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TECHNOLOGY AND THE MILITARY BALANCE

The United States stands at a crucial point in its relationship with the Soviet Union. George Kennan's latest prediction—widely echoed by other analysts—is that U.S. domestic reaction to the impending SALT II agreement will define a watershed in the U.S.-Soviet relationship. I would argue that the continuity or disruption of the détente relationship will turn on issues going far beyond arms control alone, issues involving subjective considerations and beliefs about the origins and nature of Soviet strategic objectives and the impact of technology on the military balance.

The military balance is not the only factor affecting the U.S.-Soviet political relationship. It may not even be the most important one. But it is not possible to discuss intelligently the overall relationship without due regard for the military component and the contribution that the technological element makes to national power.

The recent historical context of the U.S.-Soviet military relationship has been one of dynamic change. For at least the last 15 years the Soviet Union has invested heavily in military-related science and technology at the expense of investments in technology for all other sectors. At the same time, the Soviets have watched the United States divert its defense resources into Southeast Asia, defer service modernization programs and cut back on military research and development. During this period the Soviet Union has made great strides in exploiting technology for military purposes, has fundamentally altered the strategic balance by the deployment of large numbers of intercontinental and submarine-launched ballistic missiles, and has dramatically improved the quality of its conventional forces. The purpose of this article is to examine some of the factors that determine where, how, and how well technology is being exploited to enhance military capabilities. Technology warrants particular consideration at this time, not only

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because of SALT II, but because there is widespread speculation that new weapons technology may be further altering both the strategic and theater aspects of the military balance.

Military technology is the set of skills and techniques that contribute to the production, operation and maintenance of weapons and other military equipment. Technological progress, though difficult to calculate precisely, is simply the ability to accomplish objectives that were not possible to achieve, or to reach presently achievable objectives more cheaply or more efficiently.

A discussion of U.S. and Soviet military technology is essentially a comparison of the total efforts of the two nations in the field of research and development (commonly called, in the military context, R&D). Comparison is made especially difficult because the two systems are the product of distinctive cultures, historical experiences, institutions, geography, external threats, and political ideologies. The complexity of the issue requires the candid admission that analysts do not even know with certainty the exact factors that drive the American R&D process, let alone that of the U.S.S.R. The best one can do is to highlight some of the most important elements and attempt to show how they may influence the process of weapons selection and development in the context of culture.

Similarly, any assessment of the military balance is partly a subjective comparison of two political-military systems. It cannot easily be reduced to a listing of intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs), and nuclear warheads. Such a static, quantitative comparison omits important dynamic factors like reliability, readiness, targeting, political will, and the conditions under which such weapons would come into use. In addition, there are many semantic problems with the term "balance," implying as it often does a condition of equilibrium between the two superpowers. No such implication is intended in this article. Instead, the military balance will be treated as a useful shorthand for discussing the relationship between the military forces of the two superpowers. In the final analysis, the real measure of a nation's contribution to the military balance is its overall ability to perform assigned missions—the maintenance of deterrence, the preservation of stability, and the protection of human values.

The central themes of this discussion are that the impact of technology on the military balance may be revolutionary or incremental—depending on how it is exploited—and the military balance may be changed by improvement of older technology as well as by development of the new. The underlying proposition here is that the effective exploitation of technology for military purposes is dependent upon a range of essentially nontechnological factors such as military doctrine, tactics, training, resource allocation preferences, organizational processes, R&D style, budgets, and arms control. The discussion will focus on five major questions: how military doctrine can affect the kinds of weapons technology that are developed; how management of the military R&D process influences decisions on technology; how new conventional weapons technology could change the military balance; whether massive changes in the military competition are likely; and finally, a proposed framework for an American R&D "investment strategy."

II

The first set of nontechnological factors that affects weapons technology, and thus the military balance, involves the process of establishing military requirements through adherence to military doctrine. Soviet military doctrine extends from fundamentally different cultural and political roots from that in the United States. There is even great divergence in the usage of the terms doctrine, strategy, military science, military art, etc. The distinctions are not important for most Americans. Because of a unique combination of the Enlightenment, political pluralism and continental opportunity, Americans have never put much stock in "doctrines" or doctrinaire statements of political purpose, even though we have dubbed as doctrines many broad policy statements like "containment," the "Truman Doctrine," the "Nixon Doctrine," the "Schlesinger Doctrine," etc. Recently, a high policy official in the Department of State stated that in the current Administration's view:

> There is no Carter Doctrine, or Vance Doctrine, or Brown Doctrine, because of a belief that the environment we are looking at is far too complex to be reduced to a doctrine in the tradition of post-World War II American foreign policy. Indeed, the Carter approach to foreign policy rests on a belief that not only is the world far too complex to be reduced to a doctrine, but that there is something inherently wrong with having a doctrine at all.[1]

This statement also reflects the Administration's recognition of a basic truth: that the Soviet Union is only a part of the foreign policy problem of the United States. (Soviet thinking, on the other hand, appears to be preoccupied with American developments.)

[1] Leslie Gelb, "National Security and New Foreign Policy," address given at the U.S. Army War College, June 8, 1977, printed in *Parameters* (Army War College), November 1977.

For all these reasons most Americans neglect Soviet military doctrine. Its importance, however, should be understood. Soviet military doctrine is authoritative and comprehensive, providing statements of how and with what weapons military forces are expected to fight. Military doctrine is used to define requirements for new weapons, develop operational plans and tactics, influence resource allocation for military investment, indoctrinate military members in their tasks, and mobilize popular, professional and political support. Aside from semantic distinctions, a comparison of Soviet and U.S. military doctrines reveals differences in military thought, attitudes and approaches to the problems of warfare.

There are at least six major areas of military doctrine that bear on the relationship between technology and the military balance, and in each of them the differences between the Soviet Union and the United States are significant. First is the way the two military establishments perceive the whole problem of warfare. U.S. writings convey a healthy appreciation of the role of uncertainty in battle and the need for flexible planning in operations and force posture. This approach leads to broad-gauged American R&D planning and general, rather than highly detailed, definitions of military missions. Hence, the United States traditionally builds weapons to be multipurpose, rather than narrowly specialized, and we expect operations to differ from plans.

In the Soviet Union an article of faith and ideology is that war is a science. To Soviet officers, military science is a unified system of knowledge about preparation for, and the waging of, war in the defense of the Soviet Union and other socialist countries against imperialist aggression. Its functions include the discovery and study of objective laws of armed conflict.[2] Soviet life is characterized by compartmentalization and secrecy. Soviet officers appear to be very intolerant of uncertainty and attempt to plan and prescribe every operational maneuver to the last detail. Soviet methods depend upon extremely centralized staffs, employ scientific methodology, examine the "objective" characteristics of warfare, and derive precise military requirements. Part of the traditional Russian emphasis on large numbers of troops and weapons ("mass") may be attributable to this fear of uncertainty. Mass can average out deficiencies caused by unforeseen circumstances, and mass lessens the responsibility to achieve optimal efficiency.

Second is a basic issue of whether doctrine or weapons is the more important factor in war. Despite all the writing about the

[2] General-Major S. N. Kozlov, *The Officer's Handbook (A Soviet View)*, trans. U.S. Air Force, Moscow: Voyenizdat, 1971, pp. 47–48.

"military-scientific revolution," the Soviets say they reject the thesis that weapons should dictate military strategy. A "grand debate" apparently transpired in the Soviet Union in the period immediately following Stalin's death in 1953. The issue was joined in a dispute over the strategic meaning of the surprise attack in 1941, and it paralleled a struggle for power between Malenkov and Khrushchev. The military debate centered on the dilemma posed between "doctrine" and "armament norms" (weapons quantities).[3] John Erickson maintains that the debate was resolved in 1955 in favor of doctrine: that prewar doctrine had been fundamentally correct, but it could not produce victory until the requisite "armament norms" were met. Although there is a "chicken-and-egg" quality to this argument, the current implications for technology are that military doctrine is expected to produce weapons requirements to "pull" technology.

Within this perspective, the role of military professionals is amplified. Soviet officers have traditionally been preoccupied with the problems of training a mass army. Training is made more difficult if weapons are not standardized or if their designs change rapidly. Thus, the dominance of Soviet military professionals has tended to produce a conservative design philosophy that is very "user-oriented."

Doctrine can also be forward-looking and to a degree inconsistent with current military capabilities. This was a problem in the 1960s, when some U.S. analysts had difficulty taking Soviet writings on land warfare seriously, particularly those parts that called for offensive breakthroughs and high-speed advances. Only in recent years, with the Soviet buildup in tanks, armored fighting vehicles, self-propelled artillery, multiple-rocket launchers, mobile bridging equipment, armed helicopters, tactical fighter aircraft, and air defense weapons has the vision in their tactical doctrine been supported by technological capability. For the first time, the quality of these new weapons and their deployment in large numbers provide the kind of mobility and shock power so long called for in Soviet military doctrine. Although the United States also has a military requirements process, many would argue that doctrine is only one of many determinants of U.S. weapons design. Indeed, one gets the sense that military preferences for high performance and industry competition for contracts have dominated the U.S. process.

[3] John Erickson, "Soviet Theatre-Warfare Capability: Doctrines, Deployments, and Capabilities," in *The Future of Soviet Military Power*, Lawrence L. Whetten, ed., New York: Crane, Russak, 1976, p. 144.

The third asymmetry in military doctrines is the striking difference in attitudes toward nuclear war. Western strategic theory has largely been conceived by academic theorists and places supreme emphasis on the use of nuclear weapons for deterrence of an attack by other nuclear weapons powers. Although the twin concepts of deterrence and defense (war-fighting) are linked, there is little doubt which is given preeminence. This emphasis extends from beliefs about the unprecedented destructiveness of nuclear weapons and the inability of technology to provide high-quality assurance of defense, validated to a degree by the Anti-ballistic Missile (ABM) Treaty of 1972.

Influenced by a different historical experience, Soviet strategic thought has largely emanated from professional military men who have never made quite the same sharp distinction between deterrence and defense. Perhaps it is the traditional search for unilateral measures of security or the deep-seated belief in "balanced forces," but both Soviet representatives in the Strategic Arms Limitation Talks (SALT) and Soviet political leaders have consistently resisted the Western concept of mutual deterrence. The Russian language has no direct equivalent to the English "deterrence," an asymmetry that may well have affected the development of Soviet strategic thought in the past three decades.

While most U.S. officials agree with their Soviet counterparts that a war-fighting capability is essential to make deterrence credible, U.S. strategic policy often draws subtle, but definite, distinctions between the two concepts. Perhaps the clearest example of the difference was the emphasis of former Secretary of Defense Robert McNamara on programming forces separately for deterrence through assured destruction and defense through damage limitation. The distinction was never trivial. Whereas the weapons requirements for assured destruction are *relatively* quantifiable given certain assumptions, the requirements for security through buying a convincing war-fighting capability are much more open-ended. The arms control implications are obvious. If one side believes it has an "objective" security requirement for a well-developed war-fighting capability and high force levels, it is going to be difficult to achieve agreement that equal security can be achieved through deterrence and significant reductions in forces. Similarly, the requirements for maintaining the current U.S. policy of "essential equivalence" are much more complex and subjective than were those of assured destruction.

A related point is the contrast in the emphasis the two powers place on investment in strategic nuclear weapons. Over the tenyear period 1967–77, the level of Soviet spending on strategic forces measured in dollars has been two-and-one-half times that of the United States. While it is true that the United States made heavy investments in ICBM and SLBM forces in the previous decade (1957–67), the earlier U.S. investment only dramatizes the current divergent trends. In 1977, the Soviet investment in strategic systems exceeded that of the United States by more than three times.[4] Although one can discount some of this investment differential due to differences in efficiency, the magnitude of the disparity and the trends are disturbing.

Fourth, Soviet and American military doctrine diverge on the question of quantitative superiority. The United States has superiority in numbers of bombers, but U.S. nuclear policy has apparently abandoned the necessity, if not the desirability, of maintaining superior numbers of both ICBMs and SLBMs. Largely because of resource constraints, the NATO nations have not attempted to attain conventional numerical superiority in Europe. American R&D style has traditionally emphasized qualitative superiority, with smaller numbers, and U.S. military doctrine, while appreciating the value of mass, has adjusted accordingly. This preference for high-value, multipurpose weapons and the desire to substitute technology for manpower can be called an American "doctrine of quality." One of the results of the doctrine of quality and technological substitution has been a certain tendency for technology to drive both strategy and doctrine.

Soviet military doctrine, until recently, has had no tradition of qualitative technological excellence to draw upon, and so it has placed great emphasis on quantitative superiority. This tendency was reinforced in World War II when, faced with a qualitatively superior German force, the Soviet Union found quantity sufficient to its needs. Although most Westerners think of Russian military men as being preoccupied with "mass" in both manpower and matériel, a close reading of their doctrine indicates they are not talking simply about "mass," but about "armament norms." These are designed in the conventional case as planning guides to provide distinctive relative superiority, sufficient to seize the initiative, overwhelm an expected Western superiority in quality, and strike at the opponent's central nervous system.

In the case of strategic forces, the effect of "armament norms" is much less clear. While the Soviet Union has achieved an evident

[4] Central Intelligence Agency, *A Dollar Cost Comparison of Soviet and US Defense Activities, 1967–1977*, January 1978.

level of quantitative superiority in ICBMs, SLBMs and air defense forces, its leaders are apparently committed to the principle of equal aggregates as a result of the 1974 Vladivostok agreement. Whether SALT has had a significant impact on Soviet military doctrine and the tendency to acquire "safe margins" is still open to question.

Fifth, Soviet and American views diverge on the question of the first battle in the case of a possible NATO-Warsaw Pact confrontation. Despite certain weapons design characteristics like long range in tactical fighter aircraft, NATO declaratory policy, doctrine, force posture and deployment signal an intention to fight the first battle on the defensive. Soviet doctrine, on the other hand, reflects a clear belief in the primacy of the offensive.[5] Though their precise policy may be obscure, their written doctrine, professional debates, forward deployment, readiness, and ground force weapons all indicate a formidable offensive posture. Further, the preoccupation with concealment, deception, and surprise attack places a premium on preemption as the core value of Soviet military doctrine. Many Soviet officials frankly admit to having a "June 22 syndrome," which increases the credibility of Malcolm Mackintosh's dictum to "strike first in the last resort." Thus, Senator Sam Nunn can state with some assurance:

> What confronts NATO across the inter-German border today is not 935,000 Pact troops, but 935,000 Pact troops organized, deployed, trained and equipped for *blitzkrieg*, and governed by a doctrine based on surprise and a postulated rate of advance of 70 miles per day.[6]

Finally, a related, but not precisely doctrinal, precept is that of "troop control." Here the United States really has no equivalent: we emphasize command, control and communications, but that is not exactly what the Soviets mean by the term. What the Soviets apparently fear is the disorientation that comes when precise plans do not work out smoothly. They have an inordinate fear of the unknown and the unexpected, reflected in writings about "loss of bearing" by commanders. Soviet leaders attempt to deal with this in three ways: by placing a tremendous emphasis on troop indoctrination and officer education, by increased efforts at obtaining detailed intelligence for more precise planning, and by attempts to develop the "science of military management." This "science,"

[5] A. A. Sidorenko, *The Offensive (A Soviet View)*, trans. U.S. Air Force, 1974, Moscow: Voyenizdat, 1970, and S. N. Kozlov, *op.cit.*, p. 65.

[6] *New York Times*, November 14, 1977, p. 17. The "June 22 syndrome," in the text, refers to the date of the all-too-successful German attack on Russia in 1941.

Soviet military authors maintain, is the most recent of the military-scientific revolutions and is centered in the concept of military cybernetics. The characteristics of the "scientific" management of "troop control" are ever-increasing centralization, computerization, automation of control processes, "scientific" selection of engineer-commanders, repetitive training to routinize and automate human reactions, and development of mathematical models for prediction.

Troop control as a doctrinal precept appears to Western observers to be a pessimistic prediction of human behavior and an attempt at the manipulation of personality, but it is also derived by Soviet military tradition from a basic organizational evaluation of the educational quality and cultural heritage of Soviet recruits. For at least the last century the Russian Army has been conscripted from unskilled and uneducated manpower. With the dramatic decline in the birthrate among Russian nationalities, the Soviet Army is projected in the next ten years to include a high percentage of non-Russian recruits. The tremendous Soviet efforts at education have had remarkable results, but compared to Western armies, Soviet manpower is clearly less technically skilled and less oriented toward individual initiative.

The question of troop control is related to technology. Both the Soviet Union and the United States are investing heavily in command, control, communications, and intelligence systems to obtain better capabilities in the areas of warning and battle management. But the investment patterns differ. The United States is attempting to *centralize* intelligence and communications, based on the development of high-data-rate computer systems, but to *decentralize* execution of plans and operations. In contrast, the Soviets are investing heavily in systems that will centralize *both* intelligence and command, relying on highly redundant communications channels to pass orders to tactical units.

Examples of the contrasting approaches to mission areas include air defense, where the Soviet Union has traditionally chosen to centralize its technology in ground-based missile systems and in ground radar stations, while the United States allocates a greater percentage of its air defense/air superiority electronics to the individual aircraft. Soviet anti-submarine warfare doctrine stresses team tactics with many ships; American R&D design has placed more technology and more faith in the hands of the individual ship captain. U.S. enlisted men handle command and management responsibilities that are only entrusted to officers in the Soviet Union.

III

The second set of nontechnological factors that affects weapons technology is a nation's R&D process, or style. It is popular in some circles to deride Soviet military capability and research and development by comparing the quality of selected Soviet weapons with supposed U.S. equivalents. It should be kept in mind when analyzing individual weapons, however, that such comparisons have limited utility. Differences in capabilities are exaggerated by individual comparisons, and we tend to forget that weapons are rarely used singly. Weapons are designed, developed, produced and deployed as part of a larger cultural and military matrix, involving support systems, logistics trains, maintenance facilities, allies, terrain, manpower, doctrine, training and plans about how wars are to be fought. At best, static comparisons of present technology can provide useful guidelines in contrasting approaches; at worst, they hide trends and specifically, as far as U.S. policymakers are concerned, can delude them into thinking that "technological superiority" guarantees peace. Superior arms provide real advantages, but at some point greater quantity in deployed lower-quality weapons confers the capability to overwhelm the highest quality defense.

The main difference between U.S. and Soviet R&D systems is grounded in the contrasts between a competitive market economy and an ideologically constrained, centrally planned economy. In the United States, industrial producers draw from a superior technology base, tend to conduct civil and military research and development simultaneously, and to satisfy a high civil demand for advanced technology products. In the Soviet Union, government ministries are sharply divided between civil and military R&D, and the civil market is controlled to restrict the supply of high-quality technological goods.

The Soviets have developed a distinctive national style for weapons development and acquisition that produces large numbers of weapons of increasing quality to meet the requirements of Soviet military doctrine. The R&D decision process for weapons designs includes the Politburo, the Council of Ministers, the State Planning Commission, the Ministry of Defense, the General Staff, the Armed Services, and the nine defense-industrial ministries. Research and development decisions are made in a closed subsystem of the Soviet government, with the military and Party leadership composed of narrow, technically oriented professionals. The political leaders have extensive technical expertise, but are poorly equipped to review professional military advice on doctrine, weapons, or training against broadly based cost-effectiveness, foreign policy, or arms control advice. The compartmentalized, secrecy-dominated political system, operating largely on the principle of consensus, reinforces the tendency toward conservatism noted in the development of military doctrine. The compartmentalization reduces the flow of information and makes comparisons of effectiveness between force components (e.g., ground-attack aircraft and tanks) very difficult. Compartmentalization and continued high defense budgets also tend to reduce interservice rivalry.

Despite the bureaucratic nature of most Soviet decision-making, the lack of pluralism makes the R&D decision process perhaps less elaborate and certainly more hierarchical than that in the United States. The Soviet process is characterized by fewer reviews of major projects, less overlap of organizational responsibilities, fewer checks and balances, and more stable budgets.

The American R&D process includes a large number of industrial contractors, university research laboratories, the military departments, the office of the Under Secretary of Defense for Research and Engineering, the Executive Office of the President (including the National Security Council and the Office of Management and Budget), and the Congress. Comparatively, this American R&D process is more fragmented, more open to citizen and external influences, more concerned with "due process," and more responsive to arguments over arms-control implications, environmental impact, and a fair allocation of government contracts. Responsibility is diffused, and weapons programs are subjected to multiple reviews and yearly budget cycles. The constant exposure to external influences and the intense competition for annual budget funds give the U.S. policy process a program orientation that is probably not felt to the same degree in the Soviet Union. Despite the structural deficiencies, the U.S. system operates amazingly well because of the skill, flexibility, and ingenuity of its smaller number of scientists, engineers, and technicians.

The major Soviet institutions that actually control weapons design are the defense-industrial ministries, which are vertically integrated, each one having under its jurisdiction research institutes, design bureaus, and manufacturing plants. Although nominally centrally controlled, the organizations are usually both geographically and functionally distinct. Theoretically, research and testing is done by the research institutes, weapons design and prototype construction are done in the design bureaus, and

production is accomplished by the manufacturing plants. In reality, a complex network of inter-ministry communications, agreements, and bargaining exists.

For the more mature technologies, research institutes constrain weapons design from the very beginning by publishing handbooks for designers that specify not only research results, but an approved list of structures, design forms, components, materials, and manufacturing techniques. Designers, for their part, have a great deal of internal autonomy, but they are restrained by the research institutes, the lack of sophistication in production technology, the technical level of Soviet troops, and incentives to produce new prototypes frequently. Design bureaus exercise technical restraint, not so much because they do not have the materials or training to develop more advanced designs, but because of the influence of the doctrine that military capabilities are enhanced more by large numbers of deployed weapons with modest individual capabilities than by smaller numbers of higher quality weapons.

Soviet weapons produced from this traditional approach tend to have three main characteristics: design simplicity, interchangeable parts, and evolutionary growth.[7] Design simplicity is exemplified in the T-62 tank, which has a manual transmission, a manual, lever-type steering mechanism, and a 40-year-old engine design.

Common parts on weapons of the same type, with standardization across different weapons systems of the same vintage, is the second major Soviet characteristic. For example, many types of warships use the same auxiliary equipment and propulsion plants. In aircraft, the same turboprop engine was used in the An-22 transport as in the old Tu-20 bomber. Common parts are also used in the West, but not to the same degree. Soviet equipment is also produced by East European allies with the result that Warsaw Pact weapons—though not completely standardized—are more standardized than those of NATO.

The third traditional feature of Soviet weapons is incremental growth or cumulative product improvement as opposed to the U.S. tendency to favor whole new weapons systems. An outstanding example is the MiG-21 aircraft. The MiG-21 was first developed in the mid-1950s as a lightweight, clear-weather fighter. It has evolved with steady improvements in engine thrust, aerodynamics, fire control systems, electronics, and airborne weapons, and in 1978 performs the mission of all-weather interceptor of enemy aircraft, while other versions of the same basic aircraft have a con-

[7] Arthur J. Alexander, *Armor Development in the Soviet Union and the United States*, R-1860-NA, Santa Monica: The Rand Corporation, September 1976, p. 48.

siderable ground attack capability. This evolutionary improvement of subsystems, with extensive prototype testing, has increased Soviet military capabilities, while minimizing the large expenditures on research and development and retraining that are required with wholly new systems.

U.S. weapons development, on the other hand, is primarily oriented toward high performance. Complex computer models permit the calculation of kill probabilities and weapons lethality for different systems, and technology is then applied to maximize these numbers. Given the U.S. military requirements for high performance and low attrition rates, U.S. industrial contractors tend to respond with proposals for revolutionary developments, new subsystems, and sophisticated design. All too often, however, the resultant weapons have been overly complex, less reliable than past models, and increasingly expensive. The cost per unit of these new weapons has increased an average of four-and-one-half times per decade in constant dollars since 1950. In addition, while substituting technology for manpower at the operational end of the spectrum, the sophistication of U.S. weapons has tended to generate higher support costs and increased maintenance manpower requirements.

Occasionally U.S. weapons have made good use of incremental product improvement—most notably the Boeing B-52 and McDonnell Douglas F-4, whose longevity extends from early 1950s designs to present-day operation. In addition to lowering training costs and providing a high return on investment, such improvements in existing designs have only increased cost by a factor of two per decade. But such evolutionary developments do not have many advocates in the U.S. acquisition process.

The nature of the American R&D process has produced two other problems that are increasingly being recognized. One is the trend for the large number of decision centers to introduce procedures that lengthen the time between the beginning of a weapons program and the deployment of the system (12 years in some cases). The second is the tendency for the budget to provide less than planned funding of the number of systems placed into full-scale development and production. This discrepancy between planning and implementation often reduces production rates well below what is considered efficient. The effect of both of these process characteristics is to stretch out the American R&D cycle and to greatly increase the cost of weapons development and acquisition.

Having described the central features of the American R&D

system and characteristics of what some call the "traditional" Soviet style, an important question remains: To what degree are Soviet weapons development trends departing from the traditional pattern and adopting a more innovative style? The answer to this question is uncertain, but some data are becoming available on Soviet weapons innovations. Examples of totally new systems are not numerous, but those that exist have all appeared in the last 10 years. Many of the innovations are on systems that are better than similar U.S. systems or for which the West has no comparable items. Three examples are the BMP armored fighting vehicle, the ZSU-23/4 radar-directed, antiaircraft gun system, and the *Krivak* guided missile destroyer. The BMP contains a unique combination of innovative capabilities. It is a lightweight, armored personnel carrier with complete chemical and nuclear shielding and a low-velocity gun, firing rocket-assisted projectiles and antitank guided missiles. In service in large numbers in 1978, it is the primary vehicle (along with T-62 and T-72 tanks) that makes the doctrine of surprise attack, high-speed advance, and deep envelopment a credible threat to NATO.

Even more important, the general rule that the Soviet Union uses a conservative, traditional, incremental R&D style while the United States develops revolutionary new technology may be reversed in the ICBM case. Since 1967 when the U.S. ICBM force leveled off at 1,054 missiles, only one new strategic land-based missile has been introduced—the Minuteman III, deployed in 1970. In the intervening 11 years, the Soviet Union has deployed six major new ICBMs and several variations. In fact, it is the United States that has switched to an incremental style of development, while the Soviets, with the SS-17, SS-18, and SS-19, have made dramatic increases in ICBM capability. Incrementalism has many advantages, but most analysts agree that further improvement of the Minuteman will not solve the basic problem caused by Soviet ICBM developments—i.e., drastically increased silo vulnerability.

An estimate of the contribution of better technology to Soviet ICBM capability can be obtained by examining the SS-19's improvements over the SS-11. According to one congressional analyst, the SS-19 represents a 15 percent increase in length and diameter, which produces a 32 percent increase in hard-target kill capability, or lethality. A series of technological improvements provide the SS-19 with multiple independently targetable warhead capability, increased payload efficiency, and increased accuracy. Taken together, the technological improvements of the SS-19 over the SS-11 increase the new missile's counter-silo capability by something over 40 times.[8] These improvements in technology threaten to alter the balance of military power much more than the Soviet achievement of quantitative superiority in ICBM/SLBM force levels.

Thus, the tentative answer to our question is that the Soviets are apparently demonstrating some signs of more, if not much, innovation in conventional weapons design and have shown a surprisingly rapid evolution in ICBM/SLBM performance.

The next question concerns the relationship of the characteristics of the two R&D systems to implications for the military balance. What is the relationship between inputs to the systems and tangible military outputs? On the input side, the Soviet investment in research and development when measured in dollars was about one-half that of the United States in 1964–68, equal by 1970, and in excess of American R&D outlays by 50 percent in 1976.[9] In the category of weapons procurement and military construction, the Soviet Union by 1976 was investing *twice* as much as the United States. This large investment in procurement activity has currently given the Soviets a six to one advantage in tank production; three to one in infantry fighting vehicles; eight to one in artillery; two to one in tactical aircraft; and slight advantages in helicopters and antitank missiles.[10] The resultant defense-industrial capacity provides the Soviets a considerable technological base, with production potential that is usually not thought of in comparisons of technology.

The combination of what may be increasing innovation with the continuity, steady quality growth, and high production rates of new and improved military systems indicates a technological trend in the balance of deployed military capability that is adverse for the United States.

IV

This review of U.S. and Soviet doctrine and R&D style has stressed how these essentially nontechnological factors influence the two nations' development of military technology. A third nontechnological factor that affects weapons is arms control. Many observers feel that the failure to incorporate sufficient consideration of technical factors into the SALT negotiations is a serious flaw. With the brief discussion of the SS-19 it can be seen that

[8] Robert Sherman, "A Manual of Missile Capability," *Air Force Magazine*, February 1977, p. 39.
[9] Central Intelligence Agency, *supra*, footnote 4, p. 6.
[10] U.S. Department of Defense, *Annual Report FY1978*, January 17, 1977, p. 114.

qualitative technical factors far outweigh numerical ceilings and physical size constraints in determining the military effectiveness of intercontinental missiles. At the same time, the adoption of the principle of equal aggregates and the continued Soviet deployment of mass would seem to make it all the more imperative that the United States not constrain itself in the area where it has traditionally demonstrated a capacity for excellence.

Military doctrine and R&D style affect other areas of military preparedness, influencing both strategic and tactical programs. In the strategic area, for reasons that we do not fully understand, the Soviets are pushing hard on scientific research in antiballistic missile defense, high-energy lasers, charged-particle beams, and anti-satellite interceptors. Some analysts see in these intensive efforts (and associated reports of civil defense activity) an attempt to fulfill a Soviet doctrinal prescription to develop a complete war-fighting capability. The development of an operational capability in any one of these areas could seriously alter the military balance.

Military doctrine and acquisition style also interact with dramatic developments in new conventional weapons technology. Advances in solid-state electronics, propulsion, and computer-related fields appear to offer tactical weapons capabilities in the mid-1980s that could cause major changes in warfare. First demonstrated in combat during the 1973 Middle East War, the new technologies are clustered in the areas of tactical intelligence, precision-guided weapons, and improved conventional munitions.

While it is too early to tell whether the impact of the new conventional weapons technologies will be revolutionary or incremental, the role of military doctrines and R&D styles is going to be a key factor. While many predict that the general influence of the new weapons will be to increase the vulnerability of large ships, aircraft, tanks and armored fighting vehicles, it is not at all clear whether such changes will ultimately benefit NATO or the Warsaw Pact. The potential firepower of a "new technology" NATO defense would tend to shatter the Soviet doctrine of the offensive, but the capability of the Soviet R&D process to produce great numbers of heavily armed vehicles tends to offset high loss rates. In addition, the Warsaw Pact has begun deploying large numbers of antitank guided missiles and making other weapons and organizational changes to exploit the new technologies. Changes to date, however, have been in the direction of increasing the tactical efficiency of combined arms operations and have not indicated a revision of the basic doctrinal concepts discussed above.

In the Western alliance, there is excitement at the possibility that the new technologies may for the first time make possible a conventional defense of Europe. But such enthusiasm should be tempered by acknowledgment that NATO is not currently structured for the dispersed and decentralized warfare that seems to favor the new weapons. Changes will have to take place before the potential of the new technology can be fully explored. No area of defense policy in the next decade will require a more concerted effort to sort out the intermingled threads of military doctrine, organization, training, tactics, weapons design, and acquisition.

V

The context of the U.S.-Soviet relationship has been characterized by massive investments in military-related science and technology and a gradual improvement of the Soviet position from strategic inferiority 15 years ago to one of essential equivalence today. Looking into the future, there are some indications the Soviet Union in the next decade will be facing a period of economic and political crisis. Will arms limitation agreements and the scope of these emerging problems engender any change in policy priorities toward a redistribution of investment away from military programs into the civil sector?

Much as we would like to see a slackening of the Soviet military effort, there has been none to date and there are reasons to doubt any massive changes in the future. Although strategic arms limitation agreements are desirable, they are more likely to redirect than to diminish defense efforts. In the area of conventional arms, where the Soviet Union has already achieved well-defined advantages, arms control has moved very slowly and has had no discernible impact on Soviet armament levels. After centuries of lagging behind the West militarily, Russia has only recently achieved a position of parity. The confidence and self-assurance that this status breeds are only slowly becoming apparent. While militarily equivalent, the Soviets apparently still perceive themselves to be technologically and economically inferior and show every indication of continuing to strive energetically for further military gains. The major development decisions that will affect Soviet force posture in the next five to eight years have already been made—in a period of striking Soviet increases. Finally, Soviet leaders may find it difficult to renounce, or even modify, cultural beliefs that base domestic political stability on the acquisition of military power.

This discussion has stressed that U.S. and Soviet technology are driven by unique military doctrines, resource allocation preferences, and R&D styles. Soviet weapons appear to be remarkably

well designed and consistent with Soviet military requirements, industrial capability, level of troop training, and employment doctrine. Furthermore, massive investments and a disciplined R&D strategy have permitted the technology in deployed Soviet weapons to approach that of the United States in enough specific military mission areas so that the future stability of the military balance is in question. SALT and conventional arms control may provide new boundaries and incentives for technological development, but to date there have been no signs of slackening in the long-term military competitive relationship.

In a military balance where many quantitative measures accrue to the other side, most U.S. policymakers place a high value on retaining technological superiority. Yet recent trends indicate this superiority will be increasingly difficult to maintain without an appropriate investment strategy and the associated organizational and doctrinal changes. While many agencies of the U.S. government invest heavily in research and development, it is not clear that such a strategy now exists.

VI

There are four general areas in which a U.S. strategy needs to respond to the Soviet buildup. The first is perhaps the most difficult—the need to recognize that the United States is in a long-term competition with the Soviet Union, and political leadership will have to be directed to obtain popular support for a responsible and measured position. As a corollary the United States should respond in a way that strengthens the political cohesion of the Western alliance and does not overly distort U.S. global and domestic priorities.

The second area is in the coordination and integration of several macro-elements of an investment strategy. These are government-wide policies that can only be developed and implemented in an inter-agency forum, supervised by the National Security Council and the Executive Office of the President. They include U.S. policy in the difficult areas of arms control, arms transfer, technology exports, international cooperative research and development, and the technology base. Arms control policy is critical because, more than most other areas, it influences Soviet expectations about the overall political relationship. The United States should continue to strive for reasonable, verifiable agreements, not expecting arms control to solve the entire security problem.

Arms transfer policies should be included in this framework because the volume of sales and the technological component of U.S. weapons are a vital aspect of our global influence. Similarly, civilian technology like high-speed computers and microcircuitry are eagerly sought by the Soviet Union and Eastern bloc countries, and unchecked exports could have an adverse effect on U.S. security. The international development of cooperative R&D policies and programs is an essential ingredient in our relationship with NATO allies. The growing cost of research and development makes it apparent that the Alliance cannot afford highly redundant and wasteful national efforts. Economies of scale, an expanded fighting capability, and increased political cohesion are only some of the reasons why NATO standardization and interoperability are essential to a U.S. strategy.

A macro-approach to a U.S. investment strategy should also include a reinvigoration of the technology base. This is essential because of growing signs of slackening in the growth of U.S. industrial productivity, a decline in private investment in basic research, and a steady reduction in the number of U.S. scientists. Scarce capital and continued high inflation have caused U.S. industry to cut back on investments in the technology base for at least the last seven years. The increases in defense and government-wide budgets for basic research submitted to Congress in January 1978 by President Carter should be supported as an investment in our "technological future."

The third major area of a U.S. investment strategy is where technology, military strategy and doctrine intersect—military mission areas. Pressed by the Soviet buildup and the altered military balance on one side and the opportunities presented by the new technologies on the other, there is a critical need to review U.S. strategic and doctrinal concepts. This has already been started with detailed mission-area analyses now being conducted in the Defense Department. When completed, these studies should provide the essential core for the development of individual investment portfolios tailored to the mission areas.

Only a few military mission areas will be mentioned here. In the strategic area, there is a growing acknowledgment that the United States will need to make a major decision to meet impending threats to the land-based missile force either by modernizing or by other means. In space, the United States has a general technological lead that should be exploited by accelerated development of both manned and unmanned systems.[11] But it is now apparent that these systems will have to be hardened and provided with essential defensive capabilities to reduce their vulnerability to interference.

[11] Two programs that could have revolutionary effects on military operations are the Space Transportation System (shuttle) and the NAVSTAR Global Positioning System, a set of 24 satellites that will permit three-dimensional positioning with accuracies of ten feet.

In general purpose forces, the Soviet buildup requires an immediate U.S./NATO response to field more antitank, artillery, and air defense weapons. Over the longer term, the challenge of the new weapons technologies requires an especially searching review of organizational and doctrinal concepts.

The fourth major area of the framework consists of the micro-elements of a U.S. investment strategy. These elements deal with R&D management and style. The overwhelming need here is to devise new methods to accelerate the flow of affordable technology into the field forces. The number of formal steps in the acquisition process should be reduced, and those that remain should be viewed as flexible. Programs should be tailored to match need and technical risk. Innovative organizational styles should be attempted. Procedures should be streamlined to reduce the length of the R&D cycle in an attempt to reduce the effect of inflation and reduce overall costs. The number of systems in full-scale development and production at any one time should be controlled so that the selected systems can be fully funded at efficient production rates.

The military services should examine more closely the opportunities for meeting military requirements through the improvement of existing systems. New systems development should be reserved for those cases where evolutionary growth will not provide the capacity to meet the military challenge or where technological opportunity is unusually promising. Experimental prototyping can be a valuable guide in determining the feasibility and cost of shifting from an incremental improvement to a revolutionary jump. Even in completely new systems, the United States should expand the development of the so-called high-low mix. First attempted in tactical fighter aircraft, the concept should be applied vigorously to surface ships, tanks and other major programs. By developing a combination of high-quality/high-cost systems with larger numbers of adequate quality/lower cost weapons, the American R&D process should be able to fully exploit the potential of the new technologies and provide sufficient quantities of deployed systems to compete over the longer term.

Finally, an investment strategy should serve as the focal point to bring together the technical and tactical communities and to clarify the interaction among technology, the R&D process, military doctrine, and organizational changes. Only with broad public support and effective implementation of an investment strategy can American defense policy relate advancing technology to the military balance.