in 1954–55. But the Soviets did not have a substantial I.C.B.M. capability until 1962, an elapsed time of about ten years. Starting two or three years later, we managed to finish about two years earlier than they.[10]

Another possibility of technological surprise was nullified during the Soviet development of the fractional orbital bombardment system. The advantage of this class of system is that it permits an attack on an unusual trajectory, presumably one which would minimize the probability of detection.[11] Technical intelligence can assess what trajectories can be used, which trajectories would be most effective, possible countermeasures, and mass launch capability evaluations. This input coupled with U.S. strategic force deployment and strike plans can provide the all-important net assessment of the significance of the FOBS. This is another way in which technical intelligence can prevent technological surprise.

Transfer of technology. The national research and development "slowdown" has caused some writers to speculate on the nature of the technological threat. George Fielding Eliot has said:

> . . . danger to the U.S. of technical surprise probably does not lie in the sudden appearance of a decisive Soviet weapon system against which we would be helpless. It lies rather in the steady year-to-year cumulative gains which Soviet devotion to technological competition and determination . . . may produce.[12]

This hazard may be reduced by the transfer of advanced foreign technology to domestic use, a post-World War II example being Project Paperclip. Paperclip was designed to allow Axis scientists and engineers to continue their work in the United States after the war.[13] The net result of this effort was that the highly sophisticated missile and jet aircraft technology of the Germans was effectively transferred to this nation.

Such opportunities rarely occur. A more common situation is that a nation, having developed a militarily important technology, jealously guards it. The Soviet technology in chemical and biological warfare is probably quite advanced compared to the U.S. state of the art.[14] However, no simple transfer of this technology is possible. Such a transfer could only result from intensive intelligence efforts by analysts well schooled in the issues of chemical and biological warfare as well as the techniques of intelligence collection and analysis. Despite the difficulties, it is the job of technical intelligence to transfer the foreign technology as well as assess the threat posed by it.

Identification of weapon system weaknesses. The technical intelligence effort to identify the weaknesses of potential adversaries' weapon systems is operationally important and highly visible. Of major significance to the Air Force are the capabilities of the Communist bloc interceptors. Theoretical estimates and engineering evaluations are usually adequate for performance data or aircraft vulnerability studies. In some cases, however, only flight-test experience will suffice. Such a situation arose during the Korean conflict. Parts from damaged MIG-15 aircraft were available for analysis, but General Benjamin W. Chidlaw and Colonel H. E. Watson wanted a MIG-15 intact for flight test.[15] As a result of their efforts, a defector flew a fully operational MIG-15 in to Kimpo Air Base at Seoul in

The only whole, flyable MIG-15 beyond the Iron Curtain was flown to Kimpo Air Base near Seoul, Korea, by a North Korean officer in a daring escape to freedom. . . . The prized Russian-built jet fighter gets its first test flight with a USAF pilot at the controls, followed by an F-86 Sabrejet, which, among other tests, engaged the MIG in simulated combat.

1953. This windfall established the credibility of technical intelligence. Actual flight tests confirmed the aircraft characteristics previously estimated by engineering analysis of damaged aircraft.

As brilliant as the MIG-15 exploit was, it could not serve as a model for future technical intelligence problems. Captured hardware has rarely been available during the cold war. Instead, remote sensing techniques, extensive engineering analysis, and logical deductions based on Soviet systems concepts have provided the basis for hardware evaluations.

Determination of strategic intent. Modern weapon systems are exceedingly complex. A system may be so complex or may require compatibility with several other systems so that there can be no overall optimization. Such a situation is resolved by subsystem optimization. The nature of the subsystem optimization may be indicative of the intent of the system. In fact one might deduce the overall system intent more readily in this way than by study of the entire system.

Examples of disclosure of system strategic intent from a subsystem are not uncommon. Analysis of the Soviet SS-9 ICBM illustrates the point. The underlying question was the Soviet intent in their large SS-9 deployment.[16] Dr. John S. Foster, Director of Defense Research and Engineering, Department of Defense, described the situation as follows:

> Although we are not positive that the multiple warheads being tested on the Soviet SS-9 ICBM are designed for multiple hard-target destruction, we do know that the guidance and control system employed in the SS-9 tests has capabilities much greater than that required to implement a simple MRV. The things we do know about this mechanization are completely compatible with MIRV even though they do not prove a MIRV capability. . . . My own judgment in this matter is that the Soviet triplet probably is a MIRV and that it has little other function than the attack of large numbers of hard targets.[17]

Such an analysis has profound implications. If one accepts Dr. Foster's conclusions, the Soviets appear committed to a greater emphasis on a counterforce strategy.[18] This in turn creates an increased sense of urgency for programs intended to decrease the vulnerability of the U.S. strategic force.

current technical intelligence

Several fundamentally new factors affect the role of technical intelligence. These factors are likely to accelerate and alter the evolution of technical intelligence. Some of these problems are clearly in the domain of the technical intelligence analyst. Some fall in the large grey area between technical and classical intelligence.

The changing relative technological strength of the United States will cause important changes in the technical intelligence program. Totally different technical intelligence strategies are appropriate to a nation that is the technological leader and to one that is a follower. Consider the defense against ballistic missiles. No one would suggest that this technical intelligence area should be treated identically the same as intelligence pertinent to digital computer design. In the latter field, the United States is the international leader, the primary innovator, the standard for reference. In the other, the United States does not have an operationally deployed antiballistic missile (ABM) system, and our national attitude is much less committed to achievement in this field than the Soviet Union is.[19]

A second factor in the role of technical intelligence is that some types of technological advancement may not be particularly significant in view of the world situation. In this category one might contemplate a twenty percent change in the range of a Soviet submarine-launched ballistic missile, which would not alter the threat significantly. However, a similar change in the range capability of GUIDELINE, the Soviets' surface-to-air missile,

(Copy)

Aug 11 1861.

Maj Genl
Benj F. Butler

Sir.

I have the honor to report that on the 10th of Aug I made two ascensions in which I attained an altitude of 1500 feet and made observations as follows. About five or six miles North West from Hampton I discovered an encampment of the enemy, but owing to the misty state of the atmosphere caused by the recent rain I was unable to form a correct idea of their numerical force. but should judge from four to five thousand. There were no vessels or encampments of any kind either at York or Back River. or at Newmarket Bridge. On a branch of James River about 8 miles from Newport News on the opposite side there is a vessel at anchor On the left bank of James River about eight or nine miles from Newport News is a large encampment of the enemy from 150 to 200. tents. also an encampment in the rear of the Pig-Point batteries of from 40. to 50. tents. At Norfolk two large ships of War are laying at anchor in the stream one of which appeared all ready for sea, with sails bent &c. No observations at Fanning's Creek. I illustrate what I saw by the accompanying hasty diagram the guns which I discovered in a previous ascension proved to be only heavy Field Guns. mounted on carriages - along the coast below Sewall's Point no batteries or enemy were visible -

With respect

(Signed) John La. Mountain
Aeronaut

Air technical intelligence was slow to materialize for until World War II significant technological surprise was hardly a possibility, much less a threat. One of the earliest U.S. items of air intelligence is the diagram and report of a Union Army reconnaissance ascent over the Hampton-Norfolk region of Virginia, on August 10, 1861. This document is in the collection of the Old Records Section of The Adjutant General's Office, U.S. Army.

would represent a major threat change in their air defense system. The point to be made is that not all technological advances are of equal importance.

technical intelligence priorities

Deterrence of nuclear war is our prime strategic objective.[20] Assured destruction is an integral part of the strategy to deter war. Lieutenant General Glen W. Martin, Vice Commander, Strategic Air Command, has defined "assured destruction" as a reliable ability to "destroy a significant percentage of Soviet population and industry after the worst conceivable Soviet attack on our strategic forces." [21] Any intelligence that affects assured destruction capability is high on the priority list. Intelligence priority can be judged on the basis of the likelihood that the information will alter our understanding of the military balance of power or the comparative military capabilities. In general, intelligence, especially technical intelligence, is evaluated on the basis of relevance to U.S. decision-making. As the relevance of the intelligence varies, so should its priority. Such an approach allows allocation of resources on more critical issues at the expense of less important areas.

warfare systems

The use of Soviet military equipment by other nations brought to light the problem of the operation of Soviet warfare systems. The United Arab Republic has had difficulties with a mix of Soviet radars, interceptors, and surface-to-air missiles that must be analyzed from the viewpoint of an overall warfare system. One suspects that the command and control, maintenance, and communication are fundamental problems which tend to degrade the quality of that equipment.

As modern weapons are deployed throughout the world, part of the technical intelligence job is to assess the overall war-making capability. Each weapon system contributes to the overall total, but without an integrated assessment, any view of a national capability is grossly distorted.

sensitivity to science

Prior to World War II the impact of technology during a war had not been great. Similarly, the impact of science has not yet been fully felt in war. To be sure, science has changed the nature of war, but it has not yet been a dynamic factor during a war. Nonetheless, the lead time from scientific discovery to application is being steadily shortened. In critical areas in the future this time interval could be deceptively brief—on the order of five years. This telescoping of time from science to application is an issue of importance to the technical intelligence analyst. Formerly it was sufficient to remain abreast of technological developments and implications. Today and in the next decade the scientific base and its military potential are essential elements of any comprehensive evaluation.

This problem is particularly difficult because often the only people capable of assessing the scientific advances in other countries are the U.S. scientists in similar fields. This factor tends to bias estimates. U.S. scientists naturally believe that the approaches used in their own research are the most promising. They often believe that other approaches are less attractive. This situation is inevitable, but it forces the technical intelligence analyst into an untenable position. Either he assesses the threat as greater than the most knowledgeable scientists in the field do, or he accepts their somewhat biased views.

Further difficulties arise in the assessment of research for which no U.S. counterpart exists. On an unclassified level, one example is the problem posed in attempting to judge the significance of vernalization experiments, that is, enhancing the growth of certain plants if the seeds are planted and subsequently exposed to very low temperature. Not surprisingly, this phenomenon has been important in Soviet agriculture, but other nations have not given it high priority. Hence, no technically strong research is being conducted on a large scale outside the Soviet Union. Judgments in such areas are extremely difficult and questionable.

net assessments

An intelligence estimate, technical or otherwise, is not an end in itself. Intelligence has meaning only insofar as it enhances understanding of future interactions. Specifically, how military weapon systems will interact in combat is of prime concern. Isolated system capabilities and characteristics are not key data. For example, a capability for tracking a surface-to-air missile system is dependent upon the vehicle to be tracked. Without definition of what is to be tracked, the tracking capability really has no meaning. The Blue Ribbon Defense Panel described its concept of net assessments:

> A Net Assessment Group should be created for the purpose of conducting and reporting net assessments of the United States and foreign military capabilities and potentials. This group should consist of individuals from appropriate units in the Department of Defense, consultants and contract personnel appointed from time to time by the Secretary of Defense, and should report directly to him.[22]

This description does not treat the problems of net assessments. Problems arise because of the uncertainties of intelligence data and the fact that these net assessments will constitute fundamental constraints on DOD actions. Intelligence uncertainties are often hidden in the estimating process. Furthermore, not all technical system estimates enjoy the same level of confidence. Therefore, the art of net assessments is to translate intelligence studies and military systems data into realistic relative parameters. The vagaries of intelligence may frequently require that the comparison parameters be generated specifically for net assessments and not be a generally reported index.

A net assessment, as described here, refers to the comparison of military capabilities. It should not weigh weapon systems, because individual weapon systems do not necessarily play identical roles in the warfare system. One example would be a weapon system for which the other side has no counterpart. The Soviet intermediate-range ballistic missiles would be a case in point. There is no corresponding weapon in the U.S. inventory. Clearly, weapon systems could not be compared in this situation.

Consider the problem of comparing intercontinental ballistic missiles. One aspect of the comparison would certainly be the system capability to destroy the adversary's hard targets. Yield, accuracy, and reliability are involved as well as target hardness and targeting considerations. Net assessments would evaluate capabilities against enemy target systems, not yield, accuracy, reliability, etc.

Modern war is an incredibly complex interaction of men and machines. Technical intelligence provides a basis for forecasting the behavior of some of the elements. Technical intelligence has steadily grown and increased in sophistication. In World War II technical intelligence was in its infancy. Cold war pressures caused a maturation and major increase in sophistication. During the sixties the ultimate technical intelligence product was an individual weapon system analysis. Now these analyses are but building blocks to a broader assessment—the warfare system. The warfare systems and their component system analyses are the basis for the even broader problem of net assessments.

Not only has the problem grown in the sense that many weapon systems must be assessed as an integrated military unit, but also the development cycle has become critical. Science can be brought to bear on military issues quickly and dramatically.

Hence, there have been changes in the nature of the technical threat as well as a changing requirement concerning the form of the evaluations. These factors will have a profound influence on the growth of technical intelligence in the seventies.

Air War College

Notes

1. Thomas H. Moorer, "Inquiry into USS Pueblo and EC-121 Plane Incidents," Hearing before the House of Representatives Special Subcommittee on the USS Pueblo of the Committee on Armed Services, HASC No. 91–10, Washington, GPO, 1969, p. 635.
2. Otto J. Glasser, "Shaping the Future," *Air University Review*, XXII, 1 (November–December 1970), 3.
3. *The Soviet Military Technological Challenge*, Center for Strategic Studies, Georgetown University, September 1967, p. 8.
4. *FTD 1917–1967*, Foreign Technology Division, AFSC, Wright-Patterson Air Force Base, Ohio, 1968, p. 8.
5. Wesley F. Craven and James L. Cate, *The Army Air Forces in World War II*, Vol. III (Chicago: University of Chicago Press, 1951), p. 84.
6. *Ibid.*, p. 525.
7. *FTD 1917–1967*, p. 12.
8. *Ibid.*
9. John C. Meyer, *Supplement to Air Force Policy Letter for Commanders*, 8–1970, p. 10.
10. Harold Brown, "Planning Our Military Forces," *Foreign Affairs*, Vol. 45, January 1967, p. 280.
11. Brooke Nihart, "The Soviet Strategic Threat and U.S. Decisions," *Armed Forces Journal*, 20 June 1970, p. 8.
12. George F. Eliot, "Technological Surprise," *Ordnance*, Vol. 54, July–August 1969, p. 55.
13. *FTD 1917–1967*, p. 18.
14. *The Soviet Military Technological Challenge*, p. 76.
15. *FTD 1917–1967*, p. 24.
16. Craig Powell, "Strategic Forces," *Armed Forces Management*, Vol. 16, No. 7 (April 1970), p. 27.
17. John S. Foster, "Soviet Multiple Warheads Due Next Year," *Armed Forces Journal*, Vol. 106, August 16, 1969, p. 14.
18. Air Force Manual 2–11, paragraph 2–3, 1 December 1965.
19. William T. Lee, "Soviet Military Industrial Complex, Part II," *Armed Forces Management*, Vol. 16, No. 9 (June 1970), p. 41.
20. Melvin R. Laird, "Countering the Strategic Threat," *Supplement to the Air Force Policy Letter for Commanders*, 6–1970, p. 14.
21. Glen W. Martin, "The Strategic Deterrent," *Supplement to the Air Force Policy Letter for Commanders*, No. 6–1970, p. 21.
22. *Report to the President and the Secretary of Defense on the Department of Defense by the Blue Ribbon Defense Panel, 1 July 1970*, Washington, GPO, p. 59.

AIRCRAFT WAKE TURBULENCE

An Interesting Phenomenon Turned Killer

Andrew S. Carten, Jr.

IN SEPTEMBER 1970 the Office of the Air Force Deputy Inspector General for Inspection and Safety circulated the following message:

> THE INVESTIGATION OF A RECENT T-38 FATAL ACCIDENT INDICATES THAT EXTREME TURBULENCE FROM TRAILING VORTICES OF A LARGE AIRCRAFT, 747 OR 707 TYPE, MAY HAVE BEEN A MAJOR FACTOR IN THE ACCIDENT. THE T-38 WAS MAKING A LANDING APPROACH AND APPARENTLY FLEW INTO THE TRAILING VORTICES OF A LARGE AIRCRAFT THAT HAD JUST COMPLETED A LOW APPROACH ON A 30° BISECTING RUNWAY. ALTHOUGH THE ACCIDENT INVESTIGATION IS STILL IN PROGRESS, IT IS SUSPECTED THAT THE T-38 PILOT LOST CONTROL OF HIS AIRCRAFT DUE TO WAKE TURBULENCE.

That message called attention to a safety problem that is becoming a crisis of serious proportions—the increasing incompatibility of the various types of aircraft constituting the traffic mix at busy airfields and in flight over heavily traveled air routes. The crisis results from the excessive wake turbulence generated by the new large swept-wing aircraft. In a way, it is a rerun of the clear air turbulence (CAT) crisis of the early 1960s except that aviation is in a better position to cope with the newer problem than it was when the CAT crisis developed.

The Air Force Office of Scientific Research and the Boeing Company conducted a symposium on aircraft wake turbulence during summer 1970 in Seattle, which attracted many aircraft designers, aeronautical researchers, pilots, meteorologists, and operations personnel as well as representatives of various regulatory agencies. Several puzzling aspects of the wake turbulence picture were brought into focus at the symposium, and areas in need of investigation were identified. This article will stress some of the key points made there and will draw on other sources to explain the genesis of the problem, its operational impact, and possible alleviation techniques.[1]

Both as phenomena and as technical and operational challenges, clear air turbulence and aircraft wake turbulence exhibit striking similarities. In the belief that the wake turbulence problem will gain perspective if discussed in the light of CAT knowledge, I will review briefly the CAT situation and other related references.

the CAT crisis

In the initial stages of commercial jet transport operations in the United States (1959–1961), aviation had to face up to a serious problem for which it was not adequately prepared—the presence of random patches of very turbulent air at cruise altitudes, 25,000–40,000 feet. Since these patches are usually found in the absence of clouds, they provide no advance warning to pilots. This type of turbulence is called clear air turbulence to distinguish it from the well-known turbulence associated with convective clouds, which is generally avoidable through use of airborne radar. Several spectacular CAT-related incidents, involving both military and civilian aircraft, occurred during the early sixties and caused numerous personnel injuries and structural damage. A fatal B-52 accident during this period was blamed on CAT.

One probable reason for aviation's unpreparedness was that earlier warnings from mountain wave and jet stream research programs had not reached enough people or were not properly heeded. Those warnings, incidentally, had been supplemented during the fifties by Strategic Air Command reports of clear air turbulence encountered by high-flying B-36, B-47, and B-52 aircraft. Another reason was the magnitude of the problem. The conversion to jets was proceeding rapidly while scientists and operations personnel struggled to obtain a working knowledge of CAT and CAT countermeasures.

Today, the causes of CAT are generally established, and reasonably effective methods have been developed for identifying areas in which CAT is likely to be present. In addition, pilots now employ special turbulence penetration techniques to reduce the hazard and avoid earlier problems caused by overreaction on encountering turbulence. Although the number of severe encounters is decreasing, CAT still deserves great respect, as the passengers on a PanAm 747 caught in turbulence attributed to CAT over Nantucket on 4 November 1970 will agree.[2] Moreover, the routine circumnavigation of suspected CAT areas imposes a large economic and time penalty on civilian and military operations. Consequently research by the Air Force and other federal agencies continues, much of it at Air Force Cambridge Research Laboratories (AFCRL), under the purview of the Interagency Clear Air Turbulence Steering Group. An effective airborne CAT early-warning system is one of the major goals.

With the battle against CAT only partially won, it is ironic that the era of the second-generation jet transports—the so-called jumbo jets, 747, C-5, etc.—has been marred from the start by the presence of a second turbulence-oriented hazard, aircraft wake turbulence.

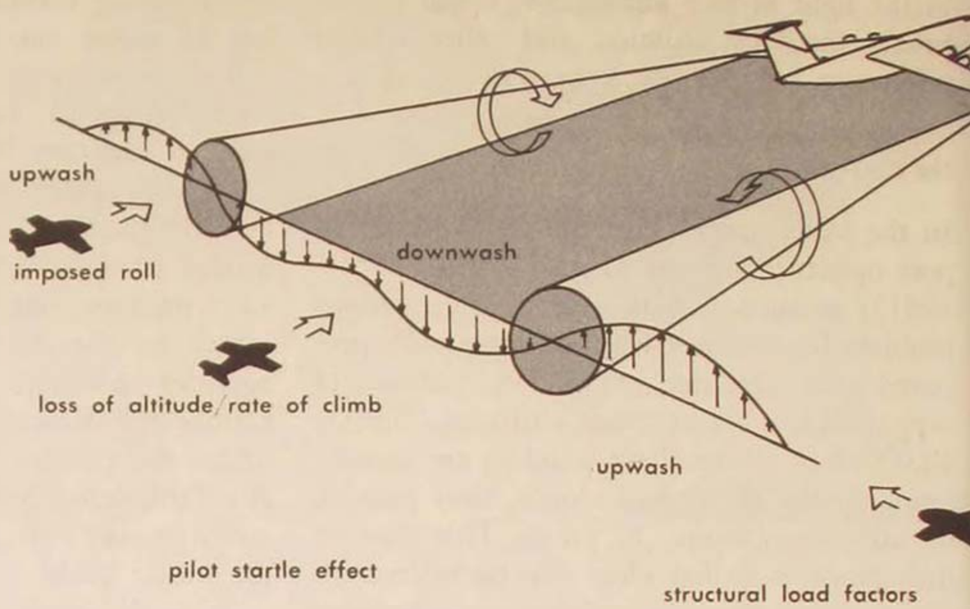
CAT versus aircraft wake turbulence

Both CAT and aircraft wake turbulence can cause loss of control of encountering aircraft. Both frequently occur in clear air, without warning.

Many reported brief CAT incidents may actually have been penetrations of wake turbulence, and airborne instrumentation concepts for detecting CAT remotely are also being applied to wake turbulence detection.

Major dissimilarities also exist between the two phenomena. CAT occurs naturally, and usually in preferred locations (i.e., over mountainous country and near the jet stream), and at preferred heights (i.e., near the tropopause and in regions of high-altitude wind shear). Aircraft wake turbulence is a man-made atmospheric disturbance found behind all aircraft in flight, wherever they may be. Severe CAT can toss very large aircraft around quite handily (witness the 747 incident over Nan-

Figure 1. Hazard potentials of trailing vortices (source: NASA)



tucket) while wake turbulence in its most severe form is a threat principally to medium-sized (DC-9, 737) and small aircraft. This does not mean that larger aircraft are unaffected by wake turbulence. The threat is simply less obvious.

A typical aircraft wake occupies a much smaller volume of the sky than that occupied by a typical "patch" of CAT, which can extend for hundreds of miles and be 2000 to 3000 feet thick. The wake also tends to dissipate more rapidly than the CAT. However, more extensive and more persistent volumes of wake turbulence may be expected under busy air lanes. Also, wake turbulence can hover over runways, where aircraft are most vulnerable to unexpected loss of altitude or control. The combination of poor visibility and a wake encounter during landing operations is especially dangerous.

the trailing vortex

Aircraft wake turbulence is not only a mark of the jumbo jet era, it is to some degree a product of it since the most dangerous atmospheric disturbances of this type are those associated with the trailing vortex wakes of the jumbo jets.* When multiple, regularly spaced vortices emanate from a source, the rings combine to form a spiral or helix (e.g., curling cigarette smoke).[3] This is essentially what happens at or near the wingtips of an aircraft in flight. Aircraft vortex wakes are, in effect, two parallel, rapidly rotating, spiral "tubes" of air, up to 35 feet in diameter, trailing downstream. (Figure 1) Although less severe than natural tornadoes, they exhibit a tornado-like drop of pressure in their cores. They are called "streamwise," "trailing," or "wingtip" vortices or, more simply, aircraft wake turbulence.

At cruise altitudes, they extend 10 to 40 miles behind the generating aircraft. They are frequently visible against a blue sky when, under proper conditions of air saturation, the familiar condensation trails produced by engine exhaust persist and are entrained in the vortex tubes—another example of flow visualization. (The reader is invited to verify this phenomenon by skywatching.)

Are aircraft wakes really turbulent?

One might question the use of the word

* A vortex is a parcel of air in circular motion. A common example is the cigarette smoke ring; the smoke enables one to see the air in motion. It also typifies the kind of flow visualization on which research in fluid dynamics depends heavily.

"turbulence" when discussing vortex wakes. By definition, turbulence is an irregular velocity fluctuation imposed on the mean airflow. It is made up of extremely variable eddies of a wide range of sizes and directions (e.g., the wide and violent fluctuations of surface winds observable on a gusty day). CAT is believed to have this random distribution of eddy sizes and directions despite its origin in organized natural wave and vortex motions of the atmosphere.

Aircraft vortex wakes, on the other hand, have a highly organized circular flow, a relatively stable geometry, and tangential velocities which remain constant for long periods of time. They are most dangerous during their organized stage. When they degenerate into random turbulence, they lack the power to cause serious upsets to following aircraft. The use of the word "turbulence" is justifiable, nonetheless, in that an aircraft crossing the vortices experiences buffeting characteristic of turbulence encounters.

early investigations of trailing vortices

Aircraft vortex wakes were known long before the advent of jet aircraft and the discovery of CAT. Early (1900–1930) aeronautical experimenters (Lanchester, Prandtl, Von Kármán) postulated or demonstrated the presence of wingtip vortices—findings that have been updated in subsequent studies. As aerodynamic shapes have become more sophisticated, vortices have been used not only to explain the dissipation of lift and drag energy but also as actual sources of lift and control. In the T-tail aircraft, vortex management prevents deep stalls. The highly swept wing of the supersonic transport (SST) relies on vortex-generated lift for safe handling qualities at low speed.[4]

In general, the effect of the vortex on the generating aircraft seems to have been stressed rather than the hazards to other aircraft. Investigators from NASA (Kraft, McGowan, Wetmore) and from the Royal Aircraft Establishment (Squire, Dee, Fose, Kerr), among others, published explicit, experimentally supported warnings on vortex hazards in the 1955–1964 time period; but these warnings, like the early CAT warnings, appear to have been largely unheeded.

the mounting evidence

Inevitably, vortex wakes were recognized as more than just interesting and sometimes useful phenomena, particularly after reports of upsets to light planes operating near the larger first-generation jets (e.g., Boeing 707, B-52). A multiple-fatality takeoff accident to a commuter aircraft at New York's Kennedy Airport in 1969 is typical. The loss of control was blamed on the residual wake of a 707. The National Transportation Safety Board has records of at least 98 wake-caused accidents in the past five years, with numerous fatalities.

action at last

There is a strong correlation between the weight of an aircraft and the strength of its vortices. With growing concern over hazardous wakes from the 300,000-pound first-generation jet transports, aviation was finally forced—in 1969—to examine the implications of wakes from the 700,000-pound C-5 and 747 aircraft.

Preliminary calculations showed the 747 and C-5, as well as the heavier versions of the earlier DC-8 and 707 (and their Russian and British equivalents), to have powerful wakes indeed. Early in 1970 the Federal Aviation Administration (FAA) and the Air Force imposed rigid separation distances (10 miles, later reduced to 5 for FAA-controlled operations) between aircraft weighing more than 300,000 pounds and following lighter aircraft, distances which many felt to be too conservative. (Previous separation distance had been 3 miles.) By reducing the number of aircraft movements per hour, this regulation has added to airfield congestion. With more jumbo jets entering service, theorists and experimenters have been working overtime to establish the true characteristics of the wakes of these planes, with emphasis on *measured* vortex diameters, tangential velocities, decay times, and horizontal and vertical transport. To appreciate their findings, one must delve a little into existing wake turbulence theory.

aircraft wake turbulence as a product of lift

Many people think of aircraft wakes in terms of "prop wash" or jet engine exhaust. The in-flight turbulence associated with the power plants is actually short-lived. The principal cause of the trailing vortices which constitute the wakes is the lift generated by wing surfaces. As proof of this, wake turbulence is present behind unpowered aircraft and even birds in flight. Geese are believed to adjust their positions in formation flight instinctively to achieve maximum lift from the vortex wakes generated by their mates, the energy saved permitting longer-range flight. (Presumably, the birds take turns in the lead position.) Helicopter pilots in Southeast Asia (SEA) refueling operations are reported to be using the wakes of tanker aircraft to decrease rotor workloads during hookup, an obvious range-extending maneuver. (Helicopters themselves generate powerful [and dangerous] vortex wakes which have been useful in fog-clearing operations in SEA, a technique tested at the Army's Cold Region Research and Engineering Laboratory and developed at AFCRL.)[5]

vortex theory

As aircraft vortex generation involves aerodynamic theories not generally familiar, a brief discussion may be of interest.

The key word in this discussion is "circulation," the concentric airflow about a body, such as that around a cylinder. Our smoke ring is an example of this circular air motion; a spinning golf ball has circulation. When airflow *past* a body is added to the circular airflow *about* the body, lift at right angles to the airflow past the body is the result. In the case of the golf ball, it could mean a long drive, a hook, or a slice, depending upon the direction of the propulsive force.

Aircraft wings have circulation about them. When the flow past the wing (produced by the forward motion of the aircraft) is added to the circulation about the wing, lift is produced. As the lift increases, there must be a corresponding increase in circulation. This has an important bearing on the strength of the spinning vortex tubes trailing from the wingtips. Their circulations are essentially the circulations "spilled" from the wing, and their tangential velocities (i.e., peripheral speeds) are directly proportional to those circulations. In other words, the larger its circulation, the greater the force a trailing vortex can impose on an encountering object, such as the wing of a following aircraft. If the ability of the following aircraft to overcome the suddenly imposed load is exceeded, loss of control (often fatal at low altitudes) will occur.

The magnitude of the circulation depends on a number of variables. It increases or decreases depending on which of the variables is changed or held constant. Thus, in discussing vortex strength, one must know how heavy the aircraft is, at what altitude and speed it is flying, and what its wingspan is. (In this paragraph and the next, let us assume a constant wingspan.) Since lift can be equated with aircraft weight, increased weight requires increased circulation. One can expect very strong updrafts, downdrafts, and lateral wind components, therefore, in the wake of a heavy aircraft.

For a given aircraft weight, circulation will vary with changes in air density and in aircraft velocities. The low, slow "dirty configuration" (i.e., flaps down) period of flight is usually considered the time of maximum vortex production. At cruise altitudes and high cruise speeds, the increase in aircraft velocity (reduced circulation) more than cancels out the effect of reduced air density (increased circulation). There are reduced cruise speed conditions, however, when the vortices at altitude can be as severe as those near the ground—conditions common to military missions (e.g., refueling and formation flights) where maximum cruise efficiency is not realizable. (The high-velocity filament described later is a further complication.)

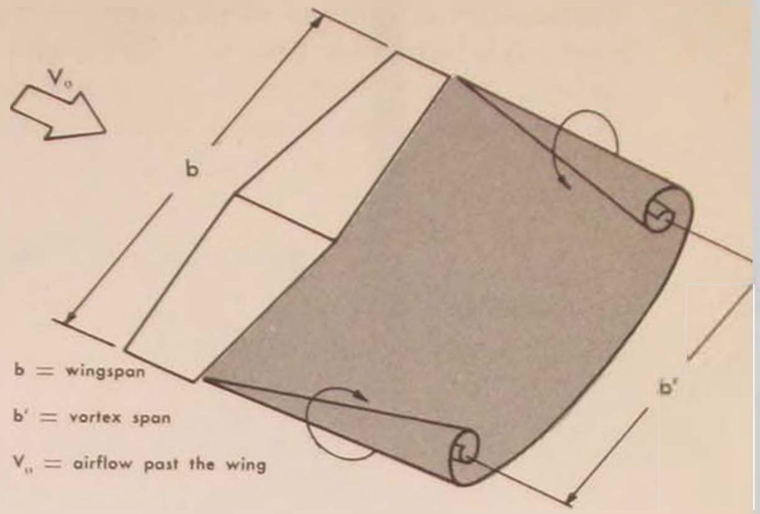
the importance of attitude and of aspect ratio

Aircraft turning motions and changes in attitude (e.g., increased climb rate) will also cause variations in vortex strength (discussed further under vortex alleviation methods). In addition, circulation will increase if the wingspan is decreased. This means that heavy aircraft of low aspect ratio, i.e., with very short wingspans such as the highly swept SST, will have very large circulations and high vortex tangential velocities. With high aspect ratio (long span) wings, added lift is possible without increased circulation.

the vortex sheet and roll-up

Aerodynamicists have developed a vortex model that features a thin vortex "sheet" flowing from the trailing edges of the wing. The sheet undergoes a rolling-up process at some distance behind the wing. (Figure 2) The roll-up is aided by the pressure differential between the bottom and upper surfaces of the wing, which imparts a characteristic rotational movement to the airflow at each wingtip (clockwise at the left wingtip, viewed from the rear of the aircraft, and counterclockwise at the right wingtip). The resultant mutual interaction between the two rolled-up vortices causes them to sink below the aircraft—a very important consideration in wake turbulence avoidance and dissipation determinations.

Figure 2. Vortex sheet roll-up process (after Spreiter and Sacks)



A photograph taken during an early AFCRL cloud-seeding operation graphically illustrates the trailing vortex formation with cloud tops serving as the flow visualization agent.

Photography can show engine exhaust smoke being caught up in the vortex wrap-up process of a landing C-5. Here the exhaust serves not only as a flow visualization agent but also as a vortex locator. There is evidence that the exhaust of T-tail aircraft with aft-mounted engines (unlike the C-5's wing-mounted engines) is not caught up in the vortices, in which event the smoke would not help to locate the vortices. (The 747's exhaust is "clean" and offers no clue at all.)

the vortex radius

In 1950 Spreiter and Sacks of Ames Aeronautical Laboratory of the National Aeronautics and Space Administration (NASA) helped to bridge the gap between the pioneering work of the Prandtl school in Germany (based for the most part on straight, high aspect ratio wings) and the need for data on the new swept, low aspect ratio wings. They showed that wing geometry greatly in-

Wingtip vortices formed aft of a B-17 flying above cloud deck (left) . . . The engine exhaust of a C-5 when landing is entrained in the vortex (below).

fluences vortex roll-up time.[6] With delta wings, for example, the roll-up is extremely rapid (within a chord length or less of the trailing edge and well within the tail region). Using certain energy cutoff assumptions, they also postulated that the core radius of each rolled-up vortex (i.e., the distance from the center of the core to the region of maximum tangential velocity) is approximately one-tenth the distance between the two vortices. This relationship allows us to estimate how completely a specific following aircraft will be enveloped by a particular trailing vortex. The Spreiter and Sacks theories were used extensively in vortex strength calculations released in the past year or two.

Typical is the accompanying Air Weather Service table.[7] It shows that an aircraft with a 32-foot wingspan would be completely captured by the vortex of a 747 if it were to fly into the vortex endwise. It would experience induced roll rates far beyond its capacity to control them. Larger aircraft would be affected in proportion to their size. (In Boeing tests, a 737 was rolled 30° in a hair-raising encounter with a 747's wake 100 feet above the ground.) Transverse crossings of the 747 wake by other aircraft would subject them to severe updrafts and downdrafts in rapid succession, with possible structural damage. (Figure 1) Flight between the vortices would place the following aircraft in the downwash region and seriously degrade its rate-of-climb performance. The table shows that wakes from other large aircraft are dangerous too, depending on the size and performance of the encountering aircraft.

Approximate Parameters and Wake Values for Selected Aircraft

Aircraft	Max Gross Weight (w) lb	Span (b) ft	Airspeed (V) ft/sec	Vortex Spacing (b′) ft	Vortex Sink Rate (w) ft/min	Vortex Radius (r) ft	Max Vertical Velocity (less w) (V_r) ft/min
Convair (C–131)	46,000	92	237	72	162	7	1800
Boeing 727	169,000	108	272	86	372	9	4100
Boeing 707	328,000	145	300	115	366	12	4000
Boeing 747	710,000	196	300	155	432	16	4700
C–5	750,000	222	290	175	354	18	3900
Concorde	385,000	84	338	67	1120	7	12900
Boeing 2707	750,000	143	338	112	760	11	8500

another look at the crisis

At this point the reader may ask: "Why the crisis, if trailing vortices have been known almost since the beginning of flight and if established theories explain their relationship to other flight parameters?" The crisis derives from the unavoidable commingling of aircraft of all sizes in the same airspace. To date, segregation by size at airfields and in the airlanes has been very difficult to implement, and conditions have become increasingly intolerable for smaller aircraft. The first sweptwing jet transports and bombers accelerated the trend; the jumbo jets have sharply increased the peril.

To appreciate the aircraft wake problem, one has only to compare it with the corresponding problem in boating, which also has greatly increased in volume and variety of traffic. Small, unpowered or lightly powered watercraft must frequently share the same river, lake, or harbor with high-powered cruisers and outboards. With boats, safe coexistence can be assured through simple speed control. With aircraft, the problem is more difficult, on several counts. Not only are aircraft wakes usually invisible; their effects can be so catastrophic that little margin for error is possible. Reducing a boat's speed automatically minimizes its wake generation, since the momentum imparted to the water thrust behind by the boat is proportional to the square of the boat's speed. With aircraft, the opposite is true. Circulation and wake turbulence increase when aircraft velocity is decreased; the hazard to other aircraft landing or taking off is actually greatest when it should be least. The flight-no-flight transition zone is too sensitive to be subjected to such large unexpected upsetting forces. This is especially true of STOL and VTOL aircraft where forward velocity is at a minimum and critical dependence is placed on high lift devices.

the needs identified

To those responsible for the safe coexistence of various sizes of aircraft in the terminal area, the minute-to-minute location of destructive vortices is of vital concern. Unless they are positive that vortices from a previous large aircraft movement have drifted out of the path of a following lighter aircraft, they must impose large time and distance separations. An alternate possibility is to have lighter aircraft take off "short," so that their flight path is consistently above the trajectory of the sinking vortices from a preceding heavy aircraft, or to land "long," which achieves the same result.[8] This method does not cover all situations, however.

With respect to terminal area operations, a primary goal is to develop methods of predicting vortex presence, movement, and decay under various traffic and environmental conditions. A longer-range goal is to develop instrumentation that will actually detect and track the vortices. A third goal is the alleviation of the problem by vortex destruction or dissipation techniques.

The problem is somewhat easier at jet cruise altitudes. Most planes that fly at these levels are not endangered by wake encounters, although all are affected to some degree. Small, short-span fighters and executive jet transports pose a special problem. They are upset easily by a strong wake, as was graphically demonstrated when a small NASA transport was probing the wake of a C-5 and rolled through 180° against the pilot's input. (Complete capture is relatively infrequent in such tests, as the wake tends to cast aside the would-be penetrator.)

At cruise altitudes, small jet aircraft should stay above the long-lived vortices of larger ones. In the event of an unexpected encounter, altitude is a saving factor and should allow recovery. Unfortunately, this was not the case in the 1966 B-70 accident at Edwards AFB in which a closely following chase aircraft was suspected to have been rolled over by the B-70 vortex wake, and both aircraft were destroyed.

vortex decay

When aircraft weight is transferred from wheels to wings during takeoff, lift is generated, and the concomitant circulation initiates trailing vortex formation, a process that ceases only on landing. What happens to the vortices is of concern now.

Cruise altitude vortices usually level off at about 1000 feet below the altitude of the aircraft as their density comes into equilibrium with that of the surrounding air. Decay processes then take over. Two commonly mentioned decay mechanisms are the mixing action of eddy viscosity and the interaction of the vortices with each other. The eddy viscosity mechanism is relatively slow and is marked by many unknowns, particularly the value of the eddy viscosity coefficient. The interaction mechanism is based on instability modes in the vortices, which propagate sinusoidal waves through the wake, bringing the two vortices in contact with each other periodically and causing them to break into vortex rings. (This occurrence can be seen in the sky when condensation trails are present.) Crow of Boeing believes that these rings quickly disintegrate into chaotic and harmless turbulence.[9] Others see the rings as still quite dangerous. Crow also suggests that the vortices of the 747 (about 1.8 times as powerful as those of the 707) should break up faster than 707 vortices. He reasons that the instability propagates much more rapidly in vortices of higher intensity.

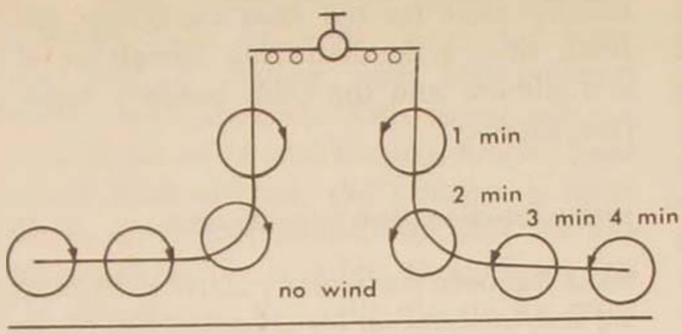
Neither the triggering mechanism nor the ideal instability wavelength for vortex breakup is known. A wavelength of 5 to 10 wingspans has been suggested. MacCready has proposed mechanical excitation of the proper wavelength.[10] Atmospheric turbulence and stability also play an important but not completely understood part in the decay of the vortex wakes.

Vortices generated below about 1500 feet usually sink to just above the ground, 50 to 100 feet. Their speed of descent varies with the type of aircraft and with the local atmospheric conditions. A figure of 450 feet per minute is typical of large sweptwing jet transports. As the vortices approach the ground, they spread apart and move sideways, at right angles to the runway, at the same 450 feet per minute, roughly 5 miles per hour. An opposing surface wind of 5 miles per hour will block horizontal movement of one vortex while doubling the movement of the other, transporting it perhaps to a runway intersection or to a parallel runway. (Figures 3 and 4) The time to disappearance of the vortices depends on the degree of low-level turbulence present, on mutual interaction, and on a number of other factors. No-wind days usually make for the most dangerous conditions, since wake-destroying turbulence is at a minimum and the calm instills a sense of complacency.

vortex detection, high-intensity cores

NASA has been particularly active in investigating instrumentation for detecting the presence and movement of vortices near runways. This work involves the use of a CO_2 Doppler laser velocity-measuring system adapted from a CAT detection system. A high-intensity, small-radius vortex jet or filament (accompanying photos), which is noted in NASA field experiments with the CO_2 laser and a collocated smoke generator, suggests a more complicated vortex picture than covered by the Spreiter and Sacks theories. These filaments (also noted by the FAA and the Australian Department of Civil Aviation) were generated by low-flying test aircraft in the "clean" (i.e., wheels up, flaps up) configuration. (In actual operations, this configuration is partially achieved in a "go-around" situation when a landing is aborted.) The filament seems common, even at high flap settings, to T-tail aircraft with aft-mounted engines (DC-9, 727), the clean wings apparently permitting tighter vortex wrap-ups. The FAA has recorded on film both the persistence of the filament and its propensity towards sudden destruction. It can be seen to whip around in the sky and then suddenly burst when it touches the smoke tower. It frequently displays a very strong axial component, probably the result of smoke being entrained in the core's intense vacuum. Acoustic verification of the filaments has also been reported by FAA personnel, who talked of "walking" the filament across the test zone by listening for the disturbed air sound.

This evidence of filament vortices was one of the highlights of the Seattle symposium. It helped to explain flight tests reported by the FAA, by NRC (Canada), NASA, and AFFDL, in which tangential velocities higher than



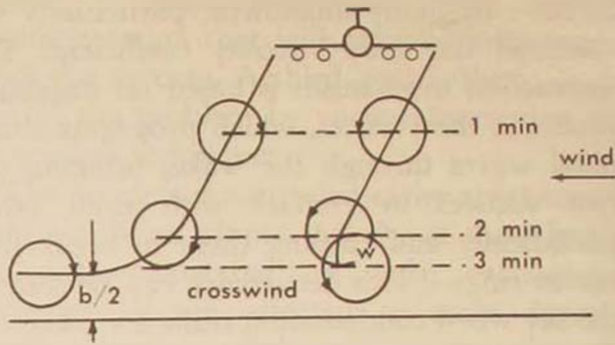


Figure 3 (left) illustrates vortex movement near the ground with no wind, and Figure 4 (right) shows vortex movement near the ground with a crosswind (after W. A. McGowan).

predicted by theory were encountered. The evidence also made it clear that much remains to be learned about the trailing vortex, especially in connection with modern aircraft. The Spreiter and Sacks theory, which places the highest tangential velocities at a core radius equal to one-tenth the vortex span, apparently correlates best with wakes generated by aircraft in the "dirty" configuration, such as at landing. Where the filament is present, tangential velocities at least twice as high as predicted have been encountered, and the vortex filament radius is only about one-third the expected value for the core radius. There is evidence also that even when the filament is present there is an induced vortex (external to the filament) whose radius and tangential velocities are in accord with the older theory. Experiments by McCormick, *et al.*,[11] who use a different energy cutoff value than Spreiter and Sacks, correlate better with the filament phenomenon.

vortex alleviation

Several vortex "alleviation" (breakup) mechanisms or techniques were discussed at Seattle. One suggestion was a porpoising of the aircraft during landing and taking off. Changes in angle of attack would presumably alter circulation, introducing periodic instabilities

Both photographs (courtesy of NASA) illustrate C-47 vortex visualization.

in the vortices. Passenger discomfort ruled out this idea. Another suggestion, which would use somewhat the same technique, involved an adaptation of the Load Alleviation and Mode Stabilization (LAMS) system, in which automatically induced symmetrical oscillatory movements of the aircraft wing control surfaces would introduce perturbations in the vortices without disturbing the passengers. (The usefulness of LAMS in alleviating structural loading and possible upset tendencies in vortex encounters was also discussed, although the application seems practical only for large aircraft.) A third proposal featured vortex alleviators on the wings of the generating aircraft—essentially flat plates lifted into the airstream. NASA-Ames is currently working on this technique, but results to date have been inconclusive. A suggested "brute force" elimination of vortices near a runway via a gigantic suction system was felt to be impractical.

SIMILARITIES between the current aircraft wake turbulence crisis and the earlier clear air turbulence have been pointed out. It has also been shown that the problem of aircraft wake turbulence has been growing over the years as a result of the tremendous quantitative increases in vortex strengths that have come with low aspect ratio heavy aircraft. The need to operate various sizes and kinds of aircraft at the same airfield at the same time is shown to be the crux of the problem.

Flight tests have demonstrated that vortex cores and tangential velocities are frequently different from those predicted from theory. This is especially true of aircraft in the "clean" configuration and of T-tail aircraft with aft-mounted engines. The need for additional knowledge and the search for methods of assuring peaceful coexistence were summed up at the 1970 Symposium on Aircraft Wake Turbulence.

Conservative separations, in time and in distance, between the large aircraft and the aircraft small enough to be affected by wake turbulence will be in order for some time. The peculiar requirements of military operations, which tend to maximize vortex production at times, will dictate against use of the same separation criteria for civilian and military flights. The use of smoke trails to mark the presence of wake vortices has some merit for daytime use but probably would not be allowed in today's world of antipollution pressures. A vortex-detection system, capable of identifying minute-to-minute conditions in the vicinity of an airfield, will be developed and should become standard equipment at major airfields within the next decade. Vortex alleviation methods may eventually bring about quick dissipation of wakes, but this cannot be predicted with certainty.

Air Force Cambridge Research Laboratories

Notes

1. The proceedings of the 1970 Aircraft Wake Turbulence Symposium are being published and will be available later this year. I must defer to that publication for a proper listing of papers given and their authors as well as for a more definitive treatment of the subject matter. In this article, it is impossible to give proper credit to individuals.

Another symposium on turbulence and CAT was held in Washington on 22–24 March 1971, with over a thousand people in attendance. Its findings did not differ significantly from those of the earlier one in Seattle.

2. References to the 707, 727, 737, and 747 are to Boeing commercial transports; DC-8 and DC-9 references are to McDonnell-Douglas commercial transports. Air Force equivalents, C-135 and C-9, may be substituted for 707 and DC-9 references.

3. B. Quinn, "Cigarettes, Vortices, and V/Stol," *Air Force Research Review*, July–August 1970.

4. P. M. Sforza, "Aircraft Vortices: Benign or Baleful?" *Space/Aeronautics*, April 1970, pp. 41 ff.

5. V. Plank, "Fog Modification by Use of Helicopters," AFCRL Report 70-0593, 23 October 1970.

6. J. R. Spreiter and A. H. Sacks, "The Rolling Up of the Trailing Vortex Sheet and Its Effect on the Downwash Behind Wings," *Journal of the Aeronautical Sciences*, January 1951, pp. 21–32.

7. D. N. Jones, "Introduction to Jet-Engine Exhaust and Trailing Vortex Wakes," *Technical Report 226*, Air Weather Service, April 1970.

8. W. A. McGowan, "Avoidance of Aircraft Trailing Vortex Hazards," NASA Report, October 1970.

9. S. C. Crow and J. H. Olsen, "The Duration of Trailing Vortices: 747 and 707," Boeing Company Flight Sciences Laboratory Technical Communication 008, October 1969.

10. P. B. MacCready, Jr., "An Assessment of Dominant Mechanisms in Vortex-Wake Decay," Aircraft Wake Turbulence Symposium, Seattle, Washington, 1–3 September 1970.

11. B. W. McCormick, J. L. Tangler, and H. E. Sherrieb, "Structure of Trailing Vortices," *Journal of Aircraft*, Vol. 5, No. 3 (May–June 1968), pp. 260–67.

SONIC BOOM AND THE SUPERSONIC TRANSPORT

MAJOR RICHARD M. ROBERDS

THE PLANNED production of a United States supersonic transport (SST) was intended as the next logical step in the evolution of space-age transportation. While there has not yet appeared to be a distinct military requirement for an SST, the Air Force nonetheless followed its progress with keen interest and anticipation. It was believed that, at minimum, spin-off from it would find valuable military application. Indeed, Dr. John S. Foster, Jr., Director of Defense Research and Engineering, seemed eminently right when he described the potential contribution of the supersonic transport to defense as "indirect but not insignificant" by "reinforcing the technological base upon which defense will be drawing for the development of military systems." [1]

As the SST operates supersonically over populated areas of the globe, a sonic boom may be created that is capable of destroying property and provoking substantial public opposition. This fact is especially critical in light of the current emphasis on environmental pollution. The sonic boom from the SST looms as a possibly serious intruder into the nation's justifiably deserved peace and quiet. The persistent lay question is simply whether the SST is worth the price of enduring its sonic boom.

Recent research has begun to shed some light on the problem. Notably, the Air Force has played a significant role in the experimental research toward an operational supersonic transport that will not be objectionable to society. To answer some of the questions concerning the impact on society of the sonic boom from the SST, the Federal Aviation Administration, in conjunction with the United States Air Force and several contracting firms, embarked on a series of sonic-boom measurement tests. These tests were the first major effort anywhere in the world to measure quantitatively the effects of the sonic boom on populated areas.

The test program was conducted at Oklahoma City from 3 February through 30 July 1964. The principal objective was to ascertain the public reaction to sonic booms of intensities on the order of 1.5 to 2.0 pounds per square foot (psf) peak overpressure. This was the predicted intensity of overpressure to be expected from an SST. Air Force B-58, F-101, F-104, and F-106 aircraft were used to generate the booms.

A second phase of the Oklahoma City area test was conducted to study specifically the effects on structures of varying sonic-boom intensities. This test series was performed at White Sands Missile Range in New Mexico from 18 November 1964 through 15 February 1965. B-58 and F-104 aircraft were employed, and sonic booms were generated of intensities up to 38 psf peak overpressure.

A third test series was carried out at Edwards AFB, California, from 3 June to 23 June 1966 and from 31 October 1966 to 17 January 1967. In this program the Air Force was designated the implementation agency and program manager, with technical assistance from the Stanford Research Institute. Again, the determination of human reaction and structural response to the sonic boom was a prime objective. Peak overpressures up to 3.0 psf were generated by F-104, SR-71, and XB-70 aircraft. Sonic-boom ground overpressure measurements for flights at altitudes in excess of 70,000 feet and at speeds up to Mach 3.0 were provided by the SR-71.

In addition to these flight research programs, data have been made available from public complaints and damage claims from operational flights of military aircraft where sonic booms have been generated of routine necessity. The SR-71 Category III testing from 1 July to 30 September 1967 is an example of such operational stimulation of public reaction.

Another research effort is presently being conducted in which operational flights of the SR-71 are being used to generate sonic booms for study. This program is being conducted by the Environmental Science Services Administration of the U.S. Department of Commerce in the Pendleton, Oregon, and Goldburg, Idaho, areas.

Other ongoing research programs continue to study the various aspects of sonic booms. Experimental and theoretical research at NASA's Langley and Ames research centers is being conducted on the feasibility of reducing or eliminating the sonic boom by modifying the shape of the airplane. This work may hold the eventual solution to the sonic-boom problem.

A consequence of these research efforts has been a substantial enhancement of understanding in three principal areas:

- Generation and propagation of the sonic boom
- Human behavioral response to the sonic boom
- Effects of the sonic boom on structures and structural material.

It is not coincidental that these areas are the ones that were outlined in 1964 by the National Academy of Sciences' Committee on SST-Sonic Boom as needing special study. While the gains made in each area have been extensive and certainly beyond the scope of a single article, it is interesting to review, if only in part, some of the fruits of the efforts.

Sonic-Boom Generation

An airplane traveling at supersonic speed is creating shock waves that will manifest themselves as a sonic boom *if* they reach the ground. The generation of the shock waves and their subsequent propagation through the atmosphere are well understood and substantiated by measurement. In fact, all the factors entering into the formation and final intensity of the boom can conveniently be placed in three categories: how the airplane is flown (flight conditions), atmospheric conditions, and airplane design. The fundamentals of each category are relatively simple.

flight conditions

An airplane that is creating a sonic boom will be flying at a particular altitude and Mach number and may or may not be maneuvering. These three flight conditions determine the magnitude of the sonic boom that is felt on the ground.

It is probably intuitive to the reader that as the altitude of the airplane increases, the sonic-boom intensity on the ground decreases. This is indeed the case; in fact, the altitude is the one single variable that has the greatest effect on sonic-boom reduction. The reason is twofold: the magnitude of the shock wave diminishes with the distance traveled, and the intensity of the shock wave as it is generated decreases with the decreasing air density.

The variation of boom intensity with flight Mach number is not as intuitive. The peak overpressure of the sonic boom increases slowly with aircraft speed up to about Mach 1.4. As velocity increases above this point, the accompanying decrease in aircraft angle of attack becomes the predominant factor, and the boom intensity begins to decrease slightly. For practical purposes, this decrease is insignificant, and the boom intensity above Mach 1.4 may be regarded as remaining constant.

If an airplane traveling at supersonic velocity maneuvers by turning, porpoising, or accelerating, the effect is to focus the sonic boom at points on the ground. The sonic booms so focused are known appropriately as superbooms. Recent French studies have indicated that magnification may be as high as five times under focusing conditions. Fortunately, such points encompass only 100 to 200 feet.

atmospheric conditions

Sonic-boom measurement tests have revealed variation in recorded peak overpressures from a single aircraft flying at constant speed and altitude. These variations are attributed to nonuniformities in the atmosphere. Clouds,

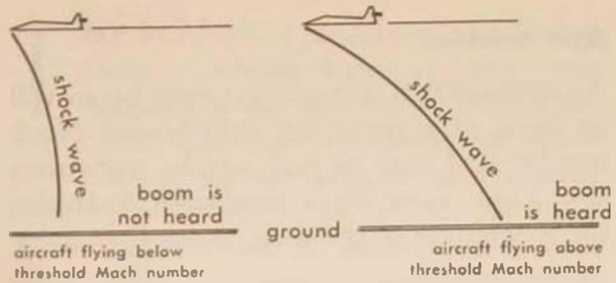


Figure 1. Threshold Mach number. Even when flying at supersonic speeds, an aircraft will not boom the ground if its speed is below the threshold Mach number.

turbulence, wind, and sharp temperature inversions are inhomogeneities in the atmosphere that alter the intensity of the sonic boom. Such atmospheric perturbations rarely cause a variation of more than 0.3 psf, however, and can be neglected in analyses of boom effects on communities.

An important phenomenon in the atmosphere that cannot be neglected is the refractive effect of the normal atmospheric temperature change on the shock-wave front. Since the speed of sound increases with increases in air temperature, as the shock-wave front nears the earth and enters warmer air, it bends forward. If the airplane is not moving at too high a supersonic speed (the shock front is not swept back too far), this refraction may cause the direction of travel of the shock front to become parallel with the ground. Under this condition, the sonic boom will not reach the ground and will not be heard. This phenomenon gives rise to the threshold Mach number effect. (Figure 1) The threshold Mach number is a speed above which an airplane must be flying for its boom to be felt on the ground. Under standard atmospheric conditions, the threshold Mach number for an airplane above 35,000 feet is around Mach 1.2.

The effect of temperature refraction acts on the sonic boom in another important way. It limits the area of ground that is exposed to the boom in the lateral direction (perpendicular to the airplane flight path). The term "lateral cutoff point" is used to describe the lateral distance from the flight path where the shock front has been refracted to move parallel with the ground. This, of course, is the border of the sonic-boom path. The boom path, or "bang zone," will grow wider as aircraft altitude and Mach number increase. For an SST flying at 65,000 feet, the boom path will be 65 miles wide.

airplane design

The third general area under which the variables that affect the intensity of the sonic boom can be grouped is that of airplane design. Within this category fall such variables as aircraft weight, length, and what are known as design parameters. "Design parameters" means the details of the shape of an airplane.

The weight of the airplane has a very simple relationship to the intensity of the sonic boom generated. The sonic-boom peak overpressure varies directly with weight. The maximum takeoff weight of the American SST was expected to be around 750,000 pounds, more than twice the original design objective of 350,000 pounds prescribed in 1963. At this heavy weight, difficulty would certainly be expected from the overpressures generated if it were the only design consideration.

A factor that tends to affect the peak overpressure is the length of the aircraft: the longer the airplane, the less intense is the sonic boom. The length of the projected Boeing 2707 SST was 298 feet, a length which would have offset, somewhat, the intensity of the sonic boom generated. However, the longer aircraft are also the heavier aircraft so that, in general, larger airplanes generate larger booms.

A problem on which a significant amount of effort is currently being expended is that of determining how airplane design parameters affect the size of the boom. It has turned out to be one of the most difficult aspects of the sonic-boom problem, almost on a scale with determining how people will react to the boom. Yet it is a tremendously significant area in which a breakthrough may mean a solution to the entire boom problem.

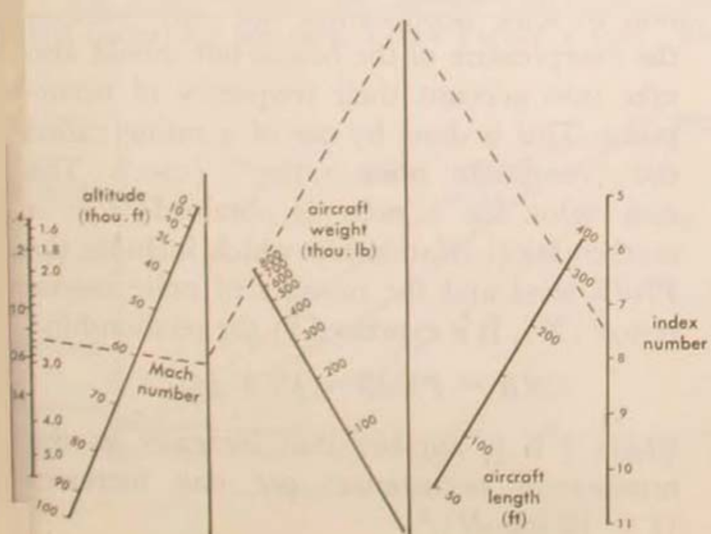
Each of the variables that is known to affect the creation of a sonic boom can be mathematically represented and combined into an equation. This allows for the calculation of the peak overpressure of a sonic boom produced by an aircraft of varying size, shape, and weight under different flight conditions. Such theoretical determination of sonic-boom intensity has been developed to a high degree of dependability.

From a nomograph presented by John H. Wiggins, Jr., in his book *Effects of Sonic Boom*,[2] I have constructed a nomograph depicting determination of overpressure. (Figures 2a and 2b) This nomograph is a product of present-day theory on the generation and propagation of the sonic boom. It can be used for reliable peak overpressure determination for the supersonic transport under varying flight conditions and weight. For illustrative purposes, a determination has been presented for an SST weighing 750,000 pounds and flying at 60,000 feet at Mach 2.7. The length of the SST was taken as 300 feet. As can be seen, the nominal peak overpressure under these conditions is 1.9 psf.

The other two areas where understanding has increased as a product of sonic-boom research are (1) human behavioral reaction to the sonic boom as it interrupts ordinary living activities and (2) damage to property from the sonic boom. Investigation within these two areas has been pointed toward answering one question: What level of sonic-boom intensity will be acceptable to society, considering both noise annoyance and boom damage?

On the basis of the data gained from the sonic-boom measurement tests, the permissible level of sonic-boom intensity may now be known. However, the maximum intensity level short of property damage is not necessarily

Figure 2a. Determination of nominal peak overpressure



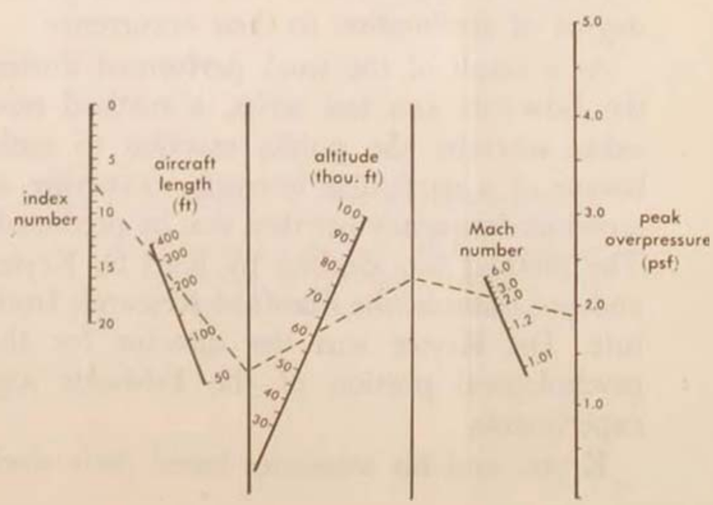


Figure 2b. Continued measurement of peak overpressure

the level that is acceptable to the public. Each area must be considered independently.

Human Behavioral Response

The most difficult part of the sonic-boom problem associated with the supersonic transport is determining how people will react to the boom. The variables in the problem are practically infinite in number and particularly elusive to measurement. The problem was stated in 1963 by Headquarters USAF:

> . . . the effect that sonic booms will have on the general public remains an open question . . . Early work has served mainly to point out the extreme complexity of the problem. Not only must the magnitude of the sonic boom be considered, but also the complaint potential of the community being studied. It has been found that community tolerance depends on such factors as an awareness of what causes the booms, people's feelings toward the Air Force and aircraft industry in general, neighborhood pride, and the presence or absence of other community problems.[3]

The Oklahoma City area tests revealed that other factors should be added to those cited above. The daily number of booms to which a community is subjected is an important consideration in determining how people will react to the sonic boom. Another factor to weigh is that a community with a history of exposure to sonic booms will tend to gain a degree of acclimation to their occurrence.

As a result of the work performed during the Edwards AFB test series, a method now exists whereby the public reaction to sonic booms of a particular intensity, occurring at a certain frequency per day, can be predicted. The method was devised by Karl D. Kryter and associates at the Stanford Research Institute. Dr. Kryter was the director for the psychological portion of the Edwards AFB experiments.

Kryter and his associates based their work on the "perceived noise decibel" (PNdB) of a sonic boom. The PNdB is a rating applied to aircraft noise that describes its annoyance or unacceptability. It is necessarily a subjective rating, for what may be extremely irritating to one person may not be so disturbing to another. An increase of ten PNdB is normally equivalent to doubling the "noisiness" of a sound.

Kryter established his PNdB levels from the subjective ratings by individuals of the noise from subsonic jet aircraft (KC-135) flying overhead at varying altitudes and engine power settings. This provided a good base to which sonic booms could be compared, since public reaction to subsonic aircraft noise is fairly well known. At Edwards, test subjects rated the acceptability of the noise from sonic booms of varying intensity against subsonic engine noise of known PNdB level. Kryter was thus able to correlate the noise from sonic booms with specific PNdB values. The results from this correlation are shown in Figure 3.[4]

The lower boundary of the affected zone in Figure 3 represents the noise rating assigned to sonic-boom overpressures by a community that had been acclimated to sonic booms. The upper boundary represents the reaction of a community that had had infrequent previous exposure to sonic booms.

An accurate prediction of the public reaction to sonic booms must not only consider the overpressure of the booms but should also take into account their frequency of occurrence. This is done by use of a rating called the "composite noise rating" (CNR). The CNR value for a noise is obtained from a mathematical relationship which includes the PNdB level and the number of noise occurrences (N). It is expressed by the relationship:

$$CNR = PNdB - 12 + f$$

where f is a number that increases as the number of occurrences per day increases ($f = 10 \log_{10} N$).[5]

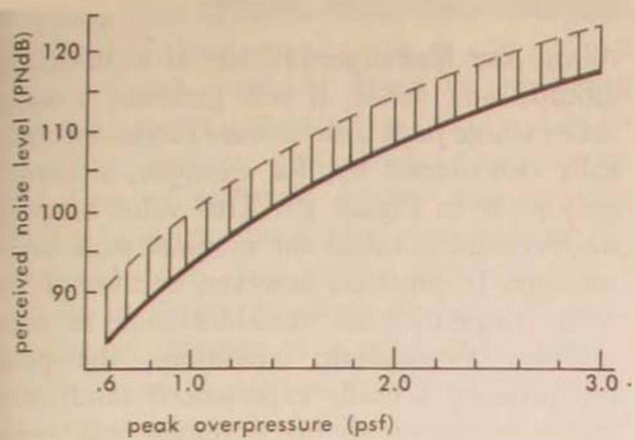


Figure 3. Perceived noise levels of sonic boom nominal peak overpressure

Several studies have been made of the acceptability of subsonic jet noise, and the public reaction has been fairly well determined. The results of these studies are presented in Figure 4,[6] which depicts the public reaction for a particular CNR value. The range of reactions depicted is to be expected, since each community's reaction depends upon its particular complaint potential.

Since PNdB values have been assigned to sonic-boom overpressures by Kryter, *et al.*, from the Edwards AFB experiments, a method is complete whereby public reaction to sonic-boom exposure can be predicted. From Figure 3 the PNdB can be obtained that corresponds to the average peak overpressure of a series of sonic booms. A CNR value can be calculated from the PNdB value and number of sonic booms occurring per day. From Figure 4 the CNR value can be converted to a range of public reactions; to determine which reaction within that range should be chosen, such factors as community motivation toward aviation and people's feelings toward the activity creating the sonic booms should be weighed. The center line of the figure represents an average community.

Damage to Property

Recorded incidents of damage attributed to sonic forces are not new to history. In fact, the first recorded occurrence took place thousands of years ago at the ancient Palestinian city of Jericho. The event was the Battle of Jericho, where, purportedly, Joshua, with a mighty blast of trumpets and shout of voices, tumbled the Jericho walls. However, a more recent investigation of the event by Major Tollack, chief engineer of the Allenby invasion of Palestine in World War I, suggested that the wall was not felled by the blast of horns and shouting. Major Tollack proposed that the wall fell because of the undermining of the foundation stones by tunneling operations while the defenders of Jericho were distracted by Joshua's horn blowing.[7] Such an explanation might seem more plausible than that originally claimed.

It is interesting that this event is strangely analogous to the present-day sonic-force problem—the boom from a supersonic airplane. For while there are many damage claims,

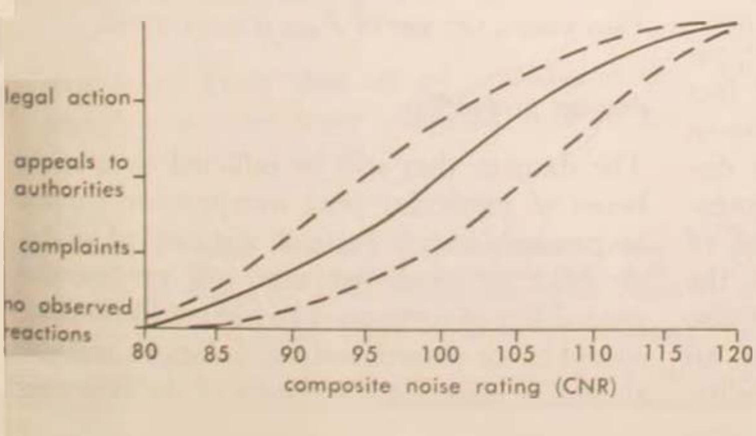


Figure 4. Relation between noise and corresponding community response. Dashed lines represent range of possible reaction; the solid line is estimated average.

purportedly due to sonic-boom forces, further investigation often reveals that other causes of the damage were more probable. Additionally, it is often military investigators who arrive at the correct explanation.

A major question posed by the advent of the supersonic transport concerns structural response to sonic booms: At what level of sonic-boom intensity can damage be expected? The answer to this question will not only aid in assessing legitimate sonic-boom damage claims; it will also serve to predict damage from the sonic boom of the anticipated SST.

The precise determination of the response of a structural element to a sonic boom is a good deal more complicated than just measuring the peak overpressure of the boom. The myriad of variables affecting the sonic boom as it is generated and propagated, plus the complexity of the response by a structure, make it difficult, if not impossible, to predict exactly the damage that will be caused by a particular supersonic overflight. To answer the question of damage expectancy, two further questions must be posed: Can the variation in boom intensity be predicted from what is known about the generation of the sonic boom? And is there some simple quantity, such as peak overpressure, to which a corresponding structural response can be predicted to an acceptable degree?

The book by Wiggins outlines a statistical method that circumvents the complexities of the problem and offers answers to these questions.[8] The many variables involved in determining both the maximum value of overpressure and the structural response cause them to behave like random variables. In fact it is reasonable to assume that the sonic-boom phenomena have a normal bell-shaped distribution, which renders the problem amenable to a statistical approach. The use of statistics provides a means to predict the variation in the sonic-boom intensity. It also allows the use of peak overpressure as an index for a corresponding damage probability.

variation in sonic-boom intensity

As the SST flies supersonically at a particular altitude and speed, it will generate a sonic boom whose peak overpressure can be theoretically determined by, for example, a nomograph (as in Figure 2). This value of peak overpressure is called the nominal peak overpressure. In practice, however, because of the many unpredictable variables such as non-uniform atmospheric conditions, the peak overpressure actually experienced rarely corresponds exactly to the nominal peak overpressure predicted by theory.

A meaningful analysis of the damage to be expected from a supersonic transport must include the higher levels of overpressure that often occur. The highest peak overpressure likely to occur when a nominal peak overpressure has been calculated is expressed by the equation:

$$P_{max} = P_{nom}\ (1 + NC_v)$$

where P_{max} is the highest likely peak overpressure, P_{nom} is the nominal peak overpressure, C_v is the coefficient of variation (C_v = .20 on a normal day), and N is the significance factor. (For $N = 2.3$, 99% of the time the peak overpressure will be at or below the P_{max}.)

It should be clear that use of the P_{max} in damage prediction will provide a conservative result, since this high value of peak overpressure will occur only rarely. However, since there is a reasonable probability of a peak overpressure occurring at or near the P_{max} value, the use of P_{max} is warranted.

damage probability

The damage that will be inflicted by a sonic boom of particular peak overpressure cannot be precisely stated. Instead, a statistical analysis must be employed that will predict the *probability* of damage. The highest likely peak overpressure determined by the above method should be used as the intensity of the boom.

Since glass is the material most susceptible to damage from sonic booms, it can serve as a convenient threshold index for predicting the sonic-boom intensity level that will begin to cause damage. Fortunately, glass damage data are of sufficient quality and quantity that a model for predicting glass damage can be constructed. Just such a representation is shown in Figure 5, which presents the probability of damage to a glass pane from a single boom of particular peak overpressure.[9] A probability of 1 means the pane is certain to break; a probability of 10^{-1} (or 1/10) means one pane out of ten will break, and so on.

At first sight, the curve in Figure 5 appears to be overly conservative. For instance, at 10 psf, which represents an unusually loud boom, there is only one chance in a thousand that a particular pane will break. Yet the probability of glass damage to one pane does not have to be very large to have one pane break when literally millions of panes are exposed to a certain overflight.

The sonic-boom intensity level at which damage begins to occur is not a fine, precise point. It can be taken as that boom intensity where glass breaks. But this intensity is a hazy range of values that depends upon the chosen probability of glass breakage. There is no problem here, however, since at the lower sonic-boom levels where community reaction is acceptable the probability of glass breakage is entirely negligible, even when millions of panes are considered.

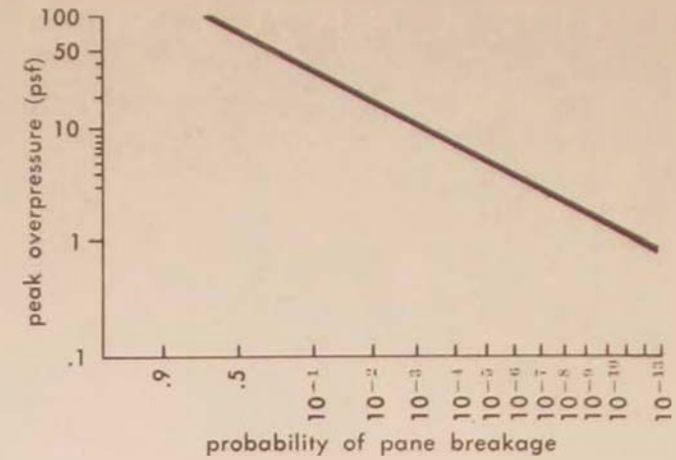


Figure 5. Probability of window pane breakage

We have seen that recent sonic-boom research programs have provided real strides toward the amelioration of an unfortunate problem: that an SST, with its many benefits, would also bring a formidable sonic boom, with its unpredictable social and economic consequences. The sonic-boom measurement programs have provided quantitative information for a better knowledge of the effect of the sonic boom on society. Indeed, because of light shed on the probable public reaction to the boom, the first-generation SST will most likely be restricted from supersonic flight except over the oceans.

The current acceptable level of sonic-boom magnitude has been reasonably well established. Advancing technology shows promise that the sonic boom can be reduced below the critical level and that a second-generation supersonic transport, unlimited in its operation, may lie in the future.

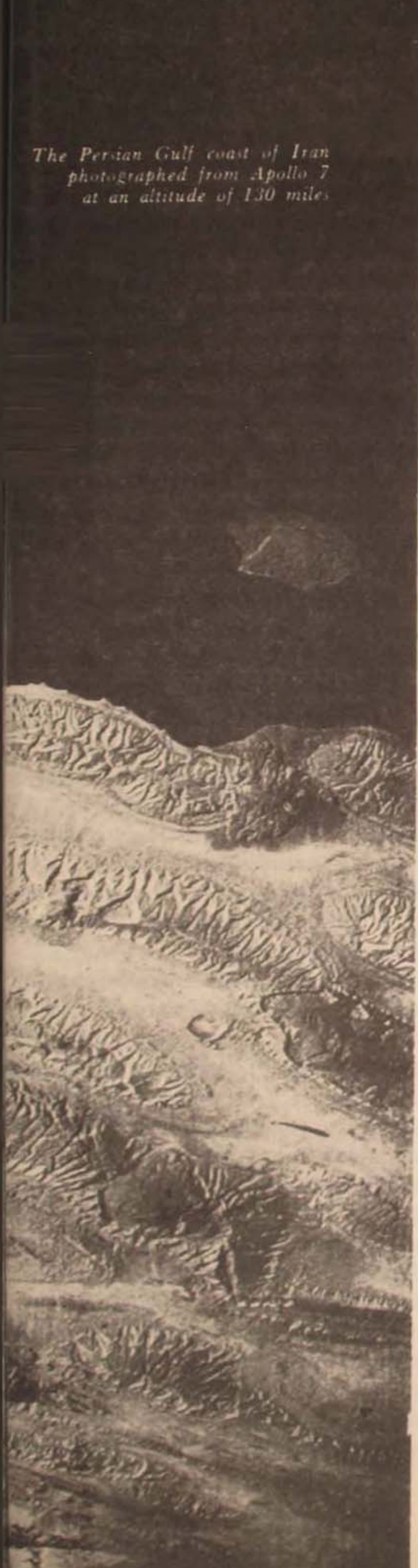
Air Command and Staff College

Notes

1. Edgar E. Ulsamer, "The SST Is Vital to the National Interest," *Air Force and Space Digest*, Vol. 53, No. 2 (February 1970), p. 52.
2. John H. Wiggins, Jr., *Effects of Sonic Boom* (Palos Verdes, California: J. H. Wiggins Company, 1969), pp. 14, 15.
3. *The Sonic Boom Problem*, Office of the Director of Development Planning, Hq USAF, March 1963, p. 26.
4. Figure 3 has been constructed from data presented in K. D. Kryter, P. J. Johnson, and J. R. Young, *Psychological Experiments on Sonic Booms Conducted at Edwards Air Force Base, Final Report* (Menlo Park, California: Stanford Research Institute, August 1968), p. 16.
5. Karl D. Kryter, "Sonic Booms and Supersonic Transport," *Science*, Vol. 163, No. 3865 (24 January 1969), p. 365.
6. *Ibid.* (Reproduced courtesy K. D. Kryter.)
7. Wiggins, p. 96.
8. *Ibid.*, pp. 133–36.
9. *Ibid.*, p. 87. (Reproduced courtesy J. H. Wiggins.)

THE UNIQUENESS OF THE EARTH

Dr. William G. Pollard



The Persian Gulf coast of Iran photographed from Apollo 7 at an altitude of 130 miles

ONE of the most significant general results of the space program of the United States has been the new perspective on our earth achieved for all mankind with the magnificent color pictures of the planet brought back from the Apollo missions. The dazzling beauty of the earth, with its swirling white cloud cover and the sparkling azure of her oceans, is breathtaking. From out in space where the earth can be seen as one among many astronomical bodies, no others have anything to compare with her beauty.

The earth has an incredibly long history, and her present adornment of atmosphere, hydrosphere, biosphere, and noosphere is the achievement of that history. It was made possible by a remarkable and delicate combination of circumstances which, when fully appreciated, suggests a largely unrecognized uniqueness for the earth. This can be best appreciated by considering the history of the earth in parallel with the contrasting histories of the other planets in the solar system and of the sun itself. For this purpose a number of other less well-known missions of the U.S. and Soviet space programs have provided much new and relevant information. With this information combined with knowledge derived from other sources, a fairly reliable general account of the history of the solar system can now be given.

The Thomas D. White Lectures continued at Air University on 2 March 1971 when the speaker was Dr. William G. Pollard, Executive Director of the Oak Ridge Associated Universities. The Review *is pleased to present an adaptation of that lecture.*

THE EDITOR

The Earth among the Planets

The sun and planets were formed 4.6 billion years ago in the collapse of a great cloud of gas and dust falling in on itself under its own gravity. The gases were mainly hydrogen and helium, with the less abundant carbon, nitrogen, and oxygen present as methane (CH_4), ammonia (NH_3), and water (H_2O). Floating in this gas was a relatively small amount of dust of silicates and metals, mostly iron. The heavy elements in this cloud, from iron through uranium, had been freshly synthesized one or two hundred million years earlier in a vast explosion of a previous star, which became a supernova.

Most of this cloud condensed into a large central body, which became the sun. A few tenths of a percent of it, however, was thrown out by centrifugal force in the rotating, collapsing mass into a great platter in the plane of the sun's equator, like the rings of Saturn. In the meantime the center of the condensing mass became hotter and hotter as the gas was more and more compressed. The temperature at the center of the sun reached the hydrogen-bomb ignition temperature of several million degrees centigrade, and the hydrogen in the central core ignited explosively. This explosion has been going on in the sun's central core for the last four and a half billion years. Elsewhere in the universe, before and since, other interstellar gas clouds have been undergoing gravitational collapse in the same way and producing stars. Our own galaxy contains over a hundred billion of them, and new ones are being formed all the time.

The young sun was quite active, producing great solar flares and an intense solar wind. In the first hundred million years, this wind swept much of the hydrogen and helium out of the space near the sun well beyond the present orbit of Mars. The heavier materials in the meantime condensed into growing chunks of stone and iron, with a good deal of ice and some entrapped ammonia and methane in them. These in turn fell together in growing bodies that became the lesser planets: Mercury, Venus, Mars, earth, moon, and the asteroids (which were prevented from consolidating into a planet by the powerful gravity of nearby Jupiter). Farther out the very cold hydrogen and helium were gathered under their gravity and condensed into the major planets Jupiter and Saturn, which are low-density bodies very different from the inner planets. They may have central cores of solid helium surrounded by thick mantles of metallic hydrogen with outer atmospheres of hydrogen, ammonia, and methane.

At first all the inner planets, including the earth, must have been much alike: bare, rocky bodies pockmarked with craters resulting from their growth by the falling together of great chunks of rock. The heat of these collisions released gases trapped in the rock so that they all acquired a growing atmosphere of ammonia, methane, and water. In all of them, radioactive materials—mainly uranium, thorium, and potassium generated in the ancestral supernova—steadily generated heat deep in their interiors. Possibly the earth and Venus collected more iron, uranium, and other metals than the others and so experienced greater internal heating than the moon and Mars. In time this internal heat also melted the rock, and the rising pressure released it in volcanoes with great lava flows and quantities of steam, additional carbon dioxide or methane, and nitrogen.

Only the earth was at just the right distance from the sun for the released steam to condense as rain and collect over the surface in rivers, lakes, and eventually oceans. On Venus and Mercury the temperature was always too high for this, and the steam remained in their atmospheres as water vapor. On Mars it came down as snow and collected as ice. Only occasionally in brief warm periods would there have been liquid water such as one sees here on the Greenland ice cap. For the first several billion years the moon may well have been a separate planet in an orbit around the sun near the earth's orbit.

There are two important and somewhat related points to be made about the hydrogen-containing compounds methane, ammonia, and water in the early history of all these planets. At the top of their atmospheres the intense ultraviolet light from the sun continually knocked hydrogen atoms out of all these molecules. The very fast-moving hydrogen atoms, when moving directly away from the planet, would occasionally have enough velocity to escape from it completely. This was very much the case with the moon, for which the escape velocity is only 1.5 miles per second. For Mercury and Mars it is a little over 3 miles per second, but the much higher temperature of Mercury would produce a much more rapid escape of hydrogen from it. For Venus and the earth the escape velocity is about 7 miles per second, so the hydrogen would escape much more slowly.

Ultimately, when all the hydrogen is gone, the oxygen left behind from the water combines with the carbon left behind from the methane to form carbon dioxide, with some remaining as oxygen gas. It also combines with metals to form oxides. The nitrogen left behind from the ammonia remains as nitrogen gas (N_2). Thus on any planet no heavier than the earth the atmosphere after four billion years will consist of nitrogen and carbon dioxide.

By now, four billion years later, even the residual nitrogen and carbon dioxide have escaped from the moon and Mercury. They have no atmosphere left at all. Mars has lost practically all its nitrogen but does have some residual carbon dioxide, much of it in the form of dry ice around the polar caps. Venus and the earth, however, have retained all or nearly all of both. The earth, with its liquid water, was able to dispose of its carbon dioxide because it went into solution in the water and there was converted to solid carbonates, such as limestone, of which the earth's crust has great quantities. On Venus, in the absence of liquid water, the carbon dioxide remained in the atmosphere. At present Venus has about the same amount of nitrogen as the earth but has an enormous mass of carbon dioxide, so that the atmospheric pressure at the surface of Venus is over a hundred times that on the earth, nearly a ton per square inch. Under this crushing atmospheric canopy, the temperature at the surface is 800°F, hot enough to melt lead. There may be mountain-forming volcanoes and earthquakes on Venus as there are on the earth, but there has never been any water erosion with resulting sedimentary beds and ore bodies. But there is probably terrifically powerful wind erosion with high winds blowing over dreadfully hot and totally arid deserts, producing sandblasts of an intensity unimagined here. For all the romanticism of which Venus has been the object in human literature, she is as near hell as one can imagine!

The Conditions for Life on Earth

We now turn to the second important point about the hydrogen-containing molecules in the early atmospheres of the planets. As hydrogen atoms were knocked out of them by ultraviolet light, free radicals of carbon, nitrogen, and oxygen were left behind. These are highly active chemically, and they generate in such an atmosphere a great variety of organic compounds basic to life. This process can easily be reproduced in a hydrogen, ammonia, and methane mixture in the laboratory, where extended ultraviolet irradiation produces a variety of amino acids, simple sugars, and bases, like adenine, essential to the formation of nucleic acids. On the earth, and perhaps for a short time on the moon and Mars as well, these compounds were washed out of the atmosphere by rain from the condensing volcanic steam. As the earth's oceans grew, they became well stocked in this way with all the basic building blocks of life. The amino acids could join to form proteins; and the sugars and bases, combined with phosphoric acid dissolved in the water, could form nucleic acids such as ribonucleic (RNA) and deoxyribonucleic (DNA). On Mars and the moon, as the water escaped, these compounds were broken up again and ended simply as nitrogen and carbon dioxide. On Venus, without liquid water and with high temperature, they met the same fate almost as rapidly as they formed.

During the first one and a half billion years of earth's existence, these organic materials in the growing oceans of the young earth had somehow become incorporated into simple cellular organisms. This we know from remnants resembling present rodlike bacteria embedded in a black chert 3.2 billion years old in the Fig Tree series of the eastern Transvaal region of Africa. In another billion years a great variety of single-celled filamentous organisms like modern blue-green algae had developed, as we know from their fossil remains in the 1.9-billion-year-old Gunflint iron formation on the northern shores of Lake Superior. These organisms were capable of photosynthesis and so continually converted carbon dioxide into oxygen in the ocean. For these early organisms the oxygen was highly poisonous, and its presence constituted a major crisis in the history of life. At first their only protection from it was its removal from the oceans by conversion of soluble ferrous iron to precipitated ferric iron. Oxygen gas began to accumulate in the atmosphere about two billion years ago, and by 1.3 billion years ago a new kind of living cell, capable of utilizing the oxidation of sugars as an energy source, had developed. The serious oxygen crisis had been successfully passed, and the stage was set for a new phase of life of tremendous potential. An impressive record of this first major ecological crisis that occurred between 2.5 and 1.5 billion years ago is left in the great iron ore beds of Lake Superior and in the Mesabi Range that used to stand in Minnesota.

For three and a half billion years of its history, the earth consisted of oceans and bare sterile land areas subject to rapid erosion by flowing water. Ultraviolet radiation from the sun was intense over the whole land and sea surface of the earth. When the living organisms in the oceans came within several feet of the surface, they were soon destroyed by the ultraviolet radiation. Nothing living existed anywhere on the land. No multicellular organisms or creatures moved through the deep waters throughout that immense period of time. No suspicion of what would later be achieved through the further elaboration of DNA codes, developed by then in the single-celled organisms in the oceans, could have been gained from an examination of the earth at that time.

Almost two billion years ago, free oxygen released in photosynthesis began to escape from the oceans and join the nitrogen and other oxygen resulting from the ultraviolet release of hydrogen from water high up in the earth's atmosphere. When some ten percent of the present amount had accumulated around a billion years ago, a layer of ozone was formed high in the atmosphere, which absorbs all of the far ultraviolet in the solar radiation. From then on, living systems could rise to the surface of the oceans and later find habitats on the land. At the same time, in response to the dissolved oxygen in the oceans in equilibrium with that in the atmosphere, DNA codes were elaborated for entirely new biological systems for which oxygen was no longer a poison but a benefit. These were the mitochondria, which, by burning sugar with oxygen, could produce the same essential organic compounds as that produced by the ancient and long-standing chloroplasts from carbon dioxide and water using the energy of visible light from the sun. A new and potent energy source was now available for incorporation into living organisms. The stage was set for an astounding new epoch in the history of the earth.

By 650 million years ago, soft-bodied multicellular organisms, jellyfish and flatworms, and novel animal forms had developed in the oceans. Their impressions are found in abundance in ancient sandstones in the Ediacara Hills in South Australia. By 600 million years ago some of these animals developed the capacity to make calcium carbonate and could cover themselves with hard protective shells. From then on, the history of life on the earth is recorded in a continuous fossil record. This was the beginning of the geological period known as the Cambrian, which began when the earth was just four billion years old.

The development of living organisms had taken place with almost infinite slowness during those first four billion years. During the Cambrian the rate of development took a quantum jump to a new order of magnitude. Sea creatures developed in great variety and profusion. Plant life began spreading over the land, followed by insects. After 500 million years of such development, the earth of 180 million years ago had acquired a fully developed biosphere, with many of today's features. An Apollo picture of the earth taken then would have looked very much the same as those taken now. Closer up, however, the scene then would have been quite different. The dominant creatures were the great reptiles, mighty dinosaurs, immense and fearful flying reptiles, and numerous reptilian sea monsters. Great conifer forests and other vegetation clothed the land, but as yet no deciduous hardwood or flowering plants and shrubs. Also at that time there was no Atlantic Ocean, and Europe and Africa formed a continuous land mass with North and South America.

Just 70 million years ago the earth entered a new period of her history called the Tertiary. Most reptiles were extinct, and the age belonged to the mammals, which developed in increasing profusion and variety. Plant life had become much as we know it now. The land was graced with a blanket of verdure, great hardwood forests, and high windswept steppes. There were birds and insects in the air, fish in lakes and rivers, and in the sea. Through forest and prairie myriads of animals ranged. By the end of the Tertiary, just two million years ago, these were much the same as we know them today: antelopes, zebras, and horses; a variety of proboscidians in herds; deer, tigers, wolves, foxes, and badgers. Through forest and prairie myriads of animals of the inner energy and dynamism of the phenomenon of life, there was by now in forest and steppe the beauty of flowering plants, shrubs, and trees embracing the whole range of color in every degree of delicacy and brilliance. Only one element was missing from this calm and lovely scene: Man had not yet appeared, and nowhere over the whole earth was there so much as a wisp of smoke rising from a camp fire.

The Question of Life on Other Planets

Science fiction conveys the impression that planets throughout the universe are very similar to the earth; that life has developed on all of them and has finally produced some manlike creature which, although possibly bizarre in appearance, nevertheless thinks, is self-conscious, and can communicate. Beyond science fiction, popular accounts of science in newspapers and magazines instill the same kind of convictions in readers. A good example is Walter Sullivan's book *We Are Not Alone.*[1] Even some very distinguished and otherwise highly reliable scientists speak this way. Within the scientific community itself the ideas of the commonness of the earth and the prevalence of life are widely held. As a result there is as yet in the public at large little appreciation of the extraordinary wonder of the earth or of what a rare and precious gem our planet is.

But now, against the background of what we know so far of the history of our solar system, let us examine critically the conditions which must be met for anything comparable to the earth to be achieved elsewhere in the universe. First and most essential is liquid water. This, of course, requires a rather narrow temperature range which must persist for at least half the planet's orbit around its star. If the earth were just 10 percent closer to the sun than it is, it would receive 23 percent more solar radiation than it does now. There might then be some liquid water in arctic regions and occasional hot pools elsewhere over the surface which would boil and dry up every summer. There would be some limestone, but the atmosphere would still be like that of Venus, with a great amount of carbon dioxide. If the earth had been 10 percent farther out from the sun, it would receive only 83 percent of the solar energy it does now. In that case most of the water would be in vast ice caps, with some melting on the surface of the ice in summer and perhaps some lakes and rivers in the tropics. Again if the earth were in a highly elliptical orbit around the sun, instead of the near-circular one it has, the oceans would boil vigorously for two or three months of the year and then freeze solid for six to eight months.

If the earth had been much smaller and less massive than it is but otherwise in the same orbit, hydrogen would have escaped much more rapidly from its gravitational hold. In that event it would not have been able to hold sizable quantities of liquid water for more than two or three billion years. By now all the water would have escaped, along with some of the nitrogen and carbon dioxide. Life could have developed up to the stage of the Gunflint algae perhaps but then would have been snuffed out as the last water left. On the other hand, had the earth been much larger and more massive than it is, it would have retained until now the reducing atmosphere of ammonia and methane plus possibly free hydrogen, which seems to have been necessary during its first few billion years for the development of life as we know it. In that case there would be now no free oxygen in the atmosphere and so no ozone layer. There would still be no life on the land. How far life would have developed in the deep oceans, we have no way of knowing. But the earth would obviously be now a very different object with a radically different history.

Those who like to think of the earth as quite common and unexceptional should contemplate quite deeply the significance of what we know now of the moon, Mars, and Venus, to say nothing of Jupiter and Saturn. Even in our own solar system, planets come in a great variety of chemical composition and physical states. Except for the earth, their several histories have led after four and a half billion years to the achievement of nothing like the complexity of organization of matter that we have come to know and take for granted.

But it is not only the planet which is important. The central star is also most important. All main sequence stars like the sun are burning hydrogen into helium in natural hydrogen bombs in their cores. When the hydrogen in the core is used up, they go into a gravitational collapse, which leads to the burning of helium in the core and a tremendous expansion of the outer envelope. The star becomes a red giant. If it previously had a system of planets around it, they are all evaporated and become a part of its outer envelope. This brings all planetary histories, of whatever character, to an abrupt termination. The more massive the star, the more rapid is the burning and the sooner is the red-giant stage reached. A star only fifty percent heavier than the sun would reach the red-giant stage in 2.3 billion years. If it had a planet the size of the earth in the right place, life could have developed to the stage of the Gunflint algae before being destroyed. In order to allow a development of at least 4.6 billion years, the star must be no more massive than 1.25 times the sun's mass. The sun itself has several billion years more to go before reaching the red-giant stage.

About half the stars are double stars or members of systems of three or more stars. In such multistar systems there are no stable near-circular planetary orbits. The other half of the stars that are single probably all have systems of several planets. Moreover, stars less massive than the sun greatly outnumber those that are larger. For example, in our region of space there are three times as many stars with half the mass of the sun as there are stars of the same mass as the sun. These smaller stars are much cooler than the sun, and their radiation is much weaker in ultraviolet. Without ultraviolet, both the loss of hydrogen from the original atmosphere would be much slowed and the production of organic materials from that atmosphere would be altered. A planet the size of the earth at the right distance from the star might well develop life, but its evolution over four billion years would probably show a very different history. The mechanism of planetary formation around such a star could well favor hydrogen-helium planets like Jupiter and Saturn close to the star. Such bodies do not offer an environment favorable to any very elaborate evolution of complex organisms.

There are so many stars now on the main sequence in our galaxy that the probability is great that somewhere another earth-like planet has held liquid water for billions of years and has enjoyed a history that could have clothed it with verdure and produced another gem of rare beauty like the earth in the vast reaches of space. But the conditions required for such an outcome, as we have considered them, suggest that such objects are quite rare—probably none at the stage of development presently reached by the earth within several hundred light years of us. If that is the case, then the earth for all practical purposes is unique. There is no other creative achievement of such a high organization of matter within any conceivable reach of us.

The Advent of Man

The preceding account of the earth's history goes through the Tertiary to the beginning of the present geological epoch, the Pleistocene, which began just two million years ago. This sequence was followed to point up the major character of the turning point in this long history which the appearance of man on the planet represents. Only three or four other turning points of comparable magnitude can be identified. One was certainly the point over three billion years ago at which nucleic acid and protein first became organized in living cells. The second was the achievement of photosynthesis around 2.5 billion years ago, with its attendant oxygen crisis. The third was the transformation 600 million years ago from the pre-Cambrian to the Cambrian, when multicellular organisms appeared and the earth began to acquire a biosphere. A fourth could have been the earth's capture of the moon sometime between these two turning points, followed by the moon's subsequent close approach to the earth and causing immense scouring tidal waves. The fifth is the very recent appearance of man, as a result of which the earth has acquired what Teilhard de Chardin aptly calls the "noosphere"—i.e., a blanket of mind and spirit covering the earth. The planetary impact and crisis proportions of this transformation of the biosphere into the noosphere are just beginning to be felt in this century.

Early in the Pleistocene one stem of the evolving and diversifying branch of primates took a fateful step. As at so many other points in the history of life, a door opened briefly and this primate stepped through it. Had he passed by instead to go through some other door, the opportunity for man could well have been gone forever. The result was the first of the species *Homo*. He left the trees and began to learn to walk on two feet. He originated in south central Africa and is called *Homo habilis*. After a long period of continuous development and diversification, a quite new version called *Homo erectus* appeared on the scene 300,000 years ago, after which all forms of *Homo habilis* became extinct. In time he showed the very human trait of wanderlust, and he migrated to the Middle East, Europe, England, China, and Southeast Asia. In Europe he is Heidelberg man, in China Sinanthropus, and in Java Pithecanthropus. By 100,000 years ago a still more human version, *Homo neanderthalensis,* emerged, and soon *Homo erectus* became extinct. Neanderthal man was the first creature in the whole history of life on earth to bury his dead. From this fact alone we know we are dealing with a self-conscious being who anticipates in anxiety or hope. Yet if we could see a Neanderthal man today, with his massive jaw and absence of forehead, we would not consider him human at all.

Some 40,000 years ago one of the diversifying lines of development in Neanderthal man made another leap, and our species, *Homo sapiens*, first appeared on the scene. After his arrival *Homo neanderthalensis* became extinct. *Homo sapiens* not only buried his dead but was an artist as well, and we still marvel at the remarkable, dynamic paintings of mammoth and reindeer that he left in the caves of southern France. But for the next 30,000 years he remained a hunter and gatherer of food, like other animals, and did not appreciably alter the pre-existing balance of nature into which he was born. Then some 10,000 years ago a drastic change began to materialize in his way of life. Settled villages were formed, based on the first agriculture and domestication of animals. In another 5000 years, another major step was taken in the emergence of the first civilizations in Egypt and Mesopotamia, leading to cities, nations, and empires, with a division of labor from slave to king, and attendant professions. Just 200 years ago, the industrial revolution ushered in a new era of mechanical power and invention, leading in the last 50 years to an efflorescence in science and technology, consumption and pollution, and, above all, population explosion. By now there is widespread recognition of the fact that the noosphere is interacting in a major and decisive way with the biosphere and that this interaction is bound to reach a crisis level before the end of the century.

Several aspects of this crisis call for consideration against the background of the total history of the earth. Perhaps the first of these which stands out is the extraordinary acceleration which the phenomenon of life has manifested in its history. Some sense of this acceleration is evident in the accompanying table; what stands out is the extraordinary compression in the time scale that has marked each new stage in this history of life. Measured first in billion-year periods, it moves to 100 million, to 10 million, to million-year spans. Thereafter for man it goes from 100,000-year to 10,000-year spans, and then from millennia to centuries, to mere decades. The acceleration of life has become breathtaking if not intolerable. We do indeed live in a time of change more rapid by orders of magnitude than any which the phenomenon of life on this planet has experienced before.

Another feature that stands out is the immense potentiality of matter as organized on the earth to rise to ever more complex modes of organization, culminating in the phosphorescence of thought and spirit which now envelops the earth in her noosphere. What stands out here is the extreme rarity of conditions throughout the universe in which this inherent, almost unlimited potentiality of matter can be realized. One need only think of the moon, Mars, and Mercury to find matter severely limited in possibility.

HISTORY OF LIFE ON EARTH

Measured in Stages in the Years before A.D. 2000

From	Historical Epoch	To
4,600,000,000	Chemical evolution of protein and nucleic acid.	3,200,000,000
3,200,000,000	Development of living cells in reducing conditions, dependent on fermentation and feeding on each other.	2,500,000,000
2,500,000,000	Blue-green algae develop photosynthesis and nitrogen fixation. Crisis of oxygen.	1,500,000,000
1,500,000,000	Development of respiratory cells using oxygen for energy. Oxygen in atmosphere. Ozone layer shields ultraviolet. Life comes to surface of sea.	650,000,000
650,000,000	Multicellular organisms and macroscopic animals develop in seas. Plant and then animal life covers the land. Coal, oil, and natural gas produced.	230,000,000
230,000,000	Dinosaurs and other reptiles. Hardwoods and shrubs.	70,000,000
70,000,000	Mammals, grasses, flowers, fruits, and vegetables. Production of the modern world other than man.	2,000,000
2,000,000	Appearance of man from most primitive through Neanderthal man.	40,000
40,000	**Homo sapiens** as hunter and gatherer.	10,000
10,000	Rural farm villages.	5,000
5,000	Cities, nations, empires. Written language and literature.	200 (1800)
200	Industrial revolution, mechanical power, and machinery.	80 (1920)
80	Age of affluence, science, and technology.	30 (1970)
30	Population explosion and ecological crisis in the biosphere. Beginning of postcivilization.	0 (2000)

Jupiter and Saturn may consist almost entirely of hydrogen and helium; and although for them such possibilities as solid helium and metallic hydrogen, unknown to us, are actualized, additional possibilities for new developments of matter are almost nonexistent. Matter in stars can occasionally be assembled into the rare and unusual forms of atoms above iron all the way to uranium and californium when the star becomes a supernova. But for the most part it is severely limited in the variety of possibilities open to it, regardless of the length of time available.

It is awesome to contemplate the immense creative investment that has gone into bringing the earth to her present stage of beauty and fulfillment. The slow but ever accelerating elaboration of information coded on DNA over an unimaginably vast reach of time has by now produced, suspended in the alien reaches of space, a magical garden and placed within it that strangest achievement of any of the manifold DNA codes, man. This was possible only because of a most delicate balance of gravity, heat, and light realized on the earth but only very rarely on the other planets. This uniqueness and the wonder of the creative achievement which it has made possible mean that the earth is a rare gem of fantastic beauty and that its desecration or destruction by any being is an act of awful sacrilege against which the heart of all meaning and purpose in the entire universe must cry out in anguish.

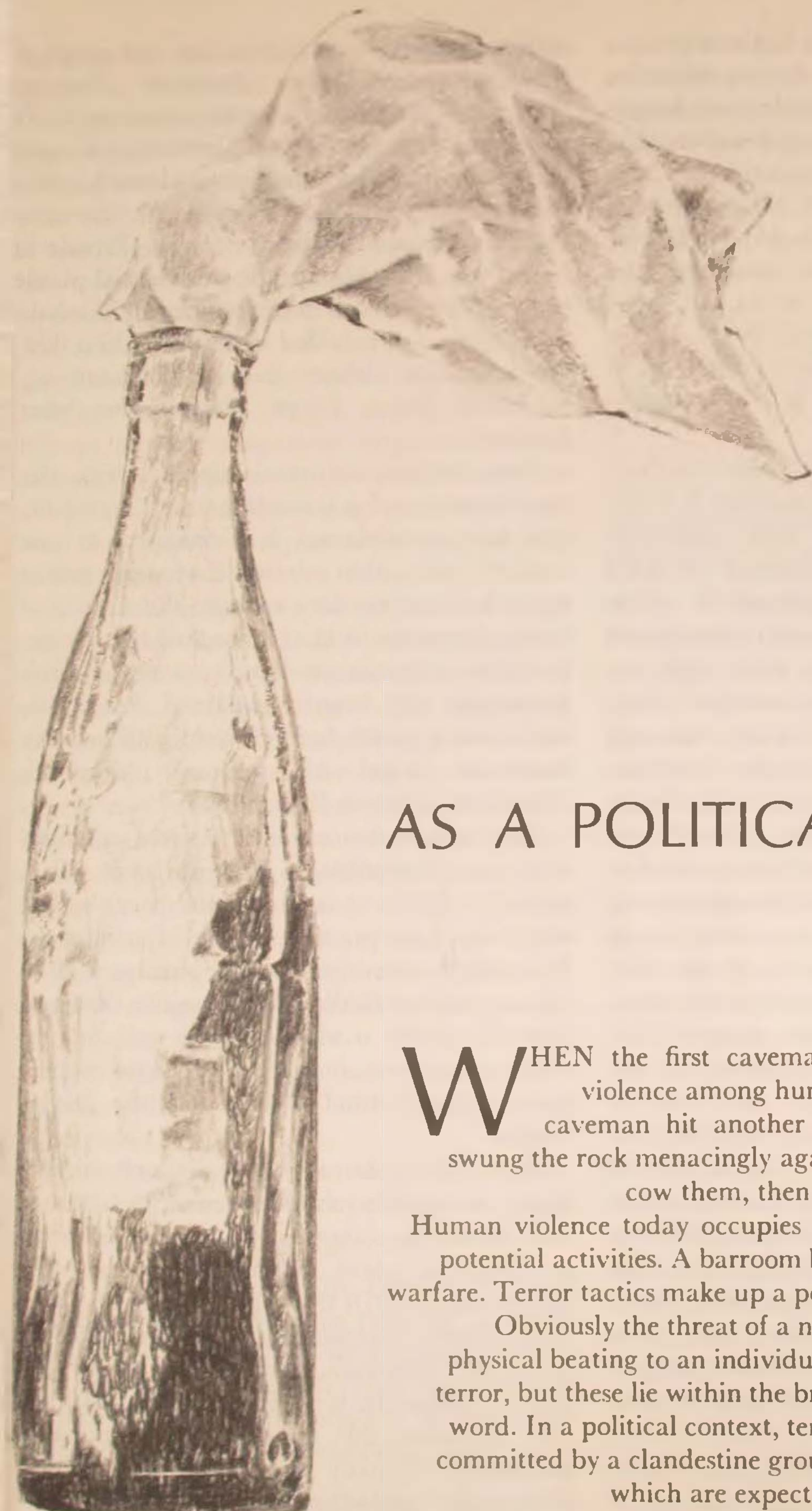
If, as I believe, the human species stands on the threshold of the next great step in its evolution, then this view of the earth may well prove to be a decisive element in the possibility of that step. A full appreciation of the beauty of the earth and of the immense creative investment that has gone into producing it, including as an integral component man himself—an appreciation of all this is essential to man's continued occupation of this planet. With such an appreciation, man will know how to love the earth as she deserves, to woo her into ever greater and more wonderful creative achievements, to celebrate the wonder of the achievement already realized, and to have a holy fear of desecrating her. To accomplish this, it is first necessary for man to recover widely and generally his lost sense of transcendent reality. The process of this recovery is now well under way and will be much accelerated during the time of judgment that is now upon us, with its destruction of secular hopes and confidences and its acute raising of the issues of meaning and purpose.

As men regain this essentially theological perspective on nature and their proper place within it, they will be enabled to respond more and more fully to the creative energies now at work in the world and to play their part in bringing into being the new creation that is now in preparation. For those meek enough to be guided in judgment, the prospect of what is coming in the world during the remainder of this century does not lead to despair. Rather their hope is deeply grounded in and sustained by the knowledge that the creative energy which has been able to accomplish such amazing results through four and a half billion years is not exhausted. Rather, in concert with man, that same energy is even now at work preparing the next great step in this long process.

Oak Ridge, Tennessee

Note

1. Walter Sullivan, *We Are Not Alone* (New York: McGraw-Hill, 1964).



TERRORISM AS A POLITICAL WEAPON

Jay Mallin

When the first caveman hit another with a rock, violence among humans was born. When the first caveman hit another man with a rock and then swung the rock menacingly against other persons in order to cow them, then terror as a weapon was born.

Human violence today occupies a wide spectrum of real and potential activities. A barroom brawl is violence; so is nuclear warfare. Terror tactics make up a portion of the overall spectrum. Obviously the threat of a nuclear war—or the threat of a physical beating to an individual—can be viewed as forms of terror, but these lie within the broad, semantic meaning of the word. In a political context, terror tactics are acts of violence committed by a clandestine group, the psychological effects of which are expected to bolster the group's cause and move it toward its objectives.

The basis of terror tactics is the threat—threat to a government that it must abandon power or face continued trouble and danger for its officials; threat to a population that they face constant disruption unless they help overthrow the government. A village chief is assassinated, and the threat of death discourages capable men from assuming the local leadership. A diplomat or an airliner is seized, and as a result political prisoners are released because of the threat to the lives of the hostages. The caveman is still swinging his rock.

Terrorism is a form of guerrilla warfare. The basic tactic for guerrilla warfare is to hit and run and hide, hit, run, hide. Guerrillas conceal themselves in mountainous or rural areas. Terror tactics are employed in urban as well as rural areas, and when carried out in cities and towns, they are often aptly referred to as "urban guerrilla warfare." Like guerrilla warfare, terrorism is a hit, run, and hide form of conflict—combat by attrition, destruction of the prevailing authority being the hoped-for end result. Often, although not always, guerrilla warfare and urban clandestine activities are conducted simultaneously and are complementary to each other, as in Cuba in 1957–58, in Venezuela in the early sixties, and in Vietnam for over two decades.

Terror tactics are not a new weapon. One of the most famous acts of terrorism of this century was committed in the Austro-Hungarian town of Sarajevo on 28 June 1914: a double assassination of royalty which precipitated World War I. Abraham Lincoln was the victim of a terror plot hatched by a small group of Southern sympathizers who hoped to destroy the Union government. Fidel Castro was still a child when Cuba was immersed in a bloody clandestine struggle aimed at overthrowing the dictator of that period.

The modern complex, crowded, interrelated world appears to be exceptionally vulnerable to political terror tactics. Electronic communications bind the various countries and peoples closely together. When Archduke Francis Ferdinand and his wife were assassinated in Sarajevo, the news reached Germany's Kaiser Wilhelm via an admiral on a launch who placed a piece of paper in a cigarette case and tossed it aboard Wilhelm's yacht. President Nixon was flying aboard the presidential plane in the United States in September 1970 when a radio message crackled in to inform him that an American airliner had been blown up in far-off Cairo, Egypt, after having been hijacked.

Over today's communications systems the reverberations of a terrorist act can travel far and fast. A diplomat is kidnapped in one country, and within minutes the foreign ministry of his own country receives the news and brings pressures to bear to secure his release. In 1904 a Moroccan bandit named Raisuli kidnapped an American named Perdicaris, but it was a month before President Theodore Roosevelt issued his famous ultimatum, "Perdicaris alive or Raisuli dead."

Delicately balanced international relationships are susceptible to acts of terror. Two bullets at Sarajevo shattered the peace of the world for four years. Airplane hijackings by Palestinian terrorists in September 1970 endangered a Middle East cease-fire that had been carefully worked out to prevent an eventual confrontation between the two superpowers, the United States and the Soviet Union.

Delicately constructed equipment is also highly vulnerable to acts of terror. A hammer can destroy a computer. A match can level an industrial plant. Within the space of a few weeks in 1970 the huge airliner in Cairo and a highly sophisticated research center in Madison, Wisconsin, were blown up by explosives placed by terrorists. One or two men can pulverize the accumulated work and knowledge of many researchers or scientists. It is easier to destroy than to build, and—tragically—as man builds ever more complex equipment, the ability to destroy remains relatively easy; and it is into this widening gap that terrorists have moved with devastating results. Once largely limited to killing people, the terrorist today has the whole wide field of technological development as his potential target. In order to further his scheme, the terrorist no longer needs an army or a guerrilla group; a fuse or a hammer will suffice. A harmless soft-drink bottle, with gasoline and a wick, becomes a Molotov cocktail that can wreck a home, destroy a factory, disrupt a communications network. Acts of sabotage can add to the intensity of a terror campaign, but in destroying material objectives their primary purpose is to inflict damage to the economy.

In considering types of action, one must not overlook the fact that sometimes more than one factor—not only the terror purpose—is involved in these deeds. The murder of village leaders may be the policy of a clandestine group; the person carrying out an actual killing may be acting out of personal revenge. The hijacking of airliners may be the policy of another group; an individual hijacker may be acting as much in search of "glory" as in compliance with orders. Furthermore, an act of violence may serve more than one purpose: when a village official is murdered, not only is authority destroyed but a terror effect is felt throughout the population, particularly among other officials and governmental adherents.

Variations in patterns of terror appear in different countries, depending on local circumstances:

• In Guatemala in 1968, with both rightist and leftist elements engaged in terror activities, revenge killings were a characteristic of the violence. Kidnappings for ransom became almost commonplace as terrorists favored this method for obtaining funds.

• In Uruguay in the late sixties, the Tupamaros, an extremist organization, first cultivated a Robin Hood image by such deeds as robbing a casino. This image, evoking laughter more than concern in the populace, enabled the Tupamaros to establish themselves as an operational and well-known organization. They then turned to more deadly activities, including the murder of a kidnapped American official.

• Terror in Vietnam in the late fifties was largely selective (e.g., the killing of village chiefs). Later it was expanded to include general targets (e.g., a mine placed in a road to catch any passing vehicle). The wider scope was given to terrorism as the Viet Cong increased their efforts to bring down the South Vietnamese government.

• The Cuban revolution of the late fifties was a classic instance of a clandestine struggle linked with guerrilla combat. Fidel Castro led the rebel guerrillas and became the popular symbol of the revolution. In the cities and towns, however, the underground also waged its battle against the government. Significantly, more rebels died in the cities than in the hills. The underground engaged in numerous terrorist activities, with varying degrees of success. There were some assassination attempts (few succeeded) and a good many acts of sabotage. Bombs were their most potent weapon; they exploded in stores, theaters, night clubs, and on the streets. The bombs served several purposes: loud blasts demonstrated to one and all, friend and foe, that the rebel underground existed and was highly active. The bombs encouraged the population, which was largely antigovernment, and helped to demoralize the government forces, aware that the enemy was present and dangerous. In May of 1957 a mighty explosion destroyed a section of a vital electrical conduit in Havana, blacking out part of the city for more than two days. In November of the same year residents of Havana thought they had come under bombardment when some forty bombs exploded in different places within a fifteen-minute period. As these and other terrorist acts were carried out, commerce slowed, investment capital dried up, tourism came to a halt, and the decline in the economy became a major factor in eventually bringing down the government.

Terrorists everywhere have confronted the question: Does terrorism in the long run do more harm than good, turning a population against the cause espoused by the terrorists? The Cuban underground, operating within a population that was basically sympathetic, sought to solve this problem by not using any metal in at least some of its bombs. This minimized casualties because flying metal fragments do the most harm to humans, not the explosion itself if it is limited in potency. The bombs were exploded primarily for their psychological effects, not to kill or maim. There were some casualties, but these were relatively few compared to the large numbers of civilians killed or wounded by Viet Cong explosions, the primary purpose of which is precisely to kill and wound.

The Cuban revolution was the incubator for two terror methods that have now come into international use: hijacking of aircraft and kidnapping of people for political purposes. The rebel 26 of July Movement was probably the first organization to carry out hijackings for political reasons. A number of domestic flights and one international flight were seized by hijackers, who thus sought to disrupt the country's communications system and demonstrate the ability of the rebels to strike appreciable blows.

In February 1958 Juan Manuel Fangio, then world auto-racing champion, was in Havana to participate in a race. Members of the rebel underground seized Fangio in the lobby of a downtown hotel, spirited him off, and held him for several days, finally releasing him unharmed. No demands were made; the kidnapping in itself served the rebels' purpose by bringing them worldwide publicity and demonstrating their capability for action within a city that was thought of as a government stronghold.

Four months later the rebels staged an even more spectacular kidnapping. Guerrillas led by Raúl Castro had occupied a portion of easternmost Cuba, but there they were being harassed by the government's aircraft. In an effort to obtain a breathing spell, the rebels seized 48 Americans and 2 Canadians. The rebels knew the government was unlikely to bomb guerrilla-held areas as long as American citizens might be endangered. By means of this mass kidnapping the rebels achieved a number of objectives: they demonstrated their effective control of a portion of the national territory, forced a letup in the government's air activity, and won *de facto* recognition of sorts from the United States when two American consuls came to negotiate the release of the prisoners.

The hijackings and kidnappings by the Cuban rebels were an ominous portent of the future use of these techniques by terrorist individuals or groups in other parts of the world. The hijacking of airliners reached a climax in September 1970 when Palestinian terrorists seized four airliners with some 599 passengers and crew within a period of four days (a fifth hijacking attempt was thwarted). All four of the seized planes were subsequently blown up.

Nowhere in the world in modern times has terror as a political weapon been used so extensively as the Communists have used it in South Vietnam. The terror tactic has ranked with the military tactic as a full-fledged component of the Communist drive to conquer that country. The Communist military commander, General Vo Nguyen Giap, stated bluntly:

> At the price of their hard-won experiences, our compatriots in the South realized that the fundamental trend of imperialism and its lackeys is violence and war; that is why *the most correct path to be followed by the peoples to liberate themselves is revolutionary*

> *violence and revolutionary war.* [Italics are Giap's.] This path conforms strictly to the ethics and the fundamentals of Marxism-Leninism on class struggle, on the state and the revolution. Only by revolutionary violence can the masses defeat aggressive imperialism and its lackeys and overthrow the reactionary administration to take power.[1]

So pervasive has terrorism become that one writer asserted that it "has long passed the stage of excess and become a vice, an intoxication with violence, one that may well be a release from the terrible and inhumanly prolonged hardships and repressions of personal interests which its adherents must undergo."[2]

Terrorism may well be an emotional outlet for persons engaging in it. It has also served very real political purposes for the Communists in Vietnam. A study of Viet Cong terror tactics by the United States Mission in Vietnam enumerated five aims the Communists hope to accomplish by employing these methods:

> 1. *Morale building within the Viet Cong ranks.* A successful terrorist act does much to create an aura of invulnerability within a guerrilla band and helps bolster spirits throughout the insurgent organization. . . .
>
> 2. *Advertising the Viet Cong movement.* . . .
>
> 3. *Disorientation and psychological isolation of the individual.* This is done by destroying the structure of authority which previously was a source of security. The particular target is the Vietnamese villager. . . . Terror removes the underpinnings of the orderly system in which the villager lives out his life. . . .
>
> 4. *Elimination of opposing forces.* . . . By means of terror the Viet Cong have sought to eliminate the entire leader class of Vietnamese villagers. . . .
>
> 5. *Provocation of the GVN* [Government of South Vietnam]. . . . Any government faced with terrorism must attempt to suppress the terrorists. Ideally, that suppression is by an orthodox use of law enforcement. But if the terrorist is effective and if the government sees itself in a crisis, it will almost inevitably use extra-ordinary repressive measures.[3]

As previously noted, the Communists have utilized both selective and general methods of terror in Vietnam. A selective target may be a village chief, a policeman, or an American official. A general target may be an audience in a theater or people crowding into a marketplace. In hitting a specific target, the terrorist strikes at the fabric of governmental control. In hitting a general target, he aims at the overall social fabric. Create chaos, the terrorist believes, and you open the way to seizing power.

The widespread Communist use of terror in Vietnam since 1957 has been fully documented in a considerable number of publications. Statistics related to events in Vietnam are often suspect, but they can serve as indicators. According to reports issued by the United States Mission to that country, assassinations in 1966 totalled 1732, rose to 3706 in 1967, and then to 6518 in 1968.[4] The 1968 figure is totally inadequate, however, because it does not include deaths during the bloody Tet offensive. By 1969, with United States and South Vietnamese forces in greater control, assassinations dropped to 6075. (See accompanying table.)

The Communists' attack in 1968 enabled them to occupy most of Hue, the country's second city. Later, once the city had been recaptured by government and American forces, it was discovered that the Communists had massacred a large number of people. The mass graves of victims were found around the city. The first discovery was made in the yard of a high school, where 170 bodies were recovered. In the months that followed more graves were found, and eventually some 2800 bodies in all were recovered. About 2000 more persons were missing, perhaps buried in graves that were not found.[5]

Douglas Pike, an expert on Vietnamese affairs, has categorized by phases the Communist rationale behind the killings: When they thought they would be able to hold the city for a short while, they killed in order to eliminate enemies and to weaken the structure of the establishment. When they thought they might be able to maintain their hold on the city, they killed in order to purge the old social order. And then when it became apparent they would lose the city, they sought to liquidate anyone who might later be able to identify Party members.[6]

General Giap's statement that "violence and revolutionary war" conform "to the ethics and the fundamentals of Marxism-Leninism" means that Communists openly favor the use of violence and terror as a means to obtain political control. Rarely do they attempt to conceal their adherence to—often preference for—the use of force. The Communist Manifesto states bluntly: "They [the Communists] openly declare that their ends can be attained only by the forcible overthrow of all existing social conditions."[7] Karl Marx wrote in *Das Kapital,* "Force is the midwife of every old society pregnant with a new one,"[8] and almost a century later Ernesto Guevara echoed Marx with the statement, ". . . We should not fear violence, the midwife of new societies."[9] China's Mao Tse-tung clearly set forth the Communist viewpoint on violence when he said, "Every communist must grasp the truth, 'Political power grows out of the barrel of a gun.' "[10]

Terrorist campaigns follow a pattern. At first there are sporadic activities, without much design. Usually these consist of occasional and scattered bombings and perhaps one or two assassination attempts. These actions are similar to the first tentative attacks that are carried out by a guerrilla group beginning operations in a rural area. If the army is unable to snuff out the guerrilla movement, it expands and becomes more active and

U.S. Mission reports of assassinations and abductions, 1966–1969, from Stephen T. Hosmer, Viet Cong Repression and Its Implications for the Future *(Santa Monica: The RAND Corporation, 1970)*

	1966		1967		1968*		1969		1966-1969*	
	Assassinations	Abductions	Assassinations	Abductions	Assassinations	Abductions	Assassinations	Abductions	Assassinations	Abductions
Government officials**	168	176	285	192	364	183	336	113	1,153	664
Government employees***	202	93	603	136	611	118	447	34	1,863	381
General populace	1,362	3,541	2,818	5,041	5,543	10,332	5,292	5,948	15,015	24,862
	1,732	3,810	3,706	5,369	6,518	10,633	6,075	6,095	18,031	25,907
TOTAL	5,542		9,075		17,151		12,170		43,938	

*These figures do not include any assassinations or abductions that may have occurred during February 1968. Official data for that month are not available.

**Includes titled officials at national, corps, region, province, district, village, and hamlet levels.

***Includes civil servants (teachers, health workers, etc.), Rural Development workers, and members of the National Police when not on military operations.

dangerous. In urban areas, if a clandestine terrorist apparatus is not eliminated completely, it, too, may grow and become more sophisticated.

One indication of sophistication is the ability of a terror group to select and carry out attacks on selected targets. This frequently takes the form of attacks on police. Lenin once wrote, "The first objective [of armed struggle] is to kill individuals such as high officials and lower-ranking members of the police and army." [11] In South Vietnam the police have been a primary target of Viet Cong terrorists. Not only have individual policemen been shot, but even police headquarters have been attacked. In the Dominican Republic, at the time of the 1965 uprising, so many police were attacked and killed by terrorists in Santo Domingo that the police disappeared from the streets of the city. Police are a symbol of the existing order; they are also a major support of that order. To strike at the police is to deal psychological as well as real blows against the existing establishment.

In the United States, today troubled by terrorism for the first time in its history, terror tactics have reached the level of sophistication in which terrorists are leveling their guns at policemen with deadly effect. As of mid-September 1970, sixteen police officers have been killed in the year as the result of unprovoked attacks, more than double the total for the previous year and nearly four times the annual average for the past ten years.[12]

There are no simple, ready solutions to terrorist activities; there is no panacea for terrorism. Counterterror is not the answer; it is, in fact, counterproductive. Although limited gains may temporarily be achieved—such as deterring fainthearted individuals from joining a rebel group—in the long run counterterror will cause repugnance in a population, turning many persons against the authorities. Such was the case in Cuba in 1957 and 1958.

There are, however, techniques that have been applied, sometimes quite successfully, to particular aspects of terrorism. Cuba, during the aforementioned period, eliminated the problem of hijacking by requiring body searches of all passengers and by placing armed uniformed guards aboard planes. The guards were seated with the crew so that they could keep watchful eyes on the passengers through peepholes set in the doors separating the crew and passenger compartments. Modern electronic equipment is today an additional aid in detecting weapons and forestalling hijackings.

Good police techniques are the best method of beating terrorism, which is, after all, a form—a political variation—of crime. Infiltration of terrorist groups, money payments to informers—the same methods used against criminal gangs—are feasible against terror groups. A detailed file, kept up to date —computerized if possible—of all persons suspected of being engaged in clandestine activities can be most helpful, just as files on criminals aid police in crime detection. In one case in a Latin American city, files on possible terrorists were combed, and over thirty suspects were brought in for interrogation. Of the persons questioned, only one was found to be engaged in terrorist activities, but when he told the authorities what he knew, they were able to break up a significant portion of an underground network.

Terrorist groups must obtain weapons and explosives in order to carry out their work. Strict controls over the sale and distribution of these can make the tasks of terrorists more difficult and sometimes can enable police to trace the purchasers of weapons used in acts of terror.

While police officers are often the targets of terrorists, by being cautious in situations that are potentially dangerous, they can reduce their risk. Policemen working in pairs are more difficult targets to attack: terrorists must either kill both policemen or chance being killed themselves. If two policemen keep a suitable distance between them when they approach or are approached by a questionable individual, that individual will find it almost impossible to kill them both at the same moment.

Security at public buildings, including theaters, can be enhanced if all packages, including women's purses, are subjected to scrutiny at entrances. A stick of dynamite can, of course, be smuggled in under a person's clothing, and it may not be feasible to search every individual fully. Searches of packages and purses, however, will at least decrease the possibility of bombs being smuggled into a building, and certainly will eliminate the possibility of any sizable explosive artifact being smuggled in.

The cities of South Vietnam have long been troubled by terror campaigns. In order to lessen the casualties and damage inflicted by terrorists, a number of steps have been taken by the authorities:

• Government agents infiltrate the Viet Cong clandestine apparatus. This is one of the most effective methods of keeping track of terrorist activities, sometimes forestalling them. Agents who have penetrated an underground system can not only identify individual terrorists but often provide enough information to enable the authorities to destroy an entire clandestine cell or series of cells.

• At roads leading into a city, authorities search vehicles to make sure none is carrying weapons or explosives. Within the city itself, police spot-check passing cars (perhaps every fifth or tenth vehicle).

• Censuses are conducted frequently in order to keep track of inhabitants. An unexplained "cousin" who has come from the interior might be a Viet Cong agent.

• Still another tactic is to cordon off an area within a city suddenly and have the police carefully sweep through that zone. They round up persons who cannot adequately identify themselves or explain their presence.

• Secure areas are maintained around or adjoining government buildings. Vehicles entering these areas are subject to search, including search by means of a mirrored device that is passed underneath the vehicle to detect any explosives concealed there.

• The military have learned the value of civic action programs aimed at winning over the inhabitants of a troubled area so that they will support the government and its forces, not the rebel guerrillas. The same tactic is valid for urban police. If the police do not make an effort at maintaining friendly relations with the inhabitants of a troubled portion of a city, such as a ghetto area, those people are more likely to help terrorists who are striking at the police and the established order. Guerrillas in rural areas need the support of the peasantry. Similarly, urban guerrillas must be assisted by local people if they are to operate effectively and evade the police.

Urban terror is a cross between crime and insurgency. By adapting the techniques of crime-fighting and counter-insurgency, the best methods can probably be found for combating the terrorists.

Coral Gables, Florida

Notes

1. Vo Nguyen Giap, *The South Vietnam People Will Win* (Hanoi, 1965).
2. George Modelski, "Viet Minh" in *Communism and Revolution*, ed. C. E. Black and T. P. Thornton (Princeton, 1964).
3. *A Study—Viet Cong Use of Terror* (Saigon: United States Mission in Vietnam, 1967).
4. Stephen T. Hosmer, *Viet Cong Repression and Its Implications for the Future* (Santa Monica: The RAND Corporation, 1970).
5. Douglas Pike, *The Viet-Cong Strategy of Terror* (Saigon, 1970).
6. *Ibid.*
7. "The Communist Manifesto," in *Essential Works of Marxism*, ed. Arthur P. Mendel (New York, 1965).
8. Karl Marx, *Capital* (New York: International Publishers Co. edition, 1967).
9. Jay Mallin, ed., *"Che" Guevara on Revolution* (Miami, 1969).
10. *Selected Military Writings of Mao Tse-tung* (Peking, 1963).
11. V. I. Lenin, "Partisan Warfare" in *Modern Guerrilla Warfare*, ed. Franklin Mark Osanka (New York, 1962).
12. "Snipers in Ambush: Police under the Gun," *Time*, 14 September 1970.

Military Affairs Abroad

Sino-Soviet border confrontation

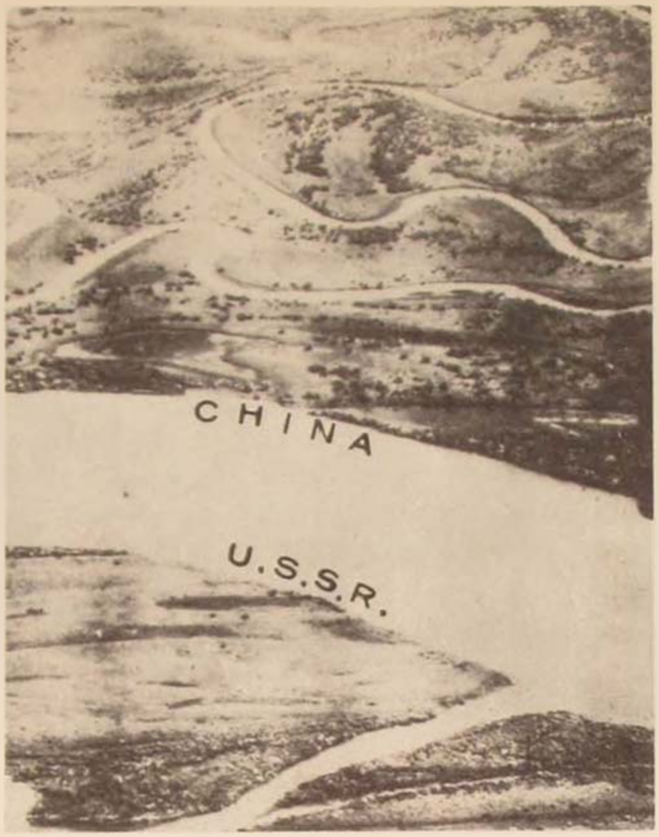
THE USSURI RIVER INCIDENT AS A FACTOR IN CHINESE FOREIGN POLICY

Colonel Donald M. Marks

THE PROBLEM of power is the fundamental problem of our time and probably will remain so in the future. Quarrels among Communist nations are normally ideological disputes, jarringly embroiled with the unavoidable issues of *power* and *policy*. In this context, the Sino-Soviet rift is no exception, notwithstanding the fact that many analysts are not in agreement as to what constituted the actual causes of the dispute.

While China and the Soviet Union are sovereign Communist nations, they embrace different cultures, histories, goals, and traditions. Other crucial elements relative to the rift concern the choice of the correct policy toward movements of "national liberation"; the risks and consequences of nuclear war; who shall lead the Communist forces in world politics; and the differing appraisals of the present balance of strategic power in the world.[1] Such an array of irritants and issues naturally tends to revive disputes that were dormant, moribund, or just forgotten. Not the least of these problems has been the one associated with territorial differences, largely stemming from old treaty settlements accomplished when China was in no position to question them simply because she had not the *power* to question them.

Border problems have plagued Sino-Russian and Sino-Soviet relations for several hundred years. In the mid-nineteenth century Russia, taking advantage of a powerless China (as did several European powers), annexed the



An aerial view of the Ussuri River south of Iman, U.S.S.R., about 200 miles north of Vladivostok and close to the Damansky Island setting of the Sino-Soviet encounter of early 1969

territory north of the Amur River and east of its tributary, the Ussuri, founded Vladivostok, and cut off China from the Sea of Japan. The loss of this huge area was accepted by China in the Treaties of Aigun (1858) and Peking (1860).[2] It is reasonable to surmise that with such a background, the momentum of history has thrust these compelling disturbances into the forefront of contemporary Sino-Soviet relations. Both sides admit that border incidents have occurred with increasing frequency, at least since 1960. In fact, Russian-Chinese contacts along that border began to constitute a significant problem by 1967. In January of that year, there were reports of a clash along the Ussuri in which the Soviets accused the Chinese of wildly provocative behavior in connection with the excesses of the Cultural Revolution. Border guards reported incidents on 23 December 1967 and in late January 1968, along both the Ussuri and the Amur.

The Chinese complaints of Soviet border violations do not have such depth as the Soviet charges. The Chinese claimed that from 23 January 1967 until 2 March 1969 Soviet troops intruded into Damansky sixteen times, using "helicopters, armored cars and vehicles." The Chinese further assert that the Soviets were guilty of "ramming Chinese fishing boats, robbing Chinese fishermen, turning high-pressure hoses on fishermen, assaulting and wounding Chinese frontier guards, seizing arms and ammunition, and even violating Chinese air space by overflights."[3] Finally, the Chinese charged that the Soviets provoked a total of 4189 border incidents from the breakdown of border negotiations on 15 October 1964 to the March 1969 incident. Thus, there was an increasing degree of border tension and dispute beginning with the January phase of the Cultural Revolution and extending to the end of that period of Chinese history, 1966–68.

In reality, the problem of the Sino-Soviet border has been raised on a sustained basis throughout the period of Communist rule in China, even to the inclusion of a mutual declaration on territorial integrity in the 1950 Sino-Soviet treaty. Along with this treaty declaration, the two powers coevally signed agreements concerning commercial interactions and use by the Soviet navy of bases in Port Arthur and Dairen. These instruments were modified in 1952, however, to permit proprietary Chinese interests, and the naval bases were returned in 1954 at the time of Khrushchev's visit to China. During that visit Mao himself brought up the question of Outer Mongolia with Khrushchev. Although the Russians refused to discuss the matter, this represents the earliest known Chinese initiative directly connected with a border revision.

Specifically, the territorial aspect of the Sino-Soviet dispute was inaugurated at the end of 1962 by Khrushchev, who, in responding to Chinese strictures about the Cuban gambit, derided the Chinese for permitting such "fragments of colonialism as Hong Kong and Macao" to survive on their soil. This attack afforded the Chinese an undeniable opportunity, and they promptly termed the border treaties signed between tsarist Russia and Ch'ing dynasty China as "unequal" and therefore subject to revision. The Chinese statement, published 8 March 1963, concluded with the well-known interrogation: "In raising questions of this kind, do you intend to raise all the questions of unequal treaties and have a general settlement? Has it ever entered your heads what the consequences will be?" It was after this date that public reports and charges of border violations were made and secret border negotiations initiated.[4]

Events could have resulted in outright military action had the polemics continued; however, history intervened with the removal of Khrushchev in October 1964. There followed a quiescent period of some two years, which, in large measure, lasted until the Cultural Revolution.

The border negotiations began on 25 February 1964. The Soviet side was represented by P. I. Zyryanov, and the Chinese delegate was Tseng Yung-chuan, both Deputy Ministers of Foreign Affairs. Some progress was achieved, but in late October the Soviets recommended that the talks be moved to Moscow, at which point the Chinese apparently balked. No response was ever given to the Soviet suggestion, and nothing eventuated until the two disputants met again on 18 June 1969 at Khabarovsk.

Even though this initial attempt failed, it is interesting to speculate what were the probable causes as there appear to be at least two points on which the two sides concurred. First, both parties were substantially in agreement on the absolute necessity of a new, meaningful border treaty. Second, both tacitly agreed that the actual amount of adjustment necessary to realign the border to mutual satisfaction was slight. Conversely, there were two disagreements. First, and by far the most compelling, were the vital differences in procedures advocated. The Chinese had a pathological fixation which demanded Soviet admission of the old treaties' unequal aspects *prior* to signing any new treaty. But the Soviets refused to submit to such a request; thus, an impasse ensued.

In retrospect, it appears that those points of agreement appreciably exceeded those of disagreement; but the treaty negotiations probably failed through lack of procedural agreement or real desire on the part of the participants. It is also quite within the realm of possibility that China, smarting from a sustained *disparity of power* vis-a-vis the Soviet Union and attempting ideologically to *project a power advantage* since 1964, did not, in truth, want a settlement at that point in time, for a settlement would have terminated a useful gambit. As long as China could aggressively act with some degree of military impunity, and assessing that she had time on her side, it is reasonable to surmise that the Chinese broke off the talks when it appeared that the Soviets would not relinquish on all points or that the talks were about to enter a stage of definitive settlement.

Some note should be taken of the relative military dispositions along the border at this time; however, as can be expected, precise information is questionable. For some time the Chinese had stationed around fourteen infantry divisions in the northeast, five divisions in Inner Mongolia, and five more in Sinkiang.[5] They supplemented these troops with "construction" personnel, so that in areas contiguous to the border there were approximately 35 to 40 divisions, or some 450,000 men.

On the other hand, the Soviets were aware that the Far East is by no stretch of the

Soviet border guards attacking on Damansky Island, as claimed by Communist Chinese source of photo

imagination "next door" to the Russian heartland, and this fact, plus overwhelming strategic superiority, disposed them to maintain only eight Red Army divisions between the Urals and Lake Baikal. (Another 26 divisions were available in southern U.S.S.R.) Thus, it would appear that the Chinese had an edge in manpower; however, the Soviet logistical and transportation postures were far superior. The Soviets also had been building airfields close to the border; consequently, they harbored an edge in terms of equipment superiority, i.e., aircraft, armor, and artillery, and their tactical mobility demonstrably exceeded that of the Chinese.[6]

As previously pointed out, border disputes began as far back as 1959 and inexorably increased to the extent that some sort of overt military buildup was justified by both powers; but this is not precisely the case. In 1966 both sides did initiate modernization programs, and of the two the Soviets had the more active. The Vietnam war and the massive American intervention undoubtedly drew Chinese attention, at least momentarily, to their southern exposure; therefore, they could not hope to keep pace with the Soviet program.

For the Soviets, 1967 ushered in some changes in policy and tactics, for it was in that year, apparently, that the border incidents assumed a more menacing aspect. The Soviets began a program of indoctrinating their citizens which included reports from inspection trips made in the border zones of contention. A major feature of the preparedness campaign was the signing of a 20-year defense pact with Mongolia and the stationing of Soviet troops on Mongolian soil. By 1968 the Soviets actually accomplished fairly large-scale maneuvers in the Mongolian area, and several bases were constructed.

Six assessments emerge from the foregoing data. First, a general balance of military forces existed in the border regions for a long time. Second, the balance assumed a more aggressive stance in 1966 with the introduction of modernization programs. Third, the Chinese appeared to actively engage in an ideological

Two Soviet armored vehicles and two cars carrying armed frontier troops crossed the frozen Ussuri River on 7 February 1969 and landed on Damansky Island, territory disputed by U.S.S.R. and Communist China. This and other incidents angered citizens of both countries.

power struggle with the Soviets, the border disputes serving as a prime vehicle. Fourth, the general military balance was disturbed after 1966 by the movement of Soviet troops onto Mongolian soil. Fifth, increased military activity by both factions, plus the attendant excesses of the Cultural Revolution, served as a fillip to border tensions. Sixth, the Soviets undertook a domestic indoctrination program anent the border problem and entered into a defense pact with Mongolia. The amalgamation of these incidents and the disruptive and highly volatile excesses of the Cultural Revolution, in conjunction with the Soviet activities along the border, certainly must have induced in the Chinese marked anxiety as to future Soviet projections of power.

Damansky Island is located in the Ussuri River, which forms the boundary between the Soviet Union and China for approximately 180 miles southward from Khabarovsk. The nearest Soviet settlement is Nizhne Mikhailovskiy, about five miles to the south, whereas the closest point of Chinese population is Kung-szu at the southern extremity of the island. Apparently the Soviets supported two border outposts within the general area, one south of the island, commanded by Senior Lieutenant Ivan Ivanovich Strelnikov, and the other, to the north, by Senior Lieutenant Vitaliy Dmitriyevich Bubenin. The solitary Chinese outpost was situated directly across the island at about its mid point. With this in mind, the following appears to be a reasonable account of what took place on the Ussuri River on 2 March 1969.

Under cover of the wintry night of 1–2 March, approximately 300 Chinese soldiers, camouflaged in white uniforms, crossed the Ussuri River to Damansky Island and established a bivouac area for the night. Early the next morning, the Soviet guard on duty at Lieutenant Strelnikov's outpost noticed some 20 to 30 armed Chinese moving towards the Soviet side, shouting Mao slogans as they approached. Strelnikov and some of his men set off to meet the Chinese. Arriving on the island, they went forward to confront the approaching Chinese.

The Soviets strapped their automatic rifles to their chests and linked arms to prevent the Chinese from passing. The Chinese positioned themselves in rows and gave the appearance of being unarmed. When they had approached within about twenty feet of the Soviet soldiers, the first row stepped aside and a second row pulled out submachine guns from under their coats and opened fire on the Soviets. Strelnikov and six of his men were killed outright. At the same time, from an ambush on the Soviet flank, the Chinese let loose an enfilade which obviously caught the Soviet unit by surprise. Mortar and machine-gun fire joined in, and then the Chinese apparently charged with hand-to-hand fighting resulting. Under such an onslaught, the Soviet unit was overrun, and according to Soviet figures the Chinese killed nineteen men on the spot.

Lieutenant Bubenin had witnessed the battle from his outpost, and with his men he raced to the scene. He forced the Chinese to divide their fire, but in the process he was also wounded. A wild melee ensued, and when the confusion had died down the Soviets eventually forced the last group of 50 to 60 Chinese to retreat to their side of the river. The battle lasted some two hours, and both sides claimed victory.

There appear to be sufficient facts which, when collated and considered with other data, tend to concentrate the causes into three finite spheres: the incidents attendant to the border confrontations; the basic national postures endemic to both countries; and the possibilities emerging from the foreign policies of the two nations.

Perhaps two situational contingencies surface. The first lies in a simplistic assessment that both sides had been invested with an inordinate amount of unit authority in dealing with border disputes. It would appear prudent that Soviet border commanders of the remote outpost, which was continually confronted with a highly volatile situation, did have a good deal of authority over local events. The Chinese situation is obscured by less precise knowledge concerning the delegation of authority and by the presence of border construction troops. Certainly, in view of the history of border incidents, some rather definite procedures and limits had been previously established.

The second contingency lies in the possibility that spontaneity or simple chance sparked the fire fight; however, this appears to belabor the point. Careful preparations were made for the confrontation, the Chinese heavily outnumbered the Soviets, and the Chinese apparently resorted to deceit prior to triggering the incident.

To explain the incident in light of Chinese national politics, four possibilities present themselves: a prime issue to heal the wounds incurred by the Cultural Revolution; dissidence; diversion; and the Ninth Chinese Communist Congress.

As a possible mollifier to the Cultural Revolution, the incident appears far too ephemeral to justify the risks associated with its preparation.

Dissidence in Communist China during the latter stages of the Cultural Revolution might be a possible explanation, as that aberration was grounded in disparate groups competing for power. By the end of that cultural convulsion, the majority of these groups had been eliminated, and the military emerged as the most dominant and cohesive group. But a note is interjected here: whenever China considered herself in danger of external threat, perceptible signs of debate appeared in open publications. Regarding the Sino-Soviet border difficulties, however, no such manifestations appeared.[7]

There is a possibility that Maoist leadership elements manipulated the 2 March incident as a diversionary ploy to create anxiety, in the hope that greater cohesiveness would redound. Immediately after the Twelfth Plenum, domestic programs were initiated which corporately could have elevated tension and strife.

These actions probably had something to do also with the continued postponement of the Ninth Congress, which was to impart the stamp of approval and steer the nation through its rough political and economic seas.

There are perhaps four Chinese foreign policy extrapolations that have a bearing on the 2 March incident. First, it is possible that Chinese leaders were aware of a Soviet military buildup along the border and feared that this preparedness presaged a more ominous move; thus, the gauntlet had to be flung down. It can only be assumed that the Chinese took a calculated gamble, or they possessed information which assured them that the Soviets would not retaliate to the extreme.

Second, it is conceivable that the Chinese actually resorted to a pre-emptive attack and rationalized it by virtue of the Soviet buildup and the fact that the attack would be at the extreme end of the Soviet lines of communication.

Perhaps a third explanation lies in a revisionist theory: that the Chinese were actually under the undeniable control of Mao Tse-tung during the Cultural Revolution and the Ussuri incident was but a manifestation of his hatred towards the more despised "revisionist enemy."

Finally, the Ussuri incident was a specific manifestation of Chinese *power politics* designed to embarrass the Soviets. The year 1968 had witnessed marked deterioration in Sino-Soviet relations, and the Chinese were adamant about opposing Soviet hegemony. Examples range from support of the Czech people against Soviet aggression to bottlenecks in Soviet supplies for North Vietnam and renunciation of most direct and indirect participation in that war.[8]

The question of timing is important, for the Chinese obtained a victory not only on the Ussuri but in Berlin as well. There, the West Germans were to hold an election, which the Soviets and East Germans had denounced as illegal. Resultant propaganda and other disruptive measures clearly indicated that both Communist regimes had committed their prestige and resources to exert pressure on West Berlin and West Germany to force movement of the election to another site. But on 2 March 1969, the date of the Ussuri incident, all the threats, military shows of force, border blockades, and other actions against the election suddenly ceased, and the news media no longer reflected a threatening attitude.[9] Only a serious external threat could have compelled the Soviets to abandon such a carefully prepared campaign, and they certainly construed the Ussuri incident to be far more than just a border incident. At any rate, the major extension of Soviet foreign policy at that point in time ceased—militarily, economically, politically, and propagandistically—in order to confront the new crisis.

The general tenor of Soviet national politics during this time span was relatively stable and rational—quite dissimilar from that in China.

It is possible (and probable) that a spectrum of opinions existed between the military leaders and their political peers in the Communist Party as to what should be the proper policy towards the border problem. Other than utterances normally associated with strategy, weaponry, and preparedness, however, there were no *specific* promulgations in Soviet literature which could be connected with the Ussuri incident.

In the area of Soviet foreign policy, a number of factors come into play. The Soviets undoubtedly did not wish a major confrontation with the Chinese on the Ussuri River. In fact, they had their hands full with the aftermath of the Czechoslovakian crisis, they were deeply involved with client states in the Middle East, they were preparing for the SALT talks, and they were deeply interested in the impending election of the West German president.

There is another consideration in the assumption that it was the Soviets who actually initiated the incident on the Ussuri on a more or less pre-emptive basis. But this possibility has small credence.

Finally, there is the possibility that the Soviets, like the Chinese, decided that events

Response to the Ussuri River incident at Damansky Island was instantaneous in China and in the U.S.S.R. In Sinkiang the Chinese (left) rail against the Russians, while in Moscow (right) the Soviets reciprocate.

had gone far enough but for purposes of world opinion the Chinese were permitted the first move. While such an explanation would be in accord with Soviet preparedness moves, it does not jibe with all aspects of national politics and foreign policy. However, the Soviet Union is quite capable of masking or distorting foreign policy.

Several conclusions can be drawn concerning the Ussuri River border dispute. First, the Soviets and the Chinese are in agreement that the conflict, which first erupted some ten years ago, did not stem from their having a common frontier; however, just three years later, the border issue became a major factor in the developing schism. Second, although there is, in actuality, little to be resolved over the border treaties, the Chinese have refused to yield, both in 1964 and at the present negotiations. Third, the deadlock is not a pristine ideological dispute (as is often asserted), nor is it a simple case of rival interests clashing; it is a grinding fusion of both. It is a classic example of *power politics* between two leading world powers, with the primary prize residing in control of the international Communist movement. Communists believe in causes, whereas theories are simply factors to advance them: where the cause compels, the theories must change.

In reality, the 2 March event assumes a greater role than just a border incident. Both disputants originally endeavored to hold negotiations to resolve it.[10] Neither faction had any *concrete* advantages to be extracted, as evidenced by the fact that both sides began the talks by disagreeing as to what they were meant to be talking about.

But the motives of the Chinese Communists seem reasonably clear when one remembers their predominant and overriding charge: that the Soviets have betrayed the revolution and are not qualified to lead the international movement. This is an *ideological* claim, a *power* claim; but it is the *Soviets* who have the power and who are, in essence, leading the movement. Consequently, Communists the world over were at the bidding of Soviet "renegades," and the Chinese Communists were compelled to redress that imbalance as best they could.

Although it is arguable that the information presented is circumstantial in portraying the Ussuri incident as a means of forcing a Soviet retreat from a projected position in Europe, it is more reasonable and credible in depicting that incident as a device to undermine Soviet leadership of the Communist bloc as well as the international movement. The attack offered substantial gain at minimal risk, as Soviet worldwide commitments would not permit anything but a modest and face-saving reaction.

The indisputable fact remains that the Sino-Soviet argument is not a simple rift involving two sovereign states. The struggle is grounded in the situation of an inferior nation dealing with a "superpower" and in fierce competition for the support and allegiance of the multifaceted components that comprise the international Communist movement. In such a struggle, the motives of power, prestige, and ideology merge and tend to blend with the charisma associated with Mao, who, in turn, is the leading exponent of Communism as the "wave of the future." Such a momentous force must be controlled by pristine Chinese Communists; thus, power and ideology coalesce to result in the pinnacle of Communist commands and goals: he who controls the movement also controls history.

As for the Soviets, they are on the horns of a real dilemma. Gone are the days when a Communist Party could survive or thrive only if it were a satellite subservient to Moscow. The crushing paradox is that the more effective a Communist Party becomes as a political force, the less dependent it becomes upon Moscow—and the less useful and malleable it becomes as an instrument of Soviet policy. The Soviets can impose their control and thereby weaken the political or electoral chances of the party in their own country, or they can give free rein and thereby lose an instrument of Soviet policy outside Soviet borders. In short, they can accede to the Chinese demands or resort to military power. The option they choose will be dictated by power—Soviet or Chinese. In that light, we should recall how the article began: The problem of power is the fundamental problem of our time and will remain the basic problem of all future history.

Annandale, Virginia

Notes

1. "The Chinese-Communist Rift: Origins and Portents," *Foreign Affairs*, Vol. 42, No. 1 (October 1963), pp. 15–17.

2. W. A. Douglas Jackson, *The Russo-Chinese Borderlands* (Princeton: Van Nostrand, 1962), p. 113.

3. "Note of the University of Foreign Affairs of the People's Republic of China," New China News Agency, 3 March 1969, *Jen-min Jih-pao*, 4 March 1969, p. 1. (Translation, Survey of China Mainland Press, No. 4372, 10 March 1969, pp. 19–20.)

4. Dennis J. Doolin, *Territorial Claims in the Sino-Soviet Conflict* (Stanford: Hoover Institution, 1965), p. 31 ff. Mao Tse-tung also is on record as having made a famous statement concerning these treaties and the resultant irredenta: "About a hundred years ago, the area to the east of Baikal became Russian territory, and since then Vladivostok, Khabarovsk, Kamchatka, and other areas have been Soviet territory. We have not yet presented our account for this list."

5. *The Military Balance*, Institute for Strategic Studies, London, 1965–1970.

6. *Ibid.* Soviet modernization programs for their border garrisons exceeded in quality those implemented by the Chinese—undoubtedly due to the latter's inferior logistical base and earlier withdrawal of Soviet aid.

7. A search of appropriate *CDSP* (Current Digest Soviet Press) journals could identify no debate on the subject.

8. *China Quarterly*, No. 25, January–March 1966, pp. 48–58, 66–76, 106–14.

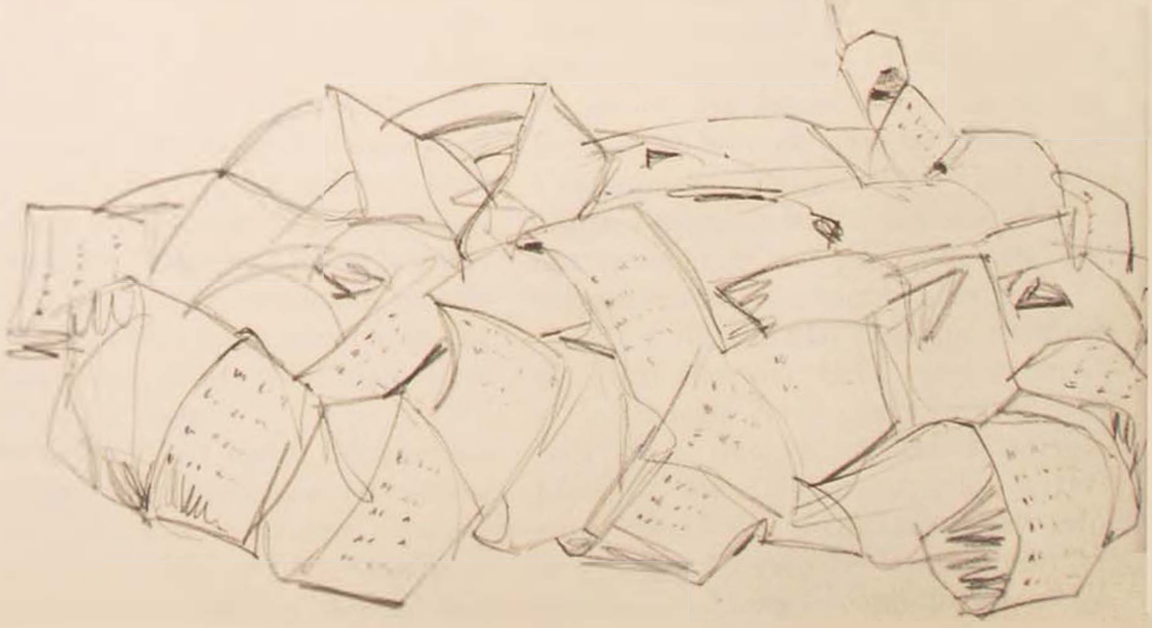
9. Press coverage from 28 February to 8 March included 22 articles in *Pravda* and 20 in *Izvestia*.

10. Major General Aleks Anikushin, "USSR Borders Are Inviolable," *Sovetskaja Rossia*, 19 March 1969, p. 3; and *CDSP*, XXI, 12 (9 April 1969), 3.

Air Force Review

MANAGEMENT USES OF COST INFORMATION

Major Frederick T. Walker



THE IDEA of "cost," expressed in monetary terms, has been an integral part of every individual's mental frame of reference for so long that it is often used as a sort of universal code word equally meaningful to just about everyone. Perhaps this is why many fledgling managers seem to be interested in "cost" for its own sake. In these days of austere funding and constant demands to reduce costs, virtually every Air Force manager needs and demands cost information. Yet often the cost information provided is useless for the intended purpose, and the manager concerned does not even recognize its inadequacy. For despite the fact that "cost" is bandied about as if it were the most explicit of words, the truth is that the word "cost," when taken out of context, has no identifiable meaning for a manager.

Management uses cost information in three distinct management activities: programming, budgeting, and operating.[1] An examination of the management uses of cost information within each of these activities may help to identify the various types of cost information and serve to demonstrate that statements such as "The cost of X is $100" have absolutely no meaning unless the *type* of cost is clearly understood.[2] It should then become apparent that in most cases management must *first* decide how cost information is to be used *before* that information can be collected.[3]

Programming and Budgeting

Within the defense establishment, programming may be thought of in terms of the annually approved Five Year Defense Program (FYDP). In essence, the programming process is that activity which itemizes those time-phased changes in mission and force structure which will be undertaken in order to attain a specified military posture at some future date. The programming objective is that military posture which must be attained in order to be able to implement a proposed military plan. To be more specific, the Joint Strategic Operations Plan (JSOP) is a *proposed* course of action to be undertaken in the event of war at some future date. The FYDP is an *approved* course of action to be undertaken now in order to develop the force structure that would be required to implement the JSOP *if* such implementation should be called for at some future time.

The programming process necessarily involves trade-offs, since there are never enough resources to satisfy every desire. Such trade-offs, however, can only be made if both the operational desirability/effectiveness and the cost of any given program are known. Here, then, is the way that cost information will be used by management in the programming activity: to ensure that a given program can be accomplished with available resources and to permit rational, objective trade-off decisions between program elements. The cost information required for this purpose is the total actual cost of each of the elements included in the program. Moreover, since the programming structure is such that only measurable costs (no allocations) are to be considered for any given program element, this type of cost information is similar to that which has been termed "Activity Cost."[4]

The concept of activity costs aggregating upwards to depict total actual program element costs for use in the programming activity has little direct impact on wing/base-level Air Force managers, since the programming activity is performed at higher organizational levels. For this reason no detailed treatment of this subject will be presented here. For present purposes, this concept is germane only to the extent that activity costs must be initially collected at wing/base level. Suffice it to say, then, that cost information collected at wing/base level must be identifiable to program elements even though this activity cost aspect of cost information will be used only at higher echelons.

The second management activity that will use cost information is the budgeting activity. In this context, "budgeting" is used in its generic sense and includes all aspects of the budgeting process—budget estimates, financial plans, operating budgets, etc. When viewed in this perspective, budgeting may be considered as a composite of three activities—requesting funds, justifying requests for funds, and planning the expenditure of funds that have been made available. These activities necessarily involve the prediction of future costs and *substantiation* of the predictions. The accuracy of these predictions determines the effectiveness of any budgeting activity.

In this regard, management uses historical cost information as a basis for predicting future costs. This is done through equating costs, extrapolating costs, developing cost estimating relationships, and similar techniques. For example, if historical data show that it cost $100 to do something last year, and if the controlling cost parameters (such as pay scales, freight charges, cost of raw materials, etc.) have not changed, then management can predict, with a high degree of confidence, that it will cost very nearly $100 to do the same thing this year. If, on the other hand, no historical cost data of any kind had been available, then management could only guess what the costs might be this year. Such guesses, of course, would not deserve nor would they receive much confidence. Cost data, then, serve two purposes in the budgeting activity: they provide a basis for predicting future costs, and they lend credence to such predictions. Such credence is of the utmost importance in budgeting. In the preceding example, for instance, when the $100 cost prediction was based on historical cost data, there is no room for hedging—if management wants the job to be done, they *must* provide $100 for that purpose.

Within the defense establishment, budgets are developed for organizational units by functional categories, corresponding to the twelve military appropriations. In order for cost information to be of use to management in the budgeting activity, it must parallel the budget format. That is, it must reflect the total costs incurred by each organizational unit and must categorize such costs by function—Officer Pay, Facility Maintenance, Family Housing, Transportation of Things, TDY Travel, etc. These types of costs may be referred to as "organizational cost" and "functional cost," respectively.

In order to relate these concepts to the introductory argument that "cost" has no meaning unless the type of cost has been identified, let us note that the statement "It costs one million dollars to operate Noname Air Force Base for one year" has several possible meanings. If the statement referred to activity costs, then it would entail only those costs attributable to the base operating support program element for Noname AFB. It would not include those costs chargeable to any mission program elements stationed at the base, such as B-52 or F-106 squadrons. If the statement had been made in reference to organizational costs, however, then it would involve those costs initially incurred by the combat support group and its subordinate units, whether or not they were chargeable to tenant units. Finally, if the statement referred to aggregated functional costs, then it would encompass all the costs incurred at Noname regardless of the unit or element incurring the cost.

We have just demonstrated three alternative meanings that could be intended by the same statement concerning cost, depending on the type of cost being discussed, and the possibilities are far from being exhausted. We have yet to consider those costs which managers use in their operating activities.

Operating—Management Control

The operating activity encompasses all the management functions involved in the day-to-day performance of organizational tasks and missions. As such, it is primarily a lower-echelon function and is, therefore, of considerable importance to wing/base-level managers. In fact, it can be said that the preponderant portion of a wing/base-level manager's efforts are expended in the operating activity. In this regard, many if not most management actions are concerned primarily with operational effectiveness, mission accomplishment, and the like—considerations which do not necessarily require cost data. Nevertheless, there are two areas of operating activity in which managers use cost information: management control and decision-making.[5]

In essence, management control is the function of ensuring that management plans and policies are implemented as intended.[6] In performing this function, cost information can help in three important ways: it can serve as a means of communication; it can be used to motivate; and it can be used as a yardstick of appraisal.[7]

communication

The communicating role of cost data is inherent in the data themselves. Their very existence constitutes a record of some activity, and the simple act of transmittal constitutes a report, be it formal or informal. Perhaps it is this characteristic of cost information that is responsible for the interest in cost information for its own sake. A cursory consideration of the communicating role of cost data could lead to the erroneous argument that, since any and all cost information by its very nature constitutes a record and/or report, any and all cost information is of use to management. This argument, however, ignores one of the basic precepts of communication: to be effective, any communication must convey the intended thought. In order to be an effective means of communication, then, cost data must be collected and presented in a fashion suitable for conveying the intended thought. This is simply another way of stating the introductory premise—cost has no meaning unless the type of cost is specified. From this discussion it follows that no special category of cost data is required in performing the communicating function. What is required is that the correct type of cost data be used, depending on the purpose of the communication.

motivation

Cost information can be used as an important tool for motivating subordinates. If nothing else, the mere collection of cost data indicates that management is concerned about costs, and this fact alone will serve to motivate subordinates to comply with management plans and policies that can be measured in terms of cost.

At this point it would be appropriate to digress for a moment and consider the importance of motivation. Motivation, really, is the only way that management can ever accomplish anything. Mr. Robert Anthony expressed this idea most succinctly:

> An obvious and fundamental fact about organizations is that they are made up of human beings. The management control process in part consists of inducing the people in an organization to do certain things and to refrain from doing others. Although for some purposes an accumulation of the costs of manufacturing a product is useful, management literally cannot "control" a product or the costs of making a product. What management does—or at least attempts to do—is control the actions of the people who are responsible for incurring these costs.[8]

Regardless of how it is attained, cost control is certainly one of the most important management objectives.[9] But, to repeat, this objective can only be realized by motivating people. However, ". . . costs can be controlled only on the basis of accurate, comprehensive, well-coordinated knowledge of their nature, amount, and reason for existence. . . ."[10] The logical consequence of these arguments is that, for management control purposes, costs must be collected *and* people must be motivated. This twofold requirement can be satisfied by measuring costs incurred and categorizing them in terms of the person or persons responsible for incurring the costs. This process will fix responsibility for costs with those individuals who have control over the costs.[11] This concept of measuring and categorizing costs as either controllable or uncontrollable serves a dual purpose: to collect the required cost data and to motivate responsible individuals toward cost control and other management objectives, thereby satisfying the need of cost data for management control.

appraisal

Closely associated with the function of motivation is the appraisal or evaluation function. As far as people are concerned, the two functions are practically inseparable—a man will be motivated to perform to the extent that he will be evaluated on his performance. Evaluation, per se, must be based on much more than just cost performance. Nevertheless, since cost performance, or efficiency, is a management objective, it must enter into evaluation to some extent. The other half of the evaluation coin is effectiveness—how well the job was done. In the military, effectiveness is rightfully considered to be more important than efficiency, and it should therefore be given primary consideration in evaluation. The problem, then, is to motivate toward efficiency and evaluate efficiency without jeopardizing effectiveness. This may be accomplished by evaluating efficiency in terms of extremes—the very good and the very bad being identified and evaluated accordingly, and all those in between being evaluated entirely on effectivenss.[12] At any rate, the same cost concepts are applicable to the appraisal of people as were developed in the preceding discussion on motivation—controllable costs and uncontrollable costs.

A further application of the appraisal function concerns the evaluation of decisions. Decisions are often based at least in part on cost considerations. In order to evaluate such decisions it is necessary to measure results in terms of the cost parameters used in the decision process.[13] It is evident, then, that the same cost considerations and categories will be used in evaluating decisions as were used in making them, and these will be considered in succeeding paragraphs.

Suffice it to say in summary that cost information is used in the management control function of the operating activity in order to communicate, to motivate, and to evaluate, and that these uses of cost information require that costs be categorized as controllable or uncontrollable.

Operating—Decision-Making

"There's more than one way to skin a cat" is a homespun adage which expresses one of the most basic and most generally accepted truisms of human activity—that there is more than one way to do anything. One of management's most basic and most frequently performed tasks is selecting the best way to do something. This, of course, is the essence of management decision-making—choosing among alternatives. Moreover, the decision-making process is one of comparing the relative effects of the various possible alternatives. Any course of action may be thought of or measured in terms of change, based on the situation existing before and after the implementation of that course of action. The more a given course of action improves a given situation (or the less it degrades the situation), the better is that alternative. Or, in the words of Haynes and Massie, ". . . decisions are based on measuring the benefits to be derived . . . against the sacrifices (costs) incurred."[14]

One of the most important aspects of cost information in the decision-making process is futurity. Decisions are concerned with the impact of alternatives on future events, not with past history. It follows, then, that "only those costs not yet incurred are important to a . . . [management] decision," and unavoidable costs should *never* even be considered in the decision-making process.[15]

This concept of future costs applicable to decision-making is clearly illustrated by W. J. Vatter's classic example of the cost of operating an automobile. The data in Table 1 depict the costs incurred relative to the operation of a family car for a one-year period.

Table 1
Annual Cost of Operating an Automobile

Item	*Annual Cost*
Depreciation	$ 500.00
Gasoline and lubricants	245.00
Tires	62.50
Garage rent	60.00
Driver's license	3.00
Registration	10.00
Insurance	139.00
Preventive maintenance	48.00
Other repairs	45.00
Miscellaneous (antifreeze, wash, wax, etc.)	27.50
Total annual cost	$1140.00
Miles driven per year	12,000
Total annual cost per mile	9½¢

If this family is considering taking a vacation trip, their decision may well hinge on transportation costs. They may also want to consider the possibility of traveling by some means other than the family car. In either case they should certainly *not* compute the cost of driving the family car on the vacation trip at 9½¢ per mile. Instead, they may consider only those costs that vary directly with the number of miles driven, such as gasoline and lubricants, tires, and preventive maintenance, which would total only 3½¢ per mile. This, too, would be far from an accurate representation of the true costs involved, for many other factors must be considered if one really wants to know the full cost of driving the family car on a vacation trip.

costs for decision-making

The effective communication of cost information for decision-making depends, in large part, on categorization of costs to reflect those aspects illustrated in the automobile example. The first requirement is to separate the costs incurred as a direct result of performing a given task from those only indirectly related to the task. These aspects may be identified as direct and indirect costs respectively.[16] All the costs listed in Table 1 are direct costs associated with owning and operating an automobile. Indirect costs would be incurred for such things as upkeep of garage and driveway, utilities for the garage, etc.

A further distinction must be made between costs that vary in direct proportion to output and those that do not, termed "variable" and "fixed" costs respectively.[17] In the illustration, gasoline and lubricants and tire replacements are examples of variable costs, and their magnitude is determined solely by the number of miles driven. Costs such as depreciation, registration, garage rent, insurance, etc., are fixed and they remain essentially the same regardless of how much the car is driven.

Of even more interest in decision-making is the distinction between costs that will be affected by a particular decision and those that will not, termed "incremental" and "sunk" costs respectively.[18] Returning to our example once more, if the family lives in a house that has a garage and driveway, the costs of these facilities are sunk costs. They have been incurred and cannot be reduced by any decision concerning the use of the family car.

Finally, a manager must consider opportunity costs (or opportunity losses). He must consider that any gain which might have resulted from employing his resources in a manner other than the one being considered must be foregone if the alternative is selected and is therefore part of the cost (sacrifice) incurred by choosing the first course of action. This aspect of cost data has been termed "implicit" cost, as opposed to "explicit" costs, which represent the resources actually consumed by the alternative selected.[10] All the costs listed in Table 1, for example, are the explicit costs of owning and operating the family automobile for one year. However, if the total amount expended could have been invested so as to earn $50 during the course of that year, then $50 is an implicit cost.

Cost information is of value to management only to the extent that it is collected and presented in a manner compatible with management's expressed purpose. The various management uses of cost data are itemized and the type or category of cost appropriate for each is identified in Table 2.

Table 2
Costs Appropriate for Management Use

Management Activity	*Appropriate Cost(s)*
Programming	Activity cost
Budgeting	Organizational cost; Functional cost
Operating	
—Management control	
Communication	As required to convey intended thought
Motivation/appraisal	
Of people	Controllable cost
Of decisions	Same as used in the decision concerned
—Decision-making	Variable/fixed cost; Direct/indirect cost; Incremental/sunk cost; Implicit/explicit cost

Since Air Force managers are continually faced with new and unanticipated problems, situations, and tasks, it is virtually impossible to begin collecting specific cost information required for the various circumstances *after* the requirement is known and still have the information available for timely action. The only practical solution to the opportune acquisition of cost data for management's use is the collection of data on a continuous basis *and identification* of each item of cost information in such a way that it can be selected and aggregated to portray any desired aspect of cost. This can be done if each element of expense is identified so as to depict

—the program element with which it is associated

—the organizational unit incurring the expense

—the functional nature of the expense

—the product or service with which it is associated (directly and/or indirectly)

—the individual(s) and/or managerial position(s) that can significantly influence the amount expended and the extent of that influence

—the nature of the expense in terms of output (fixed or variable)

—the extent to which the amount of the expense can be influenced by operating decisions.

If each element of expense is identified in these ways, then costs can be aggregated and presented to show any aspect that may be required by wing/base-level Air Force managers. However, if elements of expense are not identified to this depth, then the possible uses of cost information are correspondingly limited. Since cost data rarely are so clearly defined in the Air Force, it is imperative that Air Force managers be able to analyze the cost data available, determine what kinds of costs are represented by the data, and then be able to determine if the data are really worthwhile for their specific purpose.

Vandenberg AFB, California

Notes

1. Robert N. Anthony, "Management Uses of Expense Information," an address delivered by the Assistant Secretary of Defense (Comptroller) before the Thirteenth National Awards Banquet, Armed Forces Management Association, on 13 October 1966, p. 3.
2. Robert N. Anthony, *Management Accounting: Text and Cases*, 3d ed. (Homewood, Illinois: Richard D. Irwin, Inc., 1964), p. 6.
3. Michael Schiff and Lawrence J. Benninger, *Cost Accounting*, 2d ed. (New York: The Ronald Press Company, 1963), p. 1.
4. Howard W. Wright, *Accounting for Defense Contracts* (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1962), p. 51.
5. Anthony, *Management Accounting*, pp. 3–6.
6. Bradford Cadmus and Arthur J. E. Child, *Internal Control Against Fraud and Waste* (New York: Prentice-Hall, Inc., 1953), p. 5.
7. Anthony, *Management Accounting*, pp. 3–5.
8. *Ibid.*, pp. 361–62.
9. Carl Thomas Devine, *Cost Accounting and Analysis* (New York: The Macmillan Company, 1950), p. 9.
10. Stanley B. Henrici, *Standard Costs for Manufacturing*, 2d ed. (New York: McGraw-Hill Book Company, Inc., 1953), p. 3.
11. Cadmus and Child, p. 5.
12. *Ibid.*
13. *Ibid.*
14. Warren W. Haynes and Joseph L. Massie, *Management: Analysis, Concepts and Cases* (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1961), p. 274.
15. *Ibid.*
16. *Ibid.*, p. 283.
17. *Ibid.*
18. *Ibid.*
19. *Ibid.*

EQUIPMENT READINESS

JEROME G. PEPPERS, JR.

THROUGHOUT his existence on this planet, man has found it necessary to develop weapons of many kinds to protect himself from animals and other men. Warfare has been a major concern to him in all his levels of development as it is today to us. Not all men have required offensive forces; some armed themselves only for protection. Even so, mankind has found some form of armed might essential, and this has caused the maintenance of weaponry to be of serious concern for society's leaders. Man's weapons of defense and offense, through technological advancements, have become more powerful and more complex. As this has occurred, so, too, has an increased concern about their readiness for use.

Maintenance of military weapons and equipment is an integral part of defense capability. In today's world, the ability of military forces to react instantaneously is essential to national survival. This ability cannot exist unless an optimum quantity of mission-essential equipment is maintained in a mission-ready state. For this reason, equipment maintenance capability is provided for in the organizational structure of every military unit designed for combat or combat support. Maintenance capability consists of trained people and adequate tools, equipment, facilities, technical data, supply support, and materials. Maintenance managers are provided to insure the effective use of maintenance capability in attaining and retaining the required mission equipment readiness.

Until recently the man himself was relied upon for military effectiveness. He was equipped and, with reasonable care, could be relied upon to use his equipment to accomplish the mission. This is not true today. Today we man equipment and recognize that the condition of the equipment is at least as important as the condition of the man for military needs. In fact, the assigned mission of most units could not be accomplished without a certain quantity of mission equipment ready and capable. The man, though still essential, cannot perform unaided. A pilot is of little mission value if his aircraft is unable to fly. A tank commander is crippled if his tank is unable to move, or fire, or communicate. Equipment readiness seems to be an absolute military essential.

It is impossible to predict when, where, or in what manner our military strength might be needed. The requirement may come during a cold-war tension period or in a limited-war commitment. The threat of sudden attack and the possibility of general war add other uncertainties to the situation. Because of this uncertainty we must be prepared to meet the worst conceivable situation that would require instantaneous response ability. This places a great burden on the tactical commander and emphasizes the urgent requirement for effective equipment maintenance. The burden of the readiness mission is borne by maintenance, and it is essential that each maintenance manager and technician understand his responsibilities to his unit and his country.

Maintenance capability is developed to acquire and retain a specified state of equipment readiness for the tactical unit. The measure of maintenance success is the achieved state of equipment readiness. Therefore, maintenance receives its reason for being and its measure of success from the same source: equipment readiness. There is no more valid reason for maintenance in the tactical organization, and maintenance effectiveness thus becomes a primary factor in determining unit capability. This places the maintenance manager in a position of great importance and largely explains the growing command interest in maintenance operations.

We have not always had the present emphasis on readiness. Never before was the need so pressing. Many times in our history we have hastily scrambled to marshal resources to meet a developing need. Our ocean barriers permitted the luxury of rising to the occasion after the need for military strength was established. The 1940 conscription act is one example; the Berlin crisis and Korea are two others of recent history. In each of these instances we were able to meet the challenge because, fortunately, time to get ready was available. There is no assurance that the same fortunate circumstances will again exist.

Historical reviews and analyses following the Cuban missile crisis of 1963 revealed that some military units reported as combat-ready were, in fact, not ready because of the inability of equipment to perform as required. Some units were "combat-ready" only in the sense that command personnel felt they were. The dangers of this delusion were well expressed by General David M. Shoup, USMC:

> In determining operational effectiveness, do not delude yourself or higher command. Do not, as has been alleged, confuse willingness with readiness. Willingness is a state of mind, readiness is a matter of fact—report the facts.

General Shoup's astute observation succinctly places the problem in perspective. We must have ready equipment to have unit readiness. While other factors also enter into consideration, this one is primary. No reporting official (commander or manager) should ever report anything other than the facts of condition that actually exists. None should confuse the issue by reporting what he wishes existed rather than what actually does.

The Department of Defense has in-being today an equipment-readiness reporting system. The specific details may be found in DOD publications and the implementing directives of the military departments. Air Force Manual 65–110 serves this purpose for the Air Force, but since it is subject to change, this article will not attempt to relate to it. Rather, it describes the philosophy and concepts less likely to change.

Maintenance organizations are designed to provide the degree of equipment readiness required to accomplish the assigned unit missions. To do this, maintenance is expected to perform three basic functions:

preventive maintenance – routine scheduled attention to the equipment, to keep it safely and effectively operable;

corrective maintenance – repairing or rebuilding to rectify failure, malfunction, or damage;

qualitative maintenance – approved modification, alteration, or retrofit, to improve safety, correct defects, or improve or change performance characteristics to meet mission requirements.

The management of this maintenance effort is extremely important. Management must determine the priorities necessary for the correct application of maintenance resources. To do this, management must clearly identify and understand the unit mission-essential equipment. Further, management must communicate the mission and mission needs intelligibly to all personnel involved directly or in a support role.

Not all equipment used in the Department of Defense is mission-essential. Some items are simply convenient. Others are time-savers. But many items are of such nature that mission success is doubtful if they are not available or if they are available but not fully operable. Infantry weapons, tactical aircraft, and ships are rather obvious examples of mission-essential equipment. The specific identification of mission-essential equipment must be known by command and maintenance personnel to insure intelligent application of resources in proper priority to attain and retain the required readiness posture. However, mere identification of the mission-essential equipment is not enough. Command and management people must also know how many of each type of equipment the unit needs for the mission and how many are on hand. Such "inventory" information is imperative at unit level and equally important at each succeeding echelon of the military structure. It is needed for planning operational programs, establishing mission assignments, and selecting units for target assignments. Further, it is needed for supply support, procurement, and other functions in logistics support and budgetary activities. Thus, the first knowledge element for equipment readiness involves identification and inventory distribution of mission-essential equipment.

For readiness purposes, equipment is either ready or not ready. But the real world does not permit such simplicity; readiness reporting, while based on those two possible conditions, has complications and definition requirements.

To begin with, the total item of equipment must be thought of as a collection of systems, subsystems, and components. It is not sufficient to think of an aircraft, for example, merely as a highly mobile piece of firepower equipment. There is more to it than that. There is, for example, a propulsion system within the airframe system. There is also a fire-control system, a communication system, and more. Even the knowledge of system structure is not adequate in itself because not all systems are essential to mission ability. Some systems are for redundancy or backup capability. Some are efficiency systems rather than effectiveness systems. In view of this, the second essential knowledge element for equipment readiness is the identification of those equipment systems and/or subsystems (and sometimes individual components) that are absolutely required to perform the assigned mission or missions.

Normally, the identification of mission-essential systems, subsystems, or components is determined by a higher element of authority. The identification listing of these essentials, with full realization of the assigned and possible mission requirements, will be found in military department or major command directives. The listing must (absolutely must) be known, with familiarity and understanding, by the maintenance manager in order to establish logically mission-oriented priority-action direction to his people. Any direction for maintenance action without this consideration could only be coincidentally effective for readiness requirements.

After the manager knows what equipment is involved and knows its mission-essential elements, the third essential readiness knowledge element he must have is the current up-to-the-minute status and condition of the equipment and its mission-essential elements. Without this information the manager works in the dark and is unable to do his job intelligently. Therefore, an efficient information flow must exist to accurately provide status and condition data. Maintenance control, whether it be the maintenance manager himself or an organizational entity specifically manned for that purpose, must receive this information on a timely basis, digest it, determine its impact on readiness, and direct application of maintenance resources wherever action or work is required, in proper priority. It is at this point that equipment readiness is attained or lost. Certainly, at this point management must be most effective. No matter how well the three maintenance functions are performed, they will not be readiness-effective if the described data flow and maintenance control are not timely and pertinent to the readiness objective.

Status information will determine current readiness condition. This may be either operationally ready or not operationally ready, as dictated by the status and condition of the mission-essential systems, subsystems, and components. Those equipments classed operationally ready (OR) will be safe to use and able to perform the mission or missions of the unit. Those not operationally ready (NOR) will be either unsafe or unable to perform, or both. Logically, most management attention will be applied to those items not operationally ready, so they may be expeditiously returned to a ready condition.

Specific definitions for the terms "operationally ready" and "not operationally ready" are contained in the AFM 65–110 readiness reporting directive. Command and management personnel are encouraged to learn these definitions and exercise their management skills with full appreciation of the readiness requirements and directions.

Periodic reporting of the distribution and condition of mission-essential equipment is required. The reports are submitted by the operational unit to inform those who need this intelligence at each hierarchical level up to and including the Office of the Secretary of Defense and, often, the President and the Congress. The data are essential for many operational and command requirements as well as for logistic, budget, and other purposes. *The data are used* and must be accurate, factual, and in no way colored by desires or wishes of what might be or might have been.

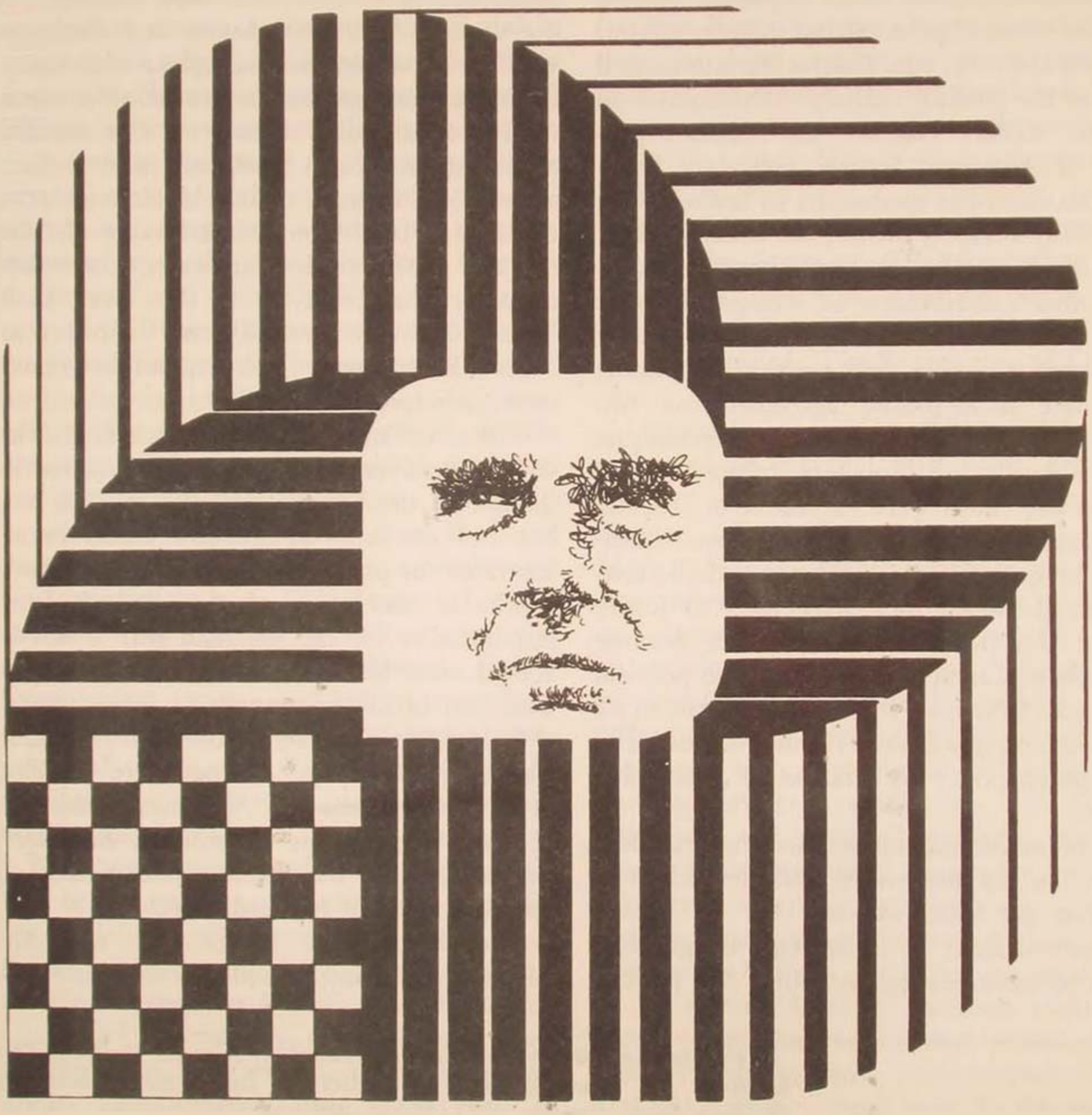
Readiness reports inform people who make decisions. Decisions are based upon judgment. Judgment can be no better than the available information about and the knowledge of the situation. The quality of readiness information affects the decision judgment of an untold number of people in every element of national defense. We can afford only realistic judgment and resource allocation in this vital area. Therefore, maintenance managers, and their commanders, must insure absolute honesty and accuracy in reporting equipment readiness. Further, they must insure an intelligent application of maintenance capability to improve the unit readiness condition and correct the causes of nonready equipment. This is their job. The nation depends upon that job being done efficiently and effectively. The end result is a major role in determining our nation's future.

Air Force Institute of Technology

Books and Ideas

THE CIVILIAN ANALYSTS, IN THEIR PRIDE AND THEIR FALL

Brigadier General Noel F. Parrish, USAF (Ret)



TWELVE years ago the Institute for Strategic Studies was founded in London, and just two years ago the annual conference of its members heard some remarkable papers on the progress of strategic studies during the life of the Institute. Now a small volume has appeared containing nine of these commentaries on what has happened to strategy during a decade that began with misplaced enthusiasm and has ended with exaggerated disillusionment.†

The star contributors to the volume are Raymond Aron, the most respected French observer of world political and military affairs; Michael Howard, who follows the late Liddell Hart as the leading military commentator in Britain; Robert Osgood, the eminent professor of American foreign policy at Johns Hopkins, who has specialized in limited war; and finally Bernard Brodie, the acknowledged dean of all nuclear analysts (nonstatistical). Five other contributors, all eminent in their more specialized fields, will be cited later.

The essays vary in style, content, and value, but there is surprising agreement on two points: First, that the analytical techniques used in developing a nuclear strategy or posture in the 1950s were successful in creating a delicate balance of terror, but these statistical techniques failed disastrously in the following decade when they were used to justify limited conventional wars. Second, because this misapplication of method violated political and social principles that are dominant in all grand strategy, we have reached a dead end in military policy as well as in diplomatic policy.

In international politics and international affairs, an era has ended with few clues as to what the next will be like. In Robert Osgood's words: ". . . strategic imagination seems to have reached a rather flat plateau surrounded by a bland atmosphere in which all military concerns tend to dissolve into the background." (p. 104) What has brought things to such a pass? In two words: overconfidence and failure.

Quoting Bernard Brodie, ". . . if pride goeth before a fall, members of the American strategic fraternity have had both their pride and their fall." (p. 174) Raymond Aron, in the first essay of the book, begins the story of how it came about: "In 1961 the analysts arrived at the White House with President Kennedy; there and then they worked out the various deterrent schemes and discussed with great passion the strategic or diplomatic doctrines that one can arrive at as a result of theoretical elaboration. . . . The analysts are living their 'finest hour,' and most of them approve, in essence, of the McNamara doctrine." (p. 16) Aron speaks further of "the *rise and decline* of nuclear strategy, or rather of the civilian analysts. If they lived their 'finest hour' with Kennedy, the Vietnam war —for which they are not responsible—represents their epitaph." (p. 20)

The term "epitaph" is much too final. The civilian analysts have become indispensable, though in the future they may be "on tap but not on top" as military leaders once described the position of specialists. But Aron's charitable absolution of the analysts from responsibility for the Vietnam war is not in accord with his more detailed judgment or with that of his colleagues.

Aron maintains that all the useful thinking was done before the analysts were installed in positions of power: ". . . towards the end of the 1950s all the main ideas had been worked out, all the theories constructed, all the doctrines put forward." (p. 17)

Michael Howard agrees that with the advent of Kennedy and McNamara "not

† ***Problems of Modern Strategy*, Foreword by Alastair Buchan. The Institute for Strategic Studies, Studies in International Security: 14 (New York: Praeger, 1970, $7.50), 219 pp.**

entirely coincidentally, the great period of American intellectual strategic speculation came to an end, after five astonishingly fruitful years. The military intellectuals were either drawn, like Kaufmann and Hilsman, into government, or returned to more orthodox studies on university campuses." (p. 67) He says "The principles established by the thinkers of the 1950s were to guide Mr McNamara in his work of remoulding American defence policy . . . 'The McNamara Strategy' had a logical coherence—almost an elegance—which may have commanded rather more admiration among academics than it did in the world of affairs. . . . European allies flatly refused McNamara's requests that they should increase their conventional forces to provide the necessary 'spectrum of deterrence'. . . . Several of Mr McNamara's emissaries received, in consequence, a somewhat gruelling introduction to the refractory world of international affairs." (pp. 67–69)

In turn, Robert Osgood, who once stressed "the need to provide the appropriate forces for the fighting of limited wars" (p. 60), now admits that "although the logic of flexible and controlled response prevailed on paper and in strategic pronouncements, the means to withstand anything more than the most limited attack for longer than a week were not forthcoming." (p. 102) Osgood does not mention what veterans of military or diplomatic service in the North Atlantic Treaty Organization (NATO) had known throughout the 1950s: that the pretense of possible conventional parity with Red forces across the European peninsula was just an academic exercise all along.

Now, says Osgood, after "the inroads of time upon novel plans . . . limited-war thinking is left somewhere between the initial Kennedy-McNamara views and the approach of the Eisenhower-Dulles administration." (p. 104) Unfortunately, after two more years of indecision in Vietnam, the Eisenhower-Dulles administration may be recalled as positively enthusiastic about limited war when compared with the mood of the nation today.

In Aron's view the second Cuban crisis (certainly not the first) "marks the triumph of the analyst" while "the Vietnam war points to his decline and compromises his prestige." (p. 32) Over Cuba the threat of escalation that we posed by mobilizing was persuasive, but over North Vietnam the practice of escalation has been ineffective. Aron does not examine the reasons why the threat over Cuba was unhesitant and apparently unlimited while that over Hanoi was apologetic and vacillating, and this is unfortunate, for the reasons have to do more with the personal role of the Secretary of Defense than with his analysts. Yet Aron is far less severe in his judgment of the analysts than is Osgood in his chapter, entitled "The Reappraisal of Limited War."

Osgood agrees with Urs Schwarz (the Swiss author of an excellent little book, *American Strategy—A New Perspective*), whose brief chapter, "Great Power Intervention in the Modern World," makes the point historically that unilateral intervention such as we essayed in Vietnam is an out-of-date gamble against impossible odds, regardless of the techniques employed. Osgood accuses his more pontifical colleagues in the study of limited war of being entranced with strategies at the expense of showing proper consideration for feasible objectives and political realities. He says bluntly that one cause of the neglect for political factors was "the propensity of American civilian strategists to propound their ideas, often with brilliant ingenuity, as revelations of an esoteric body of learning (which to some extent they were) that would rescue military thinking from conventional wisdom and put it on a rational basis. In this respect, however, the deference of the uninitiated, overawed by the secrets and rituals of the strategic priesthood, has been more important than the pretensions of the priests." (p. 97)

Osgood apparently agrees with Aron that conceptual elaborations of strategies are basically so simple that "unlike economic models of the same type, they do not even demand a subtlety of intellect in any way out of the ordinary," and with Aron's quotation from Napoleon: " 'Strategy is a simple art, it's just a matter of execution'." (p. 21) He is not content with this blast at the "priesthood" but goes on to more serious accusations. He remembers that "in the Kennedy Administration limited war became official doctrine and achieved something approaching popularity." (p. 93)

As an insider of the now quiescent fraternity of "limited warriors," Osgood is in a position to strike below the intellect in reaching the heart of the problem "Why Vietnam?": ". . . there was no inducement to question the premises about the wisdom and efficacy of intervention that underlay the prevailing American approach to limited war. The tendency was, rather, to complete the confirmation of a decade of limited-war thinking by proving the latest and most sophisticated concepts in action." (p. 99) This is a rather startling admission: that proponents of strategic doctrines may sometimes seek to have their conclusions tested in combat, just as developers of weapons are accused of doing. I am reminded of a platform encounter with an enthusiastic advocate of passive resistance who impatiently urged the unilateral disarmament and consequent occupation of his own country so that the efficacy of nonviolent revolt could be demonstrated. Fortunately most men whose professions deal with disaster—and this includes military men—are not too anxious to test their skills in unnecessary action.

Why were the "limited warriors" among the intellectuals so highly motivated in their crusade? Osgood explains that they sought "to save American military policies from the thralldom of misguided budgetary restrictions . . . they rejected the thesis of the Eisenhower-Dulles Administration that the United States would spend itself into bankruptcy if it prepared to fight local aggression locally at places and with weapons of the enemy's choosing. ¶ With the advent of the Kennedy Administration the revisionists came into office. Responding to a dominant theme in Kennedy's campaign, they were determined to fill the military gaps in containment. . . . The only remaining gap in military containment might be closed if the United States could demonstrate in Vietnam that wars of national liberation must fail." (pp. 98–99)

But why were "gaps" in defense the dominant theme in Kennedy's campaign? Michael Howard is most helpful here. He points out that "the first western government to adopt the concept of 'deterrence' as the basis of its military policy was that of the United Kingdom in 1952; very largely thanks to the thinking of Marshal of the Royal Air Force, Sir John Slessor, the then Chairman of the Chiefs of Staff." (p. 53) Howard does not say so, but it is known that the concept was officially rejected in the United States by General Omar Bradley, of the United States Army, who was then Chairman of the Joint Chiefs of Staff. Yet nuclear deterrence was even then, at the height of the Korean War, the *de facto* policy of the United States, as it had been ever since the bombing of Hiroshima and Nagasaki and the whirlwind demobilization of United States ground, sea, and air forces at the end of World War II. Other means of containing massive Red ground and air forces on the central Eurasian land mass simply did not exist.

The cost—in both casualties and resources—of trying to contain the new Chinese army on one small peninsula most favorable for defense had caused, in Howard's words, "American weariness with the Korean War, and the desire of the Republican Party to return to financial 'normalcy' " through the open avowal, at last, of "massive retaliation" as policy. Howard continues, "It should perhaps be judged, not as a coherent strategic doctrine, but as a political expedient—or even as a diplomatic communication, itself a manœuvre in a politico-military strategy of 'deterrence'. By these criteria the policy must be pronounced not ineffective. But its logical fallacies were too glaring to be overlooked." (p. 58)

Logical fallacies, both Howard and Aron are at pains to emphasize, are inherent in the concept of "deterrence," which, as Howard says, "takes us out of the familiar field of military strategy into the unmapped if not unfamiliar territory of political bargaining, where total rationality does not invariably reign supreme." (p. 56) Moreover, while the conventional forces of the West were stalled in Korea and defeated in Vietnam, nuclear weapons were not used at all, and the influence of the threat of their use was difficult to measure.

Howard continues: "These, and other points, were rapidly made with force and relish by Democrat politicians and sympathizers out of office, by academic specialists, and by members of the armed services which were being cut back to provide greater resources for the Strategic Air Command. ¶ There has perhaps never been a strategic controversy which has not been fuelled by political passions and service interests. It is entirely understandable, and for our purposes quite unimportant, that the US Air Force should have sought every argument to justify the doctrine of massive retaliation while the US Army powerfully supported its opponents. What is significant, however, is that the latter included every strategic thinker of any consequence in the United States. . . ." (p. 59)

One may quarrel with Howard's statement for several reasons, especially for his term "strategic thinker of any consequence." Obviously, there were a number of people in the Department of Defense and even a few in the Department of State who thought rather hard about these matters. Since their thinking became policy, it can scarcely be dismissed as of no consequence, any more than that of the academic thinkers whose influence came —and went—a few years later. The fact that they were too busy to write books and monographs at the moment was in itself consequential—just as it was consequential under a new regime, as the authors of this volume generally agree, that the "thinkers" in power were too busy with doctrine, formulae, graphs, and pronouncements to implement an effective policy in Vietnam. Howard himself, in another context, displays a rare insight into what is often the low-level (military) source of high-level (academic) elaboration.

The academic strategist need not, in Howard's view, remain at the commander's elbow, for there his advice may appear "either platitudinous or impracticable." (p. 49) Strategy is not a science but is rather, as Voltaire described it, "murderous and conjectural." (p. 48 n) Systems analysis may simplify problems (or complicate them), but it cannot eliminate them. The academic role is to widen the commander's range of thought, to educate his guesses.

Yet even where great commanders have followed specific principles, it is difficult to prove that these were derived from specific theorists. What, then, might be their derivation? Howard admits a truth too little known: "The most eminent thinkers sometimes do no more than codify and clarify conclusions which arise so naturally from the circumstances of the time that they occur simultaneously to those obscurer, but more influential figures who write training manuals and teach in service colleges. And sometimes strategic doctrines may be widely held which cannot be attributed to any specific thinkers, but represent simply the consensus of opinion among a large number of professionals who had undergone a formative common experience." (p. 49)

"The name of Douhet," for example, "was virtually unknown in the Royal Air Force. . . ." (p. 49) To American airmen that name, even if they heard it, sounded more like an admiral at Manila Bay than an untranslated Italian. They did not even bother to read the tirades of their naval colleagues that told them whose disciple they were. In fact, they read little of anything, and they wrote even less, for such was their tradition. The reasons for this are too numerous to cite here, other than to mention that although they listened in classes to scholars with glasses, airmen never wore them.

Howard has, after all, a valid point in his observation that the few well-known academic strategists who were writing in the late 1950s represented what was considered an Army viewpoint and were outside the establishment, while in the 1960s they tended to become a part of it. As Aron expressed it: "The analysts of nuclear problems [or of global strategy in the nuclear age] have become the diplomatic counsellors of the Prince, for the evil or the glory of Princes and analysts." (p. 16)

With the defense of the West in its most deflated state since 1949 and with American military affairs the most demoralized since Woodrow Wilson's occupation of Vera Cruz, "princes and analysts" are now more troubled by evil than dazzled by glory. Complaints against the analysts are not merely that they were "too much" but that they were too much of a kind. Brodie regrets that the recent "impressive development of systems analysis and of related techniques . . . has fostered the notion that selection of future weapons systems for appropriate development and deployment represents most of what there is to modern military strategy. I suspect that the former American Secretary of Defense, Mr Robert S. McNamara, tended automatically to think in such terms. Military history, which used to be the main acknowledged source of strategic insight—Clausewitz and Mahan are examples—has been enormously down-graded in favour of the new analytical techniques." (p. 160)

Neither Brodie nor the other contributors question the usefulness of analytical techniques, but they deplore the notion that statistics can substitute for understanding the human elements and value judgments involved in every major decision. Brodie suggests that "under the seven critical years of the regime of Mr McNamara" this notion prevailed so that "what should have been supplementary talent tended in fact to become pre-emptive of the field of strategic study." (p. 170) Disciplined thinking at "the mostly tactical levels at which systems analysis is applicable" did not prevent "sloppy thinking" in areas of inquiry where the best practitioners of the art, such as Charles J. Hitch, agreed that systems analysis "has no real applicability." Brodie refers to Amrom Katz, a RAND expert with a talent for humility, in his comment that charts are a temptation because "one can present only data on them, usually in the form of numbers" (Amrom H. Katz, "The Short Run and the Long Walk," *Air Force,* June 1967) and that the proliferation of charts leads to listing whatever data are available and pretending they are relevant.

In Vietnam, for example, with no front lines whose movement might be an indication of gain or loss, "our 'winning' is demonstrated by the use of charts containing data" that may be neither accurate nor relevant while the enemy is probably using a very different method of measurement. (p. 171) Few of the frustrations encountered in Vietnam, Brodie recalls, were "taken into account in the kinds of war games, scenarios and cost-effectiveness analyses done at places like RAND over the past twenty years." (pp. 171–72) He concedes that the restraint we have imposed upon ourselves by not invading North Vietnam "was, surely, a correct one; what was incorrect was our failing to appreciate the military burden it entailed." (p. 173)

Osgood agrees that "probably no American leader would have considered the eventual scale of war worth the costs if he had known the costs in advance"; and he adds that perhaps the strategy which "has come closest to a clear-cut failure is controlled escalation, as applied by means of selective bombing in North Vietnam." (pp. 108–9) (Unlike Brodie, Osgood ignores our failure to invade.) Nevertheless, Osgood warns against sweeping conclusions, since the purpose of our bombing was ambiguous. Was it for strategic bargaining or for purely tactical military reasons? Perhaps it is too difficult to bomb an underdeveloped country for bargaining purposes, perhaps our aims and methods in comparison to theirs were too limited and hesitant, and, most significantly, "Perhaps controlled escalation exerts the desired political effect only when there is a convincing prospect of nuclear war at the top of the ladder." (p. 110)

According to Aron, it is the nuclear threat, rather than any conventional balance, that has inhibited *"limited wars between the states which hold the supreme weapons."* (p. 21; Aron's italics) In a chapter which reviews the status of arms control, Hedley Bull is sufficiently undistracted by Vietnam to keep watch on "the field of Soviet-American competition in strategic nuclear armaments. It is this field which is the most sensitive of all areas of military activity at the present time, because on it the whole structure of power in the world depends." (p. 155) Brodie is understandably concerned about the degeneration of debate on competitive nuclear systems into epithet-terms such as "overkill," "assured destruction," and other "unappetizing word figures" which indicate "much dogmatism but little searching inquiry." There is agreement that nuclear weapons are effectively sealed from use, "but should it mean effectively a promise of non-use under almost any circumstances? If so, the utility of these systems-in-being will inevitably be much diminished, and that utility is presently high. They make major war between the superpowers and between their respective alliance systems certainly much less likely than without them and perhaps critically so." (p. 168) (This problem was explored in greater detail in an article by this reviewer entitled, "Effective Aerospace Power—1. Deterrence: The Hard Questions," in *Air University Quarterly Review,* XII, 3 and 4 [Winter-Spring, 1960–61], 148–52.)

Here again, as often in past years, Brodie issues a timely warning against the recurrent notion that nuclear warfare is already a solved equation. The smug assumption that nuclear weapons "automatically cancelled each other"—or that at least competition in nuclear weapons would become stabilized as soon as the Russians became satisfied with happy parity—was characteristic of the "newthink" of the early 1960s. Such an assumption helped to divert attention to new projects in conventional armaments, counterinsurgency, and the like. Now, against a rising tide of obscurantism, Brodie's informed colleagues again express views similar to his. Only Hedley Bull, in far-off Australia, seems inclined to postpone concern about ballistic missile defense, multiple re-entry vehicles, and improvement of submarine detection, because "experts do not now expect that trends such as these will undermine the situation of mutual deterrence within the foreseeable future." (p. 145) The other writers have talked to more anxious experts or remembered the history of visions of stability in the past. Bull himself recognizes that "mutual deterrence remains 'delicate' or unstable in principle . . . ." (p. 145)

"The Delicate Balance of Terror," Albert Wohlstetter's famous article in *Foreign Affairs* (January 1959), has driven its thesis and its inspired but uninspiring title into modern consciousness as perhaps no other magazine article has done. Howard and Aron both cite it as the classic climax of Russo-American thought and progress in deterrence and counterdeterrence, not only for the fifties but to this day. Aron recognizes there is no certainty as to the result "if one of the two super-powers was to try, by a sudden act of aggression carried out with all the resources at its disposal, to disarm and force the capitulation of the other. And it remains still more true that technical research continues to improve both the shell and the armour, the bombs and the means of delivery: the equilibrium of terror is then never completely stable." (p. 17) Howard cites the view that the maintenance of stability will require continued thought and effort plus "a certain reciprocity from the Soviet Union." (p. 64)

The same view, though much broader in its scope, is expressed by a German philosopher-scientist with the formidable name of Carl-Friedrich Freiherr von Weizsaecker in a truly remarkable chapter, "The Ethical Problem of Modern Strategy." Von Weizsaecker is a pacifist in the finest sense of the term, for he seeks to understand and solve rather than to assume and pontificate. Once Professor of Physics, now Professor of Philosophy at the University of Hamburg, von Weizsaecker says his participation in church committees on atomic weapons has proved fruitless except for studies showing that "effective ethical verdicts were confined to those weapons whose use would not turn the scales of war." He believes the atomic weapon will be used when "not using it would no longer mean to refrain from one possible means to an end, but to renounce the very end, e.g., the freedom of one's own country." At present, we have a "lucky technological situation" in which the use of the weapon does not seem vital to any power. "Technology, however, may change. . . . The technology of war does not stabilize itself automatically—peace must rest on a political stabilization." (pp. 123–26) In the same vein, Aron asserts that to prefer death to surrender "is by no means irrational, since wise men have never suggested that one should prefer life to the reasons for living." (p. 44)

Yet, von Weizsaecker says, "the average man cannot induce himself to think of his own death as a quantity in a probability game, and he is right in that. He may be unable to express himself consistently, but he feels that what we protect by this sort of deterrence is not yet peace but a delicate, haphazard truce." Mathematical estimates of probabilities are useful as "the most rational way of expressing the ideas of our strategy of deterrence," but they are at "a level of abstraction which is not common in mankind" and they display an ethical weakness. Yet von Weizsaecker sees our delicate balance of terror as an approximate temporary solution whose inventors "deserve respect on ethical grounds." He offers no easy solutions, for "to think of a better solution of the problem than the World State is a challenge to our political inventiveness." He understands that "disarmament is a consequence of a *détente* rather than its start." (pp. 129–33)

Equally sensible comments on developments in disarmament over a critical decade are made by Hedley Bull, formerly director of the British Arms Control and Disarmament Research Unit (1964–67). During this period arms control has replaced disarmament as a method for peace, for it recognizes the "possibility of reciprocation and co-operation even between potential enemies . . . ." (p. 141, quoting Thomas C. Schelling and Morton H. Halperin's *Strategy and Arms Control,* p. 2) Because of the inescapable logic and the unique success of arms control measures, the formerly troublesome advocates of general and complete disarmament (GCD) are no longer influential. The attention of radical groups, especially of violently radical groups, is now focused on other matters.

There are difficulties, of course, even with nonexistent disarmament. There is danger of disillusionment over logic or mathematics as a solution for disarmament just as previous generations hoped in vain for "the moral transformation of mankind." Bull also recognizes the difficulties of "translating the uncertain and constantly changing balance of power into the precision and fixity of a treaty." He warns that "in the accumulation of merely symbolic or hortatory treaties there is a risk that we shall repeat the errors of the 1920s and become the victims of our own illusion-making." (pp. 154 and 156)

In the strangest of all the chapters, Kenneth Boulding, an economics and behavioral science professor and a director of research in "conflict resolution," maintains that practically everything is an illusion. He quotes British philosopher David Hume to the effect that reality and mental images are incomparable. But Boulding states that "the whole organization of the international system is designed, not only to create false images in the minds of the decision-maker," etc. (p. 82)

More disturbing are Boulding's perverse declarations that all historians are "deterministic" and assertions such as "The major human conflict is seen as between the world war industry and the civilian population and enterprise which supports it, rather than between national states." (p. 88) A more typical example of the kind of language that captivates disturbed and bewildered collegians at the moment is this sentence: "In these days there is not much glorification of war as an end in itself, though what might be called the martial virtues of courage, fortitude, gallantry and so on, continue to be somewhat covertly admired even though the martial style is somewhat alien to the academic and reflective life." (p. 88) That was Boulding's most interesting sentence. The remainder of his essay can be overlooked with profit.

It would be wrong to conclude this review without a few words in explanation or defense of the strategic analysts who have been rather severely taken to task by their colleagues in some of the passages I have quoted, as well as in others not mentioned. Howard concludes with a fair judgment of these strategic thinkers: "Like Clausewitz and Mahan they are children of their time, and their views are formed by historical and technological conditions whose transformation may well render them out of date." (p. 67) Well, Clausewitz and Mahan are not yet entirely out of date, especially Clausewitz.

Howard and Aron, not unlike many others, are a bit severe with Herman Kahn, who is, after all, a large target. Howard admits the claims of Kahn's critics do not stand up to "dispassionate analysis" but says he made only two new contributions to the nuclear debate: first, that substantial survival is possible; second, that nuclear war must be controlled, through an effort to coerce the enemy, rather than to engage him in mutual destruction. Two more-important contributions could hardly be made, and after all, as Brodie observes, "The opportunities for concocting fresh generalizations in this area are not what they once were." (p. 159)

Howard is not alone in deploring Kahn's "grim jocularity" of style throughout his "huge and baroque study *On Thermonuclear War*." Who can decree that the great Kahn, a vast pleasure dome himself, sometimes called the great smiling Buddha, should be other than jocular even if it causes people like James R. Newman to become "hysterically vitriolic"? Few give Kahn the credit he deserves for bringing a lethal problem out of windowless rooms and into relatively unpolluted air.

Aron takes both Kahn and Schelling to task at considerable length over their construction of "models" to represent strategic situations. He thinks that this practice, while useful, causes analysts to slight their study of each true situation. Aron does not recognize the ingenuity these men had to exercise to pierce the wall of security classification that enclosed them. It was once this reviewer's strange duty to examine all RAND writings to determine whether any of them had to do with circumstances such as might cause the United States to surrender. The Congress, in the marathon "silly surrender" debate that was a part of the post-Sputnik hysteria, had decreed that no government-supported researcher should ever consider the possibility of surrender. Thomas Schelling's algebraic elaborations on what might happen to "Country A" or "Country B" made tedious reading, but they passed inspection.

Finally, it is unfair to blame the analysts for what Brodie once entitled "The McNamara Phenomenon." Only a few came to power in the famous anterooms of the Secretary, and such power is well diluted. Further, while Mr. McNamara brought no strategic ideas from his motor company, he did bring some attitudes which his advisers were powerless to change. As a former lieutenant colonel of statistics in the Air Force, he knew how to use statistics to a purpose—often a purpose that met the needs or desires of his commander or himself and not exclusively a purpose logically derived from the figures themselves. As lawyers learn to become their own clients and so get elected to office, as public relations practitioners learn to sell themselves along with their sponsor's assets, so are statisticians often expected to produce for their employers figures to support whatever needs to be supported.

What military man has not heard commanders, in their occupational blindness, demand legal officers who "can tell me how to do what I want to do and not why I can't" or statistical officers who can "angle that progress chart somehow so as to make that line slant up instead of down"? When analysts who may be thorough and exact despite dedication to doctrine are caught in this situation, compromise is the only solution, and compromises can become cumulative.

Mr. McNamara was long aware of such criticisms as have been quoted here and of others which have not. He showed himself especially sensitive to those which accused him of neglecting human factors and qualities such as those revealed in the lessons of history. Also he was aware of some of the doctrines of classic military theorists, particularly those who would "save humanity from nuclear arms by saving war"—even at the expense of endless war. (p. 28)

It is only fair to note that Mr. McNamara signaled his intentions in this respect and also to note that even the most outspoken hawks, before their wounding, were relatively free from attacks by doves. Osgood duly attributes to Douglas Kiker a now almost incredible public statement by McNamara, one which was little noted at the time: "If you read Toynbee, you realize the importance of a democracy learning to cope with a limited war. The greatest contribution Vietnam is making—right or wrong is beside the point—is that it is developing in the United States an ability to fight a limited war, to go to war without the necessity of arousing the public ire. . . . this is the kind of war we'll most likely be facing for the next fifty years." (pp. 99 n–100)

The reference to Toynbee is interesting, not so much because that overworked historian often serves as the busy man's claim to intellectuality, or because Toynbee himself was even then nonviolently opposed to the war, as because of the Secretary's desire to bring a historian's perspective into the "esoteric priesthood" advocating a war—a war that could properly be endless as long as it was otherwise limited. Most historians, Toynbee and a few others excluded, do not wish to cast themselves in the role of prophets or seers in support of specific theories or doctrines. They prefer to ask questions, such as Aron's at the end of his essay: "To guarantee that wars remain limited, is it not to accept permanent war? Will not limitation in means have as its corollary absence of limitation in time?" (p. 46)

Military men, unlike thinkers, must provide not questions but answers. General George C. Marshall provided a long-forgotten answer during the hearings on MacArthur in the Korean War. He said, "A democracy cannot fight a Seven Years War." The advocacy of endless limited war, or fifty years of it, may comfort some of us who are older and fear a too-violent termination of the war, but it can be infuriating to the young, who see it as their eternity.

Brodie, "as both a parent and a teacher," speaks of the young: "It does not depreciate them to surmise that most of their moral indignation over our Vietnamese adventure has been connected with the draft." (p. 172) Other moral problems involved in having planned a war without the will to finish it are the cumulative effect of the war on the people and the area where it is fought; the fatalism, either passive or desperate, induced by repeated rotation of the military professionals; and escalating costs without an advantage gained or a disadvantage avoided.

No one, in Brodie's recollection, "ever took into account what frustration from denial of victory or at least of clearly visible progress might mean with respect to the attitudes of the American people in supporting such a war, and also the attitudes of other peoples . . ." (p. 172) Here Brodie speaks for those who favored such a war regardless of interminable restraints; but there were many others—both in uniform and out, in Vietnam, in Europe, in the Pentagon and other headquarters—whose experiences on active and inactive fronts caused them to take all these considerations into account. These men were mostly members of the establishment at the beginning of the sixties, and they probably could be constrained to ride with feigned enthusiasm on the new wave.

Unlike the doctrinaire advocates of unilateral withdrawal, the contributors to this volume display no illusions as to the consequences of our failures in Vietnam. Osgood thinks the total experience will "preclude, at least for a while, . . . any renewed effort to strengthen military deterrence and resistance in the Third World by actively developing and projecting the United States' capacity to fight local wars." (p. 116) The development of such a resistance and such a capacity was said in the beginning to be the principal purpose of the Vietnam war.

"A more realistic appraisal of our true capabilities is always to the good," in Brodie's opinion, "but we have probably experienced a real constriction of those capabilities rather than merely a clarification of them. The political disunity within the United States which is so largely attributable to the war in Vietnam, and the disaster which has overtaken President Johnson as a result of his personal commitment and involvement, will not soon be forgotten by his successors." (p. 171) No one could have predicted, at the time Brodie wrote, the determined salvage operation now being attempted in the face of sabotage efforts by those who capitalize on political disunity and insist that nothing more, save honor, need be sacrificed.

A more specific but no more encouraging prediction is made in the final essay by foreign correspondent Brian Crozier: "If the Americans are forced, whether for military or for political reasons, to pull out of Vietnam, their defeat, however disguised, will be hailed by revolutionaries everywhere as the final vindication of the theory . . . that even a super-power can be defeated by a peasant army. In that event, the efforts now being made to launch such insurrections, or sustain them, in Africa, and Latin America, would be redoubled. Even the Russians, who do not appear to share the faith of the Chinese, the North Vietnamese, and the Cubans in the efficacy of the technique, will feel bound to improve on their commitment to insurgents." (p. 218)

The fact that some gains have been made, regardless of the Vietnam war, is best expressed in Osgood's conclusion: "If counterparts of the stylized limited warfare of the eighteenth century are unrealistic, counterparts of the total wars of the following centuries would be catastrophic. ¶ The nuclear age has . . . inculcated a novel respect for the deliberate control and limitation of warfare. That respect is a more significant and enduring achievement of limited-war strategists than any of their strategies." (p. 120)

Fortunately, there remain talented and capable men, sobered if not inspired by recent history, who are now trying to adapt a wide choice of military techniques to the political and social realities of our time. That is the challenge of today.

San Antonio, Texas

THE AMERICAN MILITARY NOVEL

Colonel Jesse C. Gatlin, Jr.

PROFESSOR WAYNE MILLER'S examination of the fictional face of the American military establishment,† written originally as a doctoral dissertation, begins at the beginning with James Fenimore Cooper's "military" novels, *The Spy* and *The Pilot*, and ends with *Dr. Strangelove*. Miller notes that Cooper's two books establish one extreme of the attitudinal spectrum across which the military novel is spread. Both the Cooper

† Wayne C. Miller, *An Armed America: Its Face in Fiction—a History of the American Military Novel* (New York: New York University Press, 1970, $7.95), 294 pp.

works tend to glamorize the military and concentrate on officers who accept without question the hierarchical and authoritarian assumptions that characterize the professional military.

At the other end of the spectrum Miller places *Dr. Strangelove,* the novelized version of the motion picture scenario by Stanley Kubrick and Terry Southern, who in turn based their work on the novel *Red Alert* by Peter George. *Dr. Strangelove,* as those who saw the movie will recall, creates a cast of caricatures whose very names epitomize the tone and satiric intention of the book—General Buck Turgidson, Major King Kong, Colonel Jack D. Ripper, Colonel Bat Guano, and Dr. Strangelove himself.

Between those extremes in time and attitude, Professor Miller examines an impressive number of authors and novels dealing with the military.* Herman Melville's *Billy Budd,* though set in the British rather than the U.S. navy, gets a great deal of attention, chiefly as the culminating work in what Miller sees as Melville's progressively deepening concern with the conflict between individual freedom and institutional—especially military—constriction of conscience. Miller's central assumption is that by its very nature the military stifles the best ethical, humanitarian, and intellectual impulses of those who, reluctantly or by choice, find themselves involved within it. He supports the assumption by frequent quotations from antimilitary social and political writers, such as Tristram Coffin, Fred J. Cook, and C. Wright Mills.

This argument is hard to contest if one chooses his evidence from American military novels. Especially is it true in the twentieth century that nearly every artistically worthwhile treatment of life within the military profession has been written by an author whose own experience of that life has been relatively short, relatively reluctant, and relatively unprofessional—which is to say, relatively antagonistic to the goals and assumptions of the military profession.

The image of military life in such novels as Hemingway's *A Farewell to Arms,* Mailer's *The Naked and the Dead,* Jones's *From Here to Eternity,* Heller's *Catch-22,* and of course *Dr. Strangelove* has generally been one of oppression by usually inhuman, desensitized, cruel, corrupt power-figures whose inhumanity is not only condoned but often aided and abetted by an institutionalized monolith of mechanized incomprehension and appalling stupidity. Of course, there are differences among these novels in their images of the living people and concrete situations within their common military settings. Yet it is fair to note that in nearly every one of them the major *antagonist* of the conflict or the chief object of satire is a character or number of characters who embody what the author presents as the military ethic. And the *protagonist* is usually either a young, involuntarily recruited officer or enlisted man fighting to assert his individuality in the face of the overwhelmingly hostile and insensitive forces of the professional element of the military institution.

Professor Miller's study examines in detail many novels which make these kinds of assumptions or which portray with realistic revulsion the profoundly horrible and disillusioning experiences of war. He correctly points out that this trend became firmly established in treatments of the Civil War experience in such works as Crane's *The Red Badge of Courage* and has continued as a sustaining tradition in American military fiction to the present day. His chapters on the World War I novels and on the diversity of the novelistic recordings of World War II are excellent in their treatment of major writers and trends.

Miller devotes an entire chapter to a very judicious and balanced appraisal of J. P.

*While an officer in the U.S. Air Force, Miller served in the Department of English at the Air Force Academy from 1963 until he left the service in 1967. He is now on the English faculty at the University of Cincinnati.

Marquand's *Melville Goodwin, U.S.A.* and James Gould Cozzens's *Guard of Honor,* with some attention also to W. W. Haines's *Command Decision.* These works embody, as Miller points out, balanced analysis and general acceptance of the military structure. Especially in *Guard of Honor* the setting, the characters, and the conflicts present with honest realism the day-to-day world of the military as most of those who have lived in it have come to know it. And Miller perceptively notes that characters like Cozzens's harassed yet rational and persistent Colonel Ross can fairly reflect both a full awareness of human values and a full sense of responsibility for one's decisions within the military scheme of things.

Miller follows this generally favorable treatment of the balanced and realistic portrayals of military life with a chapter devoted entirely to a most sympathetic appraisal of Joseph Heller's *Catch-22.* This novel, Miller contends, is a brilliant satire not only on the military but also, through the military as microcosm, on the whole value structure of U.S. society. Miller quotes copiously and approvingly from the book, pointing out connotations, analogies, and symbolic implications of the characters and events in Heller's mad military world. Miller's insights are indubitably an aid to the general reader's understanding of Heller's novel. The chapter is one which any reader of *Catch-22* will find illuminating. For those who have not read Heller's book, it provides an excellent introduction; for those who have, it might well incite another.

Miller's study ends with a chapter on "nuclear age" novels, among them Knebel and Bailey's *Seven Days in May* and Burdick and Wheeler's *Fail-Safe,* as well as *Dr. Strangelove.* None of these are works of real literary merit. As Miller observes, their chief appeal lies in the topicality of the issues they treat; "coupled with the non-fiction dealing with the same problems, they contribute to a composite of concern about national and human survival unprecedented in the history of American culture."

It is altogether appropriate that Professor Miller's book evaluate the American military novel in a social and political context. There is, of course, no distinctive generic criteria which identify a work as a "military" novel except the obvious requirement that it deal at least in part with a military setting and with characters who are involved in some way with the military services. However, some of the novels Miller examines, such as Melville's *Israel Potter* and Faulkner's *Soldiers' Pay,* deal chiefly with the problems of the returned veteran rather than with military life as such. The pertinence of these works to Miller's study is questionable.

On the other hand, there are a few notable omissions: a few important works by major authors do not appear either in the study or in the extensive bibliographical listing. Two of these, Carson McCullers's *Reflections in a Golden Eye* and William Styron's *The Long March,* certainly surpass in literary merit and in the scope of their implications many of the works that are included. A third novel, Anton Myrer's *Once an Eagle* (1968), is certainly a work of sufficient magnitude to deserve a place in Professor Miller's study (incidentally, it received the dubious distinction of being noticed and scorned by Ward Just in his articles on the U.S. Army in *The Atlantic* for October-November 1970 and more recently in his *Military Men*). Perhaps Myrer's work was published after Miller had completed the research for his dissertation, but the 1970 copyright date of *An Armed America* indicates at least that a supplementary notation of some kind could have been included before the book's publication. And to cavil at a detail, the book reveals several instances of careless proofreading; for instance, it is mildly annoying to the reader who knows *Catch-22* to find Milo Minderbinder repeatedly identified as Milo Mindenbinder.

A more serious objection to the book has already been suggested: Professor Miller, despite his protestation in the introduction that he has "sought resolutely to avoid oversimplification . . . in order to easily condemn or easily praise," quite obviously shares the concern of many of the writers he quotes—of both fiction and nonfiction—that the "military-industrial complex" is indeed in the saddle in our country and that its methods and motives are riding us in the direction of national disaster. He appears to believe that our problems would lessen immeasurably if the military would just go away entirely—or at least shrink to the tiniest possible dimensions. He leaves unanswered, as do many of the authors he cites, the question of how such a desired end can be accomplished, given the world as it is and men as they are. One can share his concern, even his wishes; but finally one is reduced to the hope that the Colonel Rosses of the world—both the military and the civilian world—can manage to prevail. One can hope that our institutions will learn from such men how better to become agencies of the people, by the people, for the people. Else we all may indeed perish from the earth.

Despite his emphasis on the sociological and political—as opposed to the artistic and literary—aspects of the authors and works he treats, Professor Miller has performed a service by raising serious questions about the function and influence of fictional literature in our society. He has charted a pathway that is essentially Platonic in its assumption that fiction is and should be primarily a utilitarian means of social and political comment. It is an assumption which many among the American reading public, including most military readers, are likely to share. His book will probably in the long view be important chiefly in evincing the concern of late twentieth century America with its sociopolitical problems, at the expense of any real concern that literature be judged chiefly by literary standards. But whatever topicality the book may now embody, it has much to commend it to both the military and civilian reader as a record (though sometimes incomplete) of the fictional face of the military establishment in America.

United States Air Force Academy

FIVE PATHFINDERS

The Origins of Air Navigation

Colonel Ray L. Bowers

Among the navigators of the U.S. Army Air Forces during the Second World War, few were military professionals. Most had come lately from the offices and schools of the nation, with only a fast training program to introduce them to what sometimes became one of the war's most challenging tasks. The navigator's job was seldom an exalted one. Few reached high rank; regardless of talent, a navigator never commanded the aircraft in which he flew.

He often flew as part of a massed formation of bombers or troop carrier planes, with no responsibility for actually directing his own aircraft. On the other hand, those navigators who themselves led the formations knew that a misjudgment could mean the lives of hundreds of paratroops or airmen; few responsibilities could be as awesome.

The limitations of the navigator's art became magnified in the urgency of combat. In troop carrier operations, navigating in darkness or bad weather proved so uncertain as to call into question the very efficacy of airborne assault, while the main American bomber offensives hinged on the existence of visual conditions near the target. Exemplifying the problem were the navigational mistakes on the Ploesti mission of 1 August 1943 and on the Sicily airborne assaults the same summer. In less pressing circumstances, however, wartime navigational successes were impressive: thousands of transoceanic flights by the crews of the Air Transport Command, for example, foreshadowed the global nature of air power.

The idea of a specialist, professional air navigator was itself recent in the U.S. air arm. The B-17 and B-18, which entered active Air Corps service in 1937, were the first types having crew positions designed for the navigator, and until 1941 these positions were manned by Air Corps pilots certified in celestial navigation and dead reckoning after short training courses. But if the navigators themselves were new to the Air Corps, the techniques and equipment they employed were not. These elements, along with a conceptual framework for systematic air navigation, were wholly in existence by 1940, the products of two decades of determination and resourcefulness among a handful of pathfinders in the field, men to whom the challenge of invention was all-absorbing. If the demands of combat in World War II at times went beyond the state of the navigator's art, least at fault were the "impatient young men" of the years of austerity.

During the decade following the First World War, developments in navigation within the Air Service centered around the career of Albert F. Hegenberger. Bostonian by birth, Hegenberger had left Massachusetts Institute of Technology for flying training in the wartime Air Service and had subsequently returned to MIT for studies in aeronautical engineering. After reporting to McCook Field (now part of Wright-Patterson AFB, Ohio) in 1919, Second Lieutenant Hegenberger established what subsequently became the Instrument and Navigation Branch. Here Hegenberger and his associates worked to perfect their ideas in air navigation, or avigation, turning their inventiveness toward new developments in compasses, airspeed meters, driftmeters, sextants, and maps. Limited funds for procurement yielded chronic delays and frustrations. In June 1919 Hegenberger prepared a week-long course in air navigation for the Engineering School, including ground practice in star identification and use of the sextant. After attending a special course under the Navy at Pensacola, including dead reckoning and celestial flights over the Gulf, Hegenberger returned to his work at McCook.

The June 1927 flight of Lieutenants Hegenberger and Lester J. Maitland from California to Hawaii in a Fokker trimotor reflected the advancements at McCook in long-range navigation. Hegenberger's successful navigation resulted from accurate dead reckoning using the magnetic compass and driftmeter, supplemented by celestial observations. The newer earth induction compass failed during the flight, and the radio compasses proved unreliable. Hegenberger had made azimuth and altitude precomputations for the sun and selected stars for several points along the route. His final early-morning observations, taken amid rain and clouds, indicated that the aircraft was well north of the planned course. After some persuasion, Maitland accepted the 90-degree left turn. The correction proved sound, and the pair landed successfully at Wheeler Field. The flight of their *Bird of Paradise* was the first from the mainland to Hawaii. Two years earlier two Navy flying boats had attempted the crossing but had made forced landings in the Pacific. The successful flight earned for the two Air Corps pilots the Mackay Trophy for 1927.

Soon afterwards Hegenberger (who remained a lieutenant until 1932) and two other instructors opened a new navigation school for pilots at Wright Field, incorporating in the curriculum missions over the Gulf of Mexico in the *Bird of Paradise*. The school closed shortly, and Hegenberger's attention turned to instruments for blind flying. The Collier Trophy in 1934 recognized his achievement in this work, made possible by his strong background both as pilot and engineer.

The navigator's position in the Martin B-10 was an afterthought, extemporized by installing a few essentials in the rear cockpit. The position was manned most often by pilots who lacked the 1000 hours of flying time required by regulation for eligibility as B-10 pilot. With aircraft of longer range entering service, the Army Air Corps badly needed to widen its thinking on air navigation systems. Largely on Hegenberger's urgings, the Air Corps in 1932 brought to Washington a civilian adviser in navigation, Harold Gatty, a Tasmanian of unusual qualification. Gatty had learned marine navigation at the Royal Australian Naval Academy and had had wide experience in air navigation, having navigated for Wiley Post in his round-the-world venture. At first he had trouble communicating his ideas to the officers in the headquarters, but he soon found his element in working with an experimental unit established at Bolling Field, D.C. Gatty stressed a system built about dead reckoning (DR), which he viewed as the basic element of navigation, and the meticulous use of a log form. Vital was the accurate calibration of compass and airspeed meter, along with precise in-flight determination and application of drift and groundspeed. The group spent long weeks, patiently installing and calibrating new navigational devices in the Douglas amphibian airplanes. Periscopic drift and groundspeed instruments devised by Gatty were tested, and a protected hatch fitted for sextant and pelorus, the latter used to obtain relative bearings. A temperature gage for the first time was employed for more accurate calculation of true airspeed. Meanwhile, the Naval Observatory published a simplified version of the *Nautical Almanac* for 1933, the first *Air Almanac*, incorporating information essential to the airborne celestial navigator in a form convenient for fast computations in the air.

Courses in navigation for Air Corps pilots opened at Langley Field, Virginia, and Rockwell Field, California, late in 1933, with Gatty alternating between the two locations as principal instructor in celestial navigation. In the first class at Rockwell was an officer of unusual talent whose background included the study of astronomy at Stanford. Lieutenant Thomas L. Thurlow easily grasped the essence of the air navigator's tasks, and he soon became one of the school's most innovative instructors. Thurlow's future influence on Air Corps navigation and equipment was apparent in his sole authorship of the first Air Corps text on the subject, *Celestial Air Navigation*, issued in 1934. Thurlow and Gatty jointly devised a table that simplified calculations by use of the double drift method, whereby drift readings taken on headings 90 degrees apart afforded groundspeed information.

Training flights out of Rockwell included both DR and celestial work over the Pacific, though no night missions were flown. All students were rated pilots. Each received 50 hours' air work as navigator during the course, along with instrument flying training, in the assigned Douglas amphibians. On those occasions when Thurlow himself assumed the navigation task, his mastery served as a reminder to his colleagues that navigation was more of an art than a science. Both the Langley and Rockwell schools closed temporarily during the airmail operations of 1934. Gatty shortly resigned his position as senior navigation engineer at Wright, in order to work with Pan American Airways in surveying their Pacific routes, but his brief association with the Air Corps left a lasting impression. He served during the war with the Royal Australian Air Force and afterward died in the crash of a Fiji Airways plane.

Gatty's departure in 1935 left Thurlow, then instructing at Rockwell, as the acknowledged leader in the celestial navigation field. Thurlow moved to Ohio to join the Instrument and Navigation Laboratory, the successor to Hegenberger's branch. There his contributions to navigation continued in countless projects, including reformulation of the *Air Almanac*, which had been abandoned since 1934. Thurlow served as navigator for Howard Hughes on the round-the-world journey of 1938. Colonel Thurlow's continuing work in navigation was acknowledged by an annual award established by the Institute of Navigation in 1945, a year after his death in a takeoff at Dallas while testing a new compass.

One of Gatty's students in the 1933 Langley school was energetic Second Lieutenant Curtis E. LeMay. Subsequently assigned to Hawaii, LeMay was directed to organize a navigation school in his unit, and soon, with characteristic resourcefulness, this officer was absorbed by the challenge of adapting Gatty's methods to the local aircraft. Late in 1936 LeMay was assigned to the 2nd Bombardment Group at Langley Field, which was being equipped with the new B-17s. LeMay adroitly evaded the task of setting up the unit navigation training program, but his obvious skill and inclination earned him the job of lead navigator for the important exercises soon to come. LeMay was the lead navigator for the B-17 formation interceptions of the *Utah* in the Pacific in 1937 and of the Italian liner *Rex,* 600 miles off the Atlantic coast, the next year. LeMay also navigated on the mass flight to South America in 1938, providing drift readings to the other navigators by using the only gyrostabilized driftmeter in the flight. A self-described "navigator by nature,"[1] LeMay's insight into the profession of navigation remained with him through the higher posts he afterwards held.

These four men—Hegenberger, Gatty, Thurlow, and LeMay—are the central characters in the recently published chronicle of air navigation, researched and written by Norris B. "Skippy" Harbold, Major General, USAF (Retired).† Harbold's narrative documents the events herein described, revealing that the activities of the four touched on nearly all important developments in air navigation prior to 1941. Intertwining with the work of each of the four was the career of Harbold himself. As a second lieutenant four years out of West Point, Harbold joined Harold Gatty's research group at Langley in 1932. There Harbold became a kind of interpreter for Gatty's brilliance. LeMay later recounted how only Harbold seemed able to grasp Gatty's ideas and would in turn instruct LeMay and the others.[2] LeMay and Harbold had been classmates in flying training at Kelly Field. Harbold remained in navigation work at Langley and Rockwell until 1937, working and flying with Thurlow at the latter field.

In June 1940 Harbold served on a committee assigned to organize the training programs for the influx of navigator, bombardier, and gunnery students soon to commence. Navigation training for cadets began under contract with Charles Lunn of Pan American, and Harbold spent two strenuous weeks at Coral Gables, organizing the opening of the school with 48 students but without uniforms, study materials, and (briefly) instructors. During the war Harbold directed navigator training establishments at several bases and became operations chief for Air Training Command. By September 1945 over 50,000 navigators had been trained to use a navigation system differing little from that taught by Harold Gatty a decade earlier. Thus Harbold's central contribution was to take the knowledge developed by the others and transmit it to those destined to use it in war.

There were other individuals who were less prominent in Harbold's narrative but whose contributions were large. One was P. V. H. Weems, the retired Naval officer, whose assistance to Air Corps navigational development reached over the entire period and whose methods were reflected in Gatty's. Another was John Egan, the officer who worked with LeMay in Hawaii and in the early B-17s and who later shared with Harbold many of the tasks of wartime training. Providing continuity at Wright Field over the decades was Dr. Samuel M. Burka, like Thurlow honored by the Institute of Navigation with an annual award in his name.

The record of the twenty years after 1945 was disappointing in comparison, concerning navigation developments for tactical air forces. With the passing of the tactical bombers—the

---

† Norris B. Harbold, Major General, USAF (Ret), ***The Log of Air Navigation*** **(San Antonio, Texas: The Naylor Company, 1970, $10.00), 117 pp., 36 plates.**

B-45 and B-66—all-weather navigation and bombing capabilities for manned aircraft in the Tactical Air Command (TAC) and the overseas commands declined. The C-123s and C-130s went to Vietnam with a system for airdropping which depended on stopwatch timing from a visual estimate of aircraft position, and the F-105 pilots coming off Thud Ridge sometimes discovered their targets immune to attack because of cloud cover.[3] The F-4, its advanced avionics seemingly tailored for a professional career navigator, instead went to war with pilots manning its back-seat position—officers whose career orientation focused on advancing to first-pilot status. Indeed, the belated shifting of navigators into the F-4 was reminiscent of the 1940 decision to train nonpilots as B-17 navigators. Many of the navigators of the post-war Air Force have become dedicated officers of great talent, capable of maintaining the tradition of the earlier pathfinders. Promotion and command opportunities have improved for the navigators, but often only after moving away from navigation and flying duties. Hopefully, the Southeast Asia experience, coupled with the presence of navigators in the current tactical fighter squadrons, will bring new emphasis to the work of this profession.

THE technical strengths and weaknesses of Harbold's book may be quickly summarized. The research is thorough, drawing from materials located in both the National Archives and Air Force Historical Archives; various collections of private papers, including those of Hegenberger and Thurlow; interviews with Hegenberger, Egan, and others; a wide assortment of manuals and technical journals; plus the incomparable range of the author's personal experience. The brevity of the book—117 pages—is to be regretted, for the expanse of the subject as well as the obvious depth of research would substantiate a fuller account. Stripped to the essentials, the narrative may reflect Harbold's own characteristic directness of approach. Some thirty pages of illustrations constitute priceless supplements to the text; the footnotes and indexing are precise.

Norris Harbold was chosen one of the early presidents of the Institute of Navigation, founded in 1944. Today he finds that the papers in electronics and space navigation published in the journal of that institute have outdistanced his own technical level. His humility in making this confession is unnecessary: it is in the nature of technology to advance upon the achievements of those who have gone before. As technology advances, however, the qualities needed for leadership in engineering are unchanging. Among the pathfinders of today are to be found the same deep-seated determination and creativity that marked the careers of Harbold, Hegenberger, and the others. The exhilaration of success following upon long periods of endeavor is classic. Few rewards can compare to the emotions felt by Hegenberger and Maitland on reaching Hawaii, by LeMay on intercepting the *Rex*, or by the Apollo moon walkers in July 1969. Achievements such as these mirror the highest aspirations of modern man.

Alexandria, Virginia

Notes

1. Curtis E. LeMay with MacKinlay Kantor, *Mission With LeMay* (Garden City, New York: Doubleday and Co., 1965), p. 177.
2. *Ibid.*, pp. 94–98.
3. Jack Broughton, Colonel, USAF (Ret), *Thud Ridge* (Philadelphia and New York: J. B. Lippincott, 1969).

The Contributors

COLONEL ROBERT B. KALISCH (USNA; M.S.E.E., Stanford University; M.S., Trinity University), prior to his assignment to Air War College class of 1971, was Director, Ionospheric Physics Laboratory, Air Force Cambridge Research Laboratories. Previous assignments have been as instructor, Air Training Command; Chief, Offensive Missiles Division, and PACAF liaison officer, Foreign Technology Division; and Chief, Electronics Division, Air Force Office of Scientific Research.

ANDREW S. CARTEN, JR. (M.S., Tufts University) is Chief, Equipment Engineering and Evaluation Branch, Aerospace Instrumentation Laboratory, Air Force Cambridge Research Laboratories. During World War II he served as a staff weather officer, Eighth Air Force. He joined the Air Force Cambridge Research Center in 1954 as Chief, Design Engineering Branch, Atmospheric Devices Laboratory, and in 1960 assumed his present position. He is author of numerous published articles and papers presented at meteorological conferences.

MAJOR RICHARD M. ROBERDS (M.A., Kansas University) is an Air Liaison Officer, III DASC Task Force, Vietnam. He has been a research physicist, Air Force Weapons Laboratory; a T-38 flight instructor in Undergraduate Pilot Training, where he taught Applied Aerodynamics; and an F-102 pilot in Air Defense Command. Major Roberds is a 1970 graduate of Air Command and Staff College.

DR. WILLIAM G. POLLARD is Executive Director, Oak Ridge Associated Universities. After graduating Phi Beta Kappa from the University of Tennessee and earning the Ph.D. from Rice University, he taught physics at the former, 1936–1947. While on leave in 1944–45 he worked on the Manhattan Project. An ordained priest in the Episcopal Church, he has served on the faculty, Graduate School of Theology, University of the South. He holds some dozen honorary doctorates in science, divinity, law, and letters and has written several books. Dr. Pollard was a member of the Board of Visitors to Air University from 1967 to 1970.

JAY MALLIN (B.A., Florida Southern College), a journalist, first wrote for Cuba's *Havana Herald*, later serving as correspondent for a number of U.S. newspapers and *Time* magazine. He covered the 1956–58 Cuban revolution and was there during the Bay of Pigs. He has covered the October missile crisis, the Dominican uprising, the Vietnam war, "Che" Guevara's guerrilla movement in Bolivia, and the 1969 Salvador-Honduras war. His books include *Fortress Cuba, Caribbean Crisis, Terror in Viet Nam, "Che" Guevara on Revolution*, and *Strategy for Conquest.*

COLONEL DONALD M. MARKS (M.A., Indiana University) is with the Studies, Analysis and Gaming Agency, Joint Chiefs of Staff. He served in intelligence with Hq USAFE, Germany; later as a T-33 flight commander, Webb AFB, Texas; then as Assistant Air Attaché, Yugoslavia. He has also been Chief, Standardization/Evaluation Division, Hq Air Training Command; war plans officer, Hq Seventh Air Force, Vietnam; and Air Force Research Associate, Stanford Research Institute. Colonel Marks is a graduate of Air War College and won the George Washington Honor Medal, Freedom Awards Foundation.

MAJOR FREDERICK T. WALKER (USAFA; M.S., Air Force Institute of Technology) is Director, Communications-Electronics Plans and Programs, 1st Strategic Aerospace Division (SAC), Vandenberg AFB, California. A graduate of Air Command and Staff College, he has held command and staff management positions in communications or electronics, including assignments with 5th Tactical Control Group (PACAF) and Headquarters Command.

MAJOR JEROME G. PEPPERS, JR., USAF (Ret), (B.G.E., University of Omaha), is a faculty member, School of Systems and Logistics, Air Force Institute of Technology. He served in the Air Force

1940–64, from 1951 in maintenance assignments with Strategic Air Command. Since his retirement he has taught at AFIT, principally in DOD Maintenance Management Information Systems courses. Peppers is a graduate of the Industrial College of the Armed Forces and Air University courses.

Brigadier General Noel F. Parrish, USAF (Ret), (Ph.D., Rice University) is assistant professor of history at Trinity University, San Antonio. Commissioned from flight training in 1932, from 1938 to 1946 he served as flying instructor and supervisor and as Commander, Tuskegee Army Flying School. Other assignments were as Special Assistant to the Vice Chief of Staff, Hq USAF; Air Deputy, NATO Defense College, and Deputy Director, Military Assistance Division, Europe; Assistant for Coordination, DCS/Plans and Programs; and Director, Aerospace Studies Institute, 1961–64, when he retired.

Colonel Jesse C. Gatlin, Jr. (USMA; Ph.D., University of Denver) is Permanent Professor and Head, Department of English, USAF Academy. After West Point (1945) and flight training, he served as P-47 pilot, as radiological officer at Nevada Test Site, and as exchange officer, Royal Canadian Air Force. After earning an M.A. (University of North Carolina) in 1957, he went to the Academy, where he has remained except while completing his doctorate. Colonel Gatlin has published military studies and articles on drama and fiction.

Colonel Ray L. Bowers (U.S. Naval Academy; M.A., University of Wisconsin) is assigned to the Office of Air Force History, Washington, D.C., working on a history of tactical airlift in Southeast Asia. He has flown as a B-45 navigator-bombardier and participated in the testing and early use of the B-66. He was a history faculty member, USAF Academy (1960–67), and prior to his present assignment was a C-130 navigator with PACAF. Colonel Bowers's articles have been published in various military journals.

AWARD

The Air University Review Awards Committee has selected "Force-Structure Planning" by Lieutenant Colonel Edward Stellini, USAF, as the outstanding article in the May-June 1971 issue of the *Review*.

Colonel A. E. Goldsmith, Fifth Air Force Director of Information, congratulates Colonel Robert R. Hemphill, winner of the annual Air University Review *Outstanding Award.*

AIR UNIVERSITY REVIEW AWARDS PROGRAM

Colonel Robert F. Hemphill, USAF (Retired), now engaged in research and writing in Japan, has been selected by the Air University Review Awards Committee to receive the annual award for writing the outstanding article to appear in the *Review* during fiscal year 1971. His article, "On Behalf of Perspective," was previously designated the outstanding article in the November-December 1970 issue.

The awards program provides payment to eligible authors, a $50 award for the outstanding article in each issue, and a $200 savings bond for the yearly outstanding article. Bimonthly and yearly award winners also receive a plaque.

The bimonthly winners for the past year were U. A. Coty, E. J. Daniels, and R. A. Shane, "On Military Force Planning," July-August 1970; Charles A. Roberts, "Managing the Civilian Work Force in the Seventies," September-October 1970; Colonel Robert F. Hemphill, USAF (Ret), "On Behalf of Perspective," November-December 1970; Lieutenant Colonel Donald L. Clark, USAF, "Soviet Strategy for the Seventies," January-February 1971; Brigadier General Robert N. Ginsburgh, USAF, and Captain Pember W. Rocap, USAF, "The Changing Role of the Military Profession," March-April 1971; Lieutenant Colonel Edward Stellini, USAF, "Force-Structure Planning: Considerations, Problems, and Issues," May-June 1971.

ATTENTION

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

UNITED
STATES
AIR FORCE
AIR UNIVERSITY
REVIEW