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by

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Just about everything that has to do with national security, in both foreign and defense policy, has been a matter of substantial controversy since the mid-1960s. But since about 1979 what was formerly a minor theme in the usual dissonant symphony of views has become perhaps the most popular of all. It has to do with the place of advanced technology, and of the military equipment that incorporates it, in the US defense posture. Discussions of this matter have become as adversarial as discussions of US-Soviet relations or of the proper US policy towards the Middle East.

THE SIMPLE MYTHS AND THE COMPLEX FACTS

There are three main complaints about the development and procurement of military weapons and equipment:

- US military equipment has become too complex over the past couple of decades. It incorporates too high a level of technology and aims for too high a level of performance. Because of this, the equipment is too expensive and is unreliable and unsuitable.
- The effort put into the technology of modern weapons is one reason, perhaps the major reason, for the decline of the United States's relative position in modern civilian technology and productivity, because it detracts from efforts that would otherwise go into civilian functions.
- There is an iron triangle of congressional committee members and their staffs, military and civilian officials in the Department of Defense, and contractors that works to produce this overambitious, unreliable, colossally expensive, and dangerous armament.

These concerns are expressed by a variety of commentators. Their numbers include people who have participated in weapons development programs, experienced members of Congress, and middle-level or (more rarely) senior military officers. They also include journalists and other commentators, whose less thorough familiarity with the intricacies of defense procurement does not necessarily make their allegations less worthy of serious attention.

These arguments are set forth here in their most extreme and therefore least defensible form. In fact, there is at least a little truth and sometimes a substantial truth in more moderate expressions of each. But the facts do not support the allegations. The conclusions that are in turn drawn from these allegations, and the remedies proposed, are often wildly out of line. The situation can be more realistically summarized as follows.

The United States has no real choice but to adopt advanced technology for its weapons systems, given the relative advantages it can provide over potential adversaries, and the fact that the American public and its political leaders are willing to maintain only a certain level of defense spending. Moreover, if correctly handled, US reliance on advanced technology is likely to produce a more effective military capability.

There is less spinoff from defense-oriented research and development to the civilian sector today than there was in the 1950s. That is, the civilian sector profits less from military research and development (R&D). In fact, US military research and development now rides, to a considerable extent, on the back of civilian technology, especially in the areas of advanced electronics and integrated circuits. But military R&D still contributes to civilian technology substantially. And the deficiencies of US industry in productivity and in competition with other countries, notably Japan, are very much less a consequence of the diversion of technical talent to military R&D than they are of a variety of business organization and labor union practices, and of government regulatory, employment, tax, and antitrust policies. The relationships between military and civilian R&D differ in the Soviet Union, Western Europe, and Japan. None of these is a better model for the United States.

Institutional, operational, and industrial forces create pressure to use insufficiently mature technology in military weapon systems and, more often, to use mature technology to achieve peak performance while slighting the factors of low cost, reliability, and maintainability. These forces typically cause contractors to overpromise performance and military user agencies to push for the higher performance that the contractor offered in the brochure that won the contract, to the detriment of those other factors. Together the contractor and the operator often push the developing agency and the program manager into an impossible situation. When the program manager is squeezed, so are the virtues of reliability and affordability. It takes a strong program manager, backed by the most senior military and civilian officials in DOD, to withstand those pressures. Some have—and these are not always the ones who are given credit for being great program managers. The congressional role in this matter is equivocal. Sometimes knowledgeable legislators (or their staffers) without a constituent interest or personal ax to grind will side with sensible management. More often, contractor pressure expressed through Congress, or the lure of power without responsibility combined with a congressional staffer's whim, will exacerbate the problem.

THE LESSONS OF HISTORY

Historians can speak of the advantage of the then inferior but less expensive (and therefore more numerous) iron swords over bronze ones to the Dorian invaders of Mycenaean Greece, of the iron-beaked prow to the Roman navies, of "Greek fire" in prolonging the life of the Byzantine empire, or of the rate of fire of the longbow to the English at Agincourt. There is some question of how relevant any of these examples is to the choices the United States faces today or to the appropriate criteria in deciding which technologies to choose and how to employ

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them for military purposes. The lessons of World War I and World War II are more applicable.[1]

During World War I, the United States was behind both its allies and the Germans in technology, in aircraft, in tanks, in artillery, and probably even in naval design. During World War II, the United States was again behind at the start in quality and sophistication of most military equipment. Never during that conflict did the United States outdistance the Germans in basic military hardware—tanks, artillery, or aircraft. The antisubmarine warfare problem remained unsolved, although the combination of technology and tactics that went into US aircraft carriers came to dominate the naval war in the Pacific. Moreover, in jet aircraft and guided aerodynamic (V-I) and ballistic (V-II) missiles the Germans remained ahead to the end of the war. It was primarily the quantity, not the quality, of equipment that gave the United States its advantage.

But there were some notable exceptions. These proved critical, at least in limiting the duration of the war, both by preventing the Axis powers from making even greater gains at the beginning and by terminating the war in the Pacific. The critical developments included radar, the proximity fuse, the atomic bomb, and cryptanalysis. The British did the initial work on radar, but during the last three years of the war the United States carried out most of its application. Neither the Germans nor the Japanese were able to match it in quality or quantity. US researchers were also responsible for developing the proximity fuse and nuclear weapons. Great Britain and the United States cooperated in using cryptanalysis for major military gain.

THE SITUATION TODAY

The present situation differs in two important ways from that of World War II. First, the number of troops and the amount of equipment available by 1943 clearly favored the United States and the Allies. Second, as in World War I, the United States had a period of years between the time that US participation was clearly envisioned, or at which it entered the war, and the time the crucial battles were fought.

If one considers the likely combat scenarios in which the United States today might find itself engaged, neither of these conditions would be fulfilled. In the first place, the United States and its allies would not have an advantage in numbers of personnel or quantity of materiel. Even cursory examinations of the current economic, political, and social situation make it clear that the United States would enter any such confrontation with the Soviets with a much smaller active-duty and reserve military force. The active-duty forces of the Soviet Union are about double the size of those of the United States. US and European allied forces do not fully balance those of the Warsaw Pact on the central front, and if Soviet reserves are counted, the Soviet numerical advantage is substantial. In East Asia, the United States would be at a disadvantage relative to the Soviets, even after US reinforcements arrived. The overall ratios would depend on the belligerent status of other major nations or of various proxies. In Southwest Asia, the United States would find it difficult to bring forces to bear comparable in size to those of the relatively nearby Soviets.

An even more important difference in a prospective conflict is that the United States could not expect to have a year or two to prepare before the critical battles were fought. The United States must be prepared to fight from a standing start against what would undoubtedly be Soviet blitzkrieg tactics, whether in Europe, in East Asia, or in Southwest Asia. Had that been the case in World War II, the Germans and the Japanese would have won. But the United States then had the good fortune to be allowed three years to build up its capabilities.

Technological quality, quantity of materiel, and size of forces are all important factors in the military balance. But there are many examples of military victory by numerically inferior forces with proper doctrine and tactics. Neither technology, quantity of materiel, nor numbers of troops can be counted on to substitute for morale, political and military strategy, and superior generalship. The incorporation of advanced technology into US weapon systems must not, and need not, preclude its integration into such a political and military strategy for execution by innovative military strategists and commanders.

Can greater quantities of military hardware substitute for technological superiority in US strategy, as it did in World War II? The amounts the United States now deploys are appropriate to the size of its peacetime forces. Those forces will not be much increased. If the United States were willing to raise and rely on very large reserve forces, it might be willing to pay the immense price of stockpiling the corresponding quantities of equipment for their use—tanks, planes, ships, and so on. But even that would make sense only if the United States could be sure of bringing those military forces to combat readiness and of transporting them to the theater of combat before the critical battles were fought. It now takes two years from initial order to produce a tank, three to produce an aircraft, and at least five to produce a ship. Most personnel can be trained in a short time, so it would make sense to buy and stockpile the equipment beforehand if the US anticipated (as I do not) that a global or even a European war could last for years. It does make sense, within economic constraints, to shorten those procurement lead times so that the United States could increase its forces during a period of much higher tensions lasting two or three years.

If the United States looks for comparative advantages against a potential Soviet adversary with superior numbers of forces, one of the most obvious is the relatively lower cost of incorporating high technology into US military equipment. The same is true for US allies. In contrast, a low technology-high manpower mix is more advantageous to the Soviets, who are behind on technology but have greater numbers. What follows is a discussion of a few areas in which US high technology can and must be applied to counter Soviet numerical advantages.

Tanks

The Soviets have 40,000 tanks in their inventory, as compared to about 10,000 first-line US tanks. On the NATO central front, which is a more relevant measure of what might be encountered in a combat situation, the ratio is about 2.5 to 1 in favor of the Warsaw Pact. If the United States were to try to redress this difference by manufacturing and deploying a comparable number of tanks, the initial equipment cost (not the total systems cost) for 30,000 tanks would probably be about $50 billion (1982 dollars). Over ten years, such an inventory buildup might be economically feasible. But it would also be necessary to provide crews for those tanks. Given pipeline and training figures, that would probably require 150,000 to 200,000 additional troops in the tank crews alone, and given the US support ratios (or even the much more austere Soviet support ratios), it would probably require an increase in the US Army of 300,000 or 400,000. There is no prospect that this will happen in peacetime, even if the United States returns to conscription.

The United States and its allies must therefore counter this advantage with some combination of innovative tactics and technology. One way to do this would be to have much better tanks. But in technologies for ground forces the Soviets are able by and large to match the United States. In fact, they produce new variations of armored vehicles at about twice the frequency of NATO, so that most of the time the best of their deployed technology tends to be ahead of NATO's. The Soviet T-72 is at least a match for our most modern versions of the M-60 tank. The US M-1 tank is better than the T-72, but the Soviets will follow that up within a few years with the T-80, which will probably be more advanced than the M-1. In some areas of tank technology, such as armor protection, stability as a platform for target acquisition and firing, and crew comfort, the United States is ahead. In others, such as tank guns and low tank height to make the tank more difficult to see and to hit, the Soviets have advantages. In view of the claims that Soviet systems are less complex, it is interesting to note the presence of an automatic gunloader on the T-72. One more mechanical system to go wrong—but for lack of it the M-1 needs one more crew member (four, as opposed to three on the T-72) to lift and insert the 50-pound shells. The M-1 turret must also be bigger, and it must frequently revolve for loading and again to retarget.

The appropriate comparison, especially in a situation in which NATO would be defending against a Soviet attack, is that between Soviet tanks and NATO antitank capability. This is where the technology of the industrialized democracies, and specifically of the United States, can play a critical role. The United States took the lead in antitank guided missiles in the mid-1960s. Since then, the Soviets have made gains. But the United States has now introduced laser-guided artillery shells and bombs, and infrared imaging systems to guide air-to-ground ordnance. It is developing ground-launched and air-launched missiles that will contain submissiles guided by millimeter waves to acquire tanks as targets and penetrate the thinner armor on their tops from above. Such technological innovations, based on US capabilities in sensor technology and in data processing, can be expected to make a major contribution to the allied ability to stop Soviet tank attacks.

Air-to-Air Missiles

A second example of the uses of technology in offsetting numerical deficiencies is in air-to-air combat capabilities. US tactical air forces now hold a distinct advantage because of the longer range of US air-to-air missiles, coupled with longer-range radars, more advanced data processing systems, and the ability of shorter-range, heat-seeking, infrared-guided missiles (such as the AIM-9L version of the Sidewinder) to home in on opposing aircraft from the side or even from the front as well as from the rear. The ability to fire such a missile and then have it home in on its own, without continued attention by the firing aircraft, will inevitably be incorporated into the next generation of air-to-air missiles, thanks again to US advantages in integrated circuits and data processing.

There are, as always, limits to how far such advantages can be pushed. Extensive tests in simulated air combat indicate that even the best air-to-air combat system cannot overcome a ten-to-one numerical advantage when combat takes place in an adversary's air space, with ground radar controlling the adversary's aircraft. And much of the advantage of long-range air-to-air missiles is lost if the air-to-air combat doctrine does not include firing at long range on any aircraft that fails to give the correct IFF (identification friend or foe) signal. US military doctrine has in the past been at best ambiguous on this point, and restrictions have been placed on the use of long-range missiles in air combat tests. As a result, some analysts have drawn incorrect conclusions, overvaluing the advantages of superior numbers of fighter aircraft engaged (say, two-to-one or three-to-one ratios) as compared with the advantages of superior long-range air-to-air radars and missiles.

The United States must pay more attention to the competition in electronic countermeasures and counter-countermeasures, in which the Soviets have by no means lagged behind. But overall, US capability in air-to-air missiles is one area in which US technology has paid off.

Precision-Guided Air-to-Surface Missiles

A third general area in which US technological sophistication has become to a substantial degree a substitute for large numbers is precision-guided munitions. The ability to destroy military targets is greatly dependent on the accuracy of delivery of ordnance. In many cases only a tenth or even a hundredth as many sorties by tactical aircraft are needed to accomplish the same mission, provided that they carry such precision-guided munitions. The cost and complexity of the munitions are therefore repaid many times over, not only in the reduced numbers of rounds of ordnance that are needed, but also in the reduced loss of aircraft and pilots, which constitutes the most severe price paid to accomplish a given military mission.

The three examples given share the common features of advanced electronics, integrated circuitry, and computers and data processing. In that area the United States and its European and Japanese allies maintain a five-to-seven-year lead over the Soviet bloc. This is perhaps the most solid single technological advantage possessed by the industrialized democracies. They have a much smaller, though real, lead in aircraft engines and aerodynamics and a substantial lead in antisubmarine warfare capabilities, which again results largely from advantages in data processing and sensors. As for new applications of materials science, the Soviets are ahead in some and the industrialized democracies in others.

There are thus several critical areas in which US technology leads that of the Soviets. To a considerable extent these leads now offset and will continue to offset some of the Soviet numerical advantages. There are limits, however, to the numerical advantages they can offset, and they are not a substitute for wise strategy, effective tactics, strong leadership, trained personnel, or any of the other elements of military strength, let alone for the nonmilitary aspects of national security policy. But to fail to take advantage of them would be to throw away a major equalizing factor, much of whose cost has already been paid in any event because, for other good reasons, the United States has a large civilian and a relatively small military sector in its industrial economy. Among the technological areas in which we can expect in the future to enjoy such an advantage are precision-guided munitions, cruise missiles, air-to-air missiles and their associated sensors, low-observability "stealth" technology, technical systems for intelligence to offset the Soviet advantage of tighter military security, and antisubmarine warfare capabilities. Without these advantages, the comparative military position of the United States and the other industrialized democracies would be much more precarious than it is.

There is some experimental evidence that supports this assessment of US military technology. When US-equipped forces have engaged Soviet-equipped forces in recent years, US tanks and antitank equipment, advanced fighter aircraft, air-to-air missile systems, and US-inspired air battle and antiaircraft suppression tactics have worked well. These results were not against the most modern Soviet equipment or against Soviet forces, and factors other than equipment have played an important part in the outcome. But even making allowances for those factors, US military equipment and doctrine for its use acquitted themselves well in both the Iran-Iraq War and the Arab-Israeli conflicts of 1973 and 1982.

THE HORRIBLE EXAMPLES

Whenever a new weapons system reaches the testing stage, a predictable pattern emerges. Test failures occur and are highly publicized. No one explains that tests would not be necessary if it were not expected that some of them would result in failures, or that these failures illuminate the changes that need to be made in the system's design. Cost overruns are announced by officials or Congressmen or discovered by investigative journalists. One source from which the cost overruns are unearthed is the so-called Selected Acquisition Report program cost summary, mandated by Congress for military systems (though not for civilian entitlement programs or for congressional office building construction). These include as overruns the effects of overall cost inflation in the economy, for which some think congressional actions bear part of the responsibility.[2] The General Accounting Office conducts investigations and finds that some characteristics of the system are not (or might not be) what was advertised or are (or might be) disliked by some of the people in the testing organization or the potential user organization. The new system is compared unfavorably to an existing system a few years older, now in the inventory. Exactly the same negative comments were being made about the existing, now praised program by the same critics a few years earlier: Compare the situation of the F-18 in the early 1980s with that of the F-16 five years before. It is all great sport, but it is not a very useful contribution to decision-making or to national security policy.

The cycle of research, development, systems design, testing, and procurement is an extremely complex one. Judgments are difficult to make about when a technology is ripe for incorporation in a weapons system, what performance trade-offs should be made, and what degree of concurrency there should be in the development, testing, and procurement schedule. The need to balance such factors and to make such trade-offs naturally produces differences of judgment, even from those who have spent their professional lives considering such matters. The people of the United States are trusting both their money and their lives to these judgments. The decisions have often left much to be desired, resulting in high costs, delayed schedules, and imperfect performance. But the American public should not place more trust in the conclusions drawn about these matters by journalists and television personalities.

Some defense critics conclude from the problems they find in new systems that what is needed is a return to the good old days of wooden ships and iron men, or of spit and baling wire. Such an attitude is dangerous nonsense. Large numbers of low-technology weapons cannot be counted on to outfight smaller numbers of modern weapons. Even if they could, the United States cannot, as explained above, expect to have enough troops to operate larger numbers of weapons. The United States would almost surely end up with about the same numbers of weapons as at present, but of much less capable systems. The United States does need the cruise missile, it does need the F-18 fighter aircraft, it does need the M-1 tank.

It is a sensible management practice on the part of the Secretary of Defense to have the production of each new system carried out at only a low rate until the development and operational testing have adequately demonstrated performance and reliability, thus encouraging the contractor to meet those requirements before going into a high rate of production. In peacetime, a crash program substantially telescoping development and production is justified only when the availability of some single weapon system at a particular time is seen as representing the difference between peace and war or between victory and defeat. With the present multiplicity of weapon systems, such a situation almost never arises. But caution in approving high rates of production early in a program is quite different from concluding, as some critics have, that the modernization of US systems has caused reduced military capability, or that more modern systems are necessarily more complex to operate or even to maintain. The jet engine goes longer between overhauls than the piston engine. The F-4, much older than the F-16, requires more hours of maintenance for each hour of flight time. And modern electronic technology has made radar and guided missiles more reliable than they were in the 1940s or 1960s.

A new generation of "smart bombs" allows the operator to designate the target and then have the munition itself hold to that designation while the operator turns his attention elsewhere. This requires less training for the operator, not more. A "joystick" approach, in which a bomb or antitank missile is flown into the target, requires much more training and experience on the part of the operator than does a system in which the operator keeps the crosshairs on the target. The electronic and control systems that in the latter case automatically steer the munition to the target will be more complex. In both of these systems the operator must watch the target until impact. The "fire and forget" approach will require still more design complexity, and will cost more, but it does not require operator attention after target designation, and it does not expose the launcher or operator to counterfire after target designation.

There is much to be said for separating the responsibility for operational test and evaluation of a new system from the developing agency when making the decisions on whether to proceed with procurement. But those who advocate separation of this responsibility from the military service that will use the system go too far. Moreover, development objectives and the needs of operational evaluation must often be met in the same test. Efficiency therefore dictates that the developer be involved in some operational testing. But there should be an operational organization to evaluate the performance of systems before they are bought in large numbers. It should consist not of personnel specially selected for their technical skills, but of ordinary troops. And it should report to the service Chief outside development channels. The Navy's Operational Test and Evaluation Force does just this.

HOW SOME OTHERS DO IT

It is often alleged that the Soviets have solved all these problems of judgment, while the United States has not. There are cases in which the Soviets have emphasized simplicity with some success. Moreover, they tend to keep a much larger number of development programs going at one time in a given area. By and large they introduce about twice as many models of tanks, armored personnel vehicles, aircraft, and air defense systems, and they tend to blanket all the fields of technology more completely. They can do this because they are willing to devote to military expenditures more than double the percentage of GNP and to spend about 50 percent more on military research and development than the United States does and to pay their troops and workers much less. Massive Soviet military development and production place a substantial premium on the United States' making correct judgments both on which technologies to push and on which weapons to develop and produce. Because US military R&D funding is smaller, the United States has chosen to concentrate on a few choices rather than playing the entire field. Inevitably this leads to a few big systems and leaves less room for errors. If US judgments are generally correct, this approach is more efficient than the Soviet approach; if incorrect, less effective than theirs.

There is another alternative. The United States could adopt the Soviet approach and pursue almost everything of interest in technology, doubling the number of full-scale systems brought through development and production. That would require the United States to augment by about 50 percent its present military R&D expenditures—now more than $20 billion a year and growing at a rate of more than six percent a year in real dollars.

In my view, such a switch would probably be a mistake, even if it were politically and economically feasible. There is more to be gained by achieving a more efficient and rational allocation of development and production tasks with US allies. Major steps in that direction have been taken since the mid-1970s. Allied defense-oriented R&D spending, at a current level of about 40 percent of that of the United States, helps offset the Soviet advantage, despite the existing inefficiencies. Furthermore, there is a large civilian R&D infrastructure in the United States and the other industrialized democracies, especially in microcircuitry and data processing and to a lesser extent in aerodynamics and even in materials, that is not duplicated in the Soviet Union.

One generally unrealized sign that the US development approach is comparable in its effectiveness to that of the Soviets is that US systems take about as long to develop and procure as do theirs, though the United States could probably shorten this if some changes were made in the industrial base and in our congressional appropriations and executive procurement procedures. For the Soviets, the time from initiation of development to achievement of an operational capability is limited by the level of their managerial efficiency, which is better in their military than in their civilian sector, and sometimes by their technological shortcomings. The decisions to proceed through the key stages of development and production for major systems are made at the top level of the party and government. Once that decision is made, resources are assured and programs are seldom modified—even when they should be.

Development times in the United States benefit from the advanced state of US technology and the support of an efficient civilian sector, though competition from the civilian sector has lately lengthened the lead time for some components. Delays result from the number of levels of government that can delay execution after development is initiated and from the stop-and-go funding associated with multiple reviews.

THE REAL PROBLEMS

If the widely heralded criticisms are often off the mark, what are the real problems in choosing technologies to push and in applying them to the weapon systems needed by US military forces to give them an edge against potential adversaries?

One problem is the tendency to try to achieve the best possible performance (speed, payload, range) in systems and to take full advantage of the newest technology only for that purpose. The operating commands have often insisted, for example, on the highest possible speed for a given aircraft design, without asking what value the last 100 knots provide and what is sacrificed, to achieve that capability, in other desirable performance characteristics or in reliability. In other cases, fleet air-defense missiles have been given ranges considerably beyond those at which the radar associated with them could provide reliable target information. This situation is reversed in the new Aegis fleet air-defense system: There the radar outperforms the missile. Almost always, these unnecessary increments of performance have been paid for in unreliability, demonstrated in either more frequent equipment failure or more frequent maintenance requirements. Accepting a performance five percent or ten percent lower than the peak that could be obtained from new technology and using the design freedom thus achieved to operate engines at lower temperatures, structures at lower stresses, or circuits at higher redundancy pays rich dividends in reliability. Moreover, it is better to achieve higher reliability by using for that purpose part of the capabilities of advanced technology (for example, the redundancy made possible by microelectronics) than it is to seek reliability by using older technology or older equipment beyond its time. Failure to use modern technology to get the right combination of performance and reliability creates a high risk that the Soviet materiel will be superior. Given the inevitable Soviet advantage in numbers, that is an unacceptable risk.

A second real problem is the need to train US military forces, both the combat forces who will operate the equipment and the support personnel who will maintain it. The increasing unit cost of weapons has reduced their use for practice and training. More realistic simulators provided by modern technology can ease this problem.

It is US practice to do much of the equipment maintenance in the field, as opposed to the Soviet system of maintaining large stocks of equipment and replacing complete units from replacement depots. There has been a real erosion since World War II in the mechanical experience of military recruits and in their technical education. The decline in the mathematical and technical course work in the high schools and even in the universities over the last 15 years, after the brief renaissance engendered by Sputnik, is alarming. One new craze may help: The generation raised playing computer games may find that experience as useful in operating some kinds of military equipment as the World War II generation found its experience repairing a simpler generation of automobiles in dealing with the materiel of World War II, the first really mechanized large-scale combat operation.

It will take a variety of skilled and educated personnel to conceive, design, manufacture at acceptable cost, operate, and maintain the advanced and complex weapons and support systems that will be needed. These personnel include research scientists, design and production engineers, technicians, and technically trained military people. The erosion of training of technician-level personnel in the civilian educational system, the poor mathematics and science curricula in US elementary and secondary schools, the declining proportion of students in science and engineering at the undergraduate and graduate levels, and the lack of growth or even the shrinkage in federal support for research, teaching, and equipment in these fields during recent years are real and serious problems.

Distinctions must be made between complexity of function, complexity of design, difficulty of maintenance, and difficulty of operation. The first is inevitable; the United States has often overdone the second, which has led to the third; US equipment usually avoids the fourth. Reliability and ease of maintenance must be emphasized from the time requirements are set and design begins, even at the expense of performance. Greater automaticity will inevitably involve greater complexity, which will reduce reliability and increase maintenance requirements. The former can be compensated for, to some degree, by providing redundancy of subsystems where that is made possible by the lower weight and smaller size associated with advanced technology. Very-high-speed integrated circuit technology and designs now being developed under DOD sponsorship are one example of a way to achieve this capability.

The extra maintenance that complex equipment may require is best split. One segment of a maintenance program could include the replacement of modular sections in the field. If the design is modular and the equipment is self-testing, equipment replacement would not require highly-trained personnel, but it would require that replacement modules be available at field maintenance facilities. The other segment should include rear-echelon repair of faulty modules and of subsystems or systems that cannot be either replaced or repaired in the field.

Another real and serious problem is the inflation of major defense systems costs at a rate higher than the general inflation rate in the economy. This phenomenon was experienced from 1978 to 1980. Its effect was to cut the quantities of major systems procured by 10 or 15 percent below what had been planned. This is a separate phenomenon from the increase in unit costs as a result of reductions in the rate of procurement. It can be traced instead to competition for resources with a then-healthy part of the economy. The civilian aerospace industry had a brief boom as a consequence of the need to replace an earlier generation of jet aircraft with a new generation that is quieter and consumes much less fuel per ton-mile. At the same time, the airlines projected an increase in passenger traffic, largely as a result of the airline deregulation scheduled to be phased in from 1978 to 1985. This increase has since proven illusory. Simultaneously, a growth in consumer electronics products using integrated circuits (video games, pocket calculators) increased the demand for the same kind of electronic components that are used in major weapons systems. This competition for air frame, engine, and electronic components drove up prices for those items more rapidly than the average prices in the civilian economy. There emerged correspondingly and simultaneously a shortage of engineers, which drove up their salaries. There was also a rapid increase in the price of certain strategic materials heavily used in defense systems.

All of these phenomena were exacerbated by the shrinkage in the defense subcontracting structure that had taken place over the previous 15 years. The decline in levels of defense procurement, the uncertainties in the program as a result of the cycles of increased and decreased defense procurement, the relatively low profit, and the opening up of new civilian markets all pushed some subcontractors (especially the second-tier and third-tier subsubcontractors) entirely out of defense subcontracting and caused most of the others to reduce the percentage of their business given over to defense. These factors made it more difficult for the prime contractors on defense systems to get competitive bids from subcontractors for the components of their systems. This in turn raised prices. As a result, major defense systems rose in price at an annual rate five percent or even ten percent higher than the budgetary figures assumed by the Office of Management and Budget in its government-wide projections for those years. Inflation in overall defense procurement, about half of which is in major systems, corresponded rather closely to the producer price index.

This phenomenon suggests a more general problem connected with the fact that the political process tends to produce unsteadiness in programs, with an off again, on again cycle. At the very least there is likely to be a four-year cycle, corresponding to presidential elections. But there are also annual budget cycles. Defense spending is set forth as a five-year program, but even during the 1960s, when more stability in programs was politically possible, the funding for a given weapon system such as the F-111 could be seen after the fact as five one-year segments of five different five-year programs. Such unsteadiness in funding clearly makes for inefficiency and cost escalation; it is compounded by the instability of personnel assignments, especially for program managers. This complex of deficiencies is far more serious in its effects than the allegations of the new generation of defense critics that are listed at the beginning of this article.

SOLUTIONS

If these are the real problems, what are some of the real solutions? There are no panaceas, and few really new ideas. Fundamental solutions must be contingent on fundamental changes not only in the management structure of the Department of Defense but in the way that the federal government does business, including such basic issues as the relations between the executive and legislative branches. But there are some important palliatives that suggest themselves strongly.

One is stable management. Broad policies, whether in international relations, military strategy, or procurement practices, change slowly even when administrations change. Individual weapon systems are considerably more subject to the attitudes of subordinate officials who, at the political level, change even more rapidly than administrations. The predilections, right or wrong, of individual legislators and their staffers also have a significant effect on the stability of programs, usually a bad one because programs become an element in political bargaining. Multiyear contracting, urged on Congress by previous administrations and pushed to partial adoption in the Reagan Administration, should help to ease this problem. But what hurts most of all are the changes in program managers that tend to occur every two or three years as part of the normal military rotations. Continuity of assignments and holding program managers accountable would have a big payoff. Major program managers should be kept at the head of a given system's program office for six or seven years, allowing them faster-than-normal rates of promotion if they manage their programs well. This would be a change from the usual situation, which is that an officer at the colonel or Navy captain level who is not moved around among assignments has reduced chances for promotion. In such programs as the Special Projects Office of the Navy (which ran the Polaris and Poseidon missile programs), the ballistic missile division of the Air Force, and more recently the joint service Cruise Missile Program Office, this pattern has been followed. These programs have been among the most successful, although in their later phases all encountered production cost overruns.

A second measure that would improve the application of technology and the effectiveness of modernized weapon systems would be to give the system contractors performance specifications rather than technical specifications. Performance specifications indicate the performance to be achieved; technical specifications detail the way to achieve it. To the extent that technical specifications are used, they inhibit contractor creativity. The prime contractor needs to have some leeway for trade-offs among the various performance specifications, giving substantial weight to maintainability and reliability. The development of the F-16 was a successful example of such an approach.

A third prescription, to avoid making inflation rates higher in defense than in the rest of the economy, is to have defense procurement grow at a modest rate in real dollars. Real growth of 10 percent a year in military systems procurement is not likely to cause inflation in unit prices. Overall procurement expenditure growth of 20 percent to 30 percent in a year will increase unit prices significantly. In extreme cases, more of the increased funding can end up in higher unit costs than in larger output of units.

One desirable change would be to use the profit incentive more effectively and to give more weight to past performance and less to the quality of the brochures that prospective contractors prepare as part of their bids in choosing among contractors. A larger return on investment than what has become common in defense work may be required to bring more subcontractors to bid on defense programs and to encourage both subcontractors and prime contractors to invest more of their own resources. This is not a popular idea. Such defense critics as John Kenneth Galbraith have argued that the defense industry ought to be nationalized, because it takes no risks and is not responsive enough to direction from the federal bureaucracy. Professor Galbraith lauds the flexibility allowed by federal shipyards and arsenals. Such an attitude could be held only by one who has never tried to close down or reduce the size of a federal shipyard or arsenal. In my experience, that is enormously more difficult to do than to cancel a contract or allow a contractor to go into bankruptcy. There was much criticism of the famous "golden handshake," a government guarantee of bank loans to the Lockheed Aircraft Corporation in connection with the C-5 aircraft contract. That arrangement levied a $200 million loss on Lockheed, from which the company has not fully recovered, though the government has never had to pay out any money on the guarantee. The settlement was harsh but just. It is difficult to imagine treating a government facility as sternly. Because the private sector is by and large more efficient than the government sector, that sector should be encouraged to use on defense programs the efficiencies of which it is fundamentally capable.

SUMMARY

There are real problems in employing modern technology in defense weapon systems—although they are not the ones set forth by the current crop of popular critics—and the solutions to those real problems are not easy. But the United States cannot afford to abandon the advantages that modern technology offers. It also needs to keep its lead in military technology by employing in the military sector advanced technologies available in the US civilian economy but not in that of the Soviets. There are alternatives to this reliance on technology: doubling the number of US personnel under arms to approach Soviet levels, increasing defense procurement budgets by 50 percent over what they would otherwise be to compete with the Soviets in quantities of equipment, and substituting purchase of production by allies for much of the current US production of military equipment. None of these would be acceptable to the American people. The defense procurement budget will have to continue to grow. The United States will have to share more rationally the task of defense development and procurement with its allies. US defense personnel requirements will prove a difficult problem in any case. But to exacerbate the difficulty of all these choices by abandoning the advantages of technology is an unnecessary, unintelligent, and self-defeating course.

The military balance between the United States and its allies and friends on the one hand and the Soviet Union and the states subordinated to them on the other is not nearly so unfavorable as the denigrators of US military capability have been proclaiming for the last few years; but it is precarious enough. The United States must not fail to *take* advantage of the advantages that it has—economic, political, ideological, or any other. And among all of these, the US technological advantage is one of the most important and valuable.

NOTES

1. The Korean War showed that superior technology and materiel resources can compensate for inferior numbers of personnel. The Vietnam War showed that technology, along with an enormously superior GNP, larger forces, and more materiel will not win a war in the absence of an adequate political infrastructure in the nation being defended, a determination comparable to that of the forces on the other side, or a willingness to use those advantages.

2. The costs of defense systems or of decisions made about them have come to be expressed publicly in terms of lifetime acquisition costs or overall system costs (including operation), because the analyses in the Department of Defense are sufficiently detailed to take a stab at such numbers. Defense critics sometimes object (correctly) when only acquisition, not personnel, spares, or maintenance costs, are included. For a social program, the annual costs are given, often for the first year (before full implementation). Presumably this is because, the program being likely to go on forever, there is no system "lifetime" cost. The result is that some legislators and analysts will press for a choice between a new weapon system and a domestic social program. In principle, the comparison may be feasible. They announce that the weapon system, estimated at $40 billion in current dollars, will probably cost $80 billion considering inflation and overruns. They may well be right. The social program will cost only $3 billion. Right again—and the comparative cost (and by implication, the priority) seems clear. But the cost of the weapon system is a 20-year cost and includes the effects of inflation. The cost of the social program is an estimated first-year cost. In fact, the social program is likely to cost $5 billion in current dollars the first year, $10 billion the fifth year (because eligibility will be expanded and because benefits are indexed to inflation), and even more thereafter. At the end of 20 years, the weapon system will have cost $80 billion in current dollars, and a new one will be in process. The social program will have cost, over the same 20 years, say, $300 billion in current dollars and will be spending $40 billion a year. It can be expected to be continued, at an ever-increasing rate, thereafter. Comparisons are not easy.