How technology fuels the arms race.

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FROM the 1985 Geneva summit to the meetings in Moscow last May, the thaw in superpower relations has raised hopes for a comprehensive U.S.-Soviet arms-control agreement. But amidst all the speculation about the elements of a possible settlement, observers have overlooked a central issue. the persistence of the arms race is deeply rooted in contrasting U.S. and Soviet approaches to weapons innovation, approaches that reflect the very different characters of the two societies.

The relative openness of U.S. society shapes the development of new weapons in this country. Compared to the Soviet Union, U.S. military research and development is widely decentralized, encouraging the free flow of information and rewarding low-level initiative. As a result, the process fo weapons innovation takes place from the "bottom up" with scientists and technologists in government and the private sector playing a leading role. this process fosters the attitude that technological innovation is the surest guarantor of national security.

In the more closed Soviet Union, military R&D is highly centralized, hierarchical, and characterized by excessive secrecy and compartmentalization--all of which inhibit technological innovation. But these very same characteristics allow the Soviet Union to concentrate its resources from the "top down" and respond to U.S. technological initiatives by mass-producing weapons.

For decades these two systems have been locked in a vicious circle. The United States has depended on technological innovation to provide a decisive advantage over the Soviets. The Soviets have depended on the mass production of weapons to overwhelm U.S. technical quality with Soviet quantity. And whenever the Soviets have mastered an American innovation, they have been able to deploy it to negate the original U.S. advantage, often posing an unforeseen and even more serious threat. That threat has served to justify further U.S. innovations, starting the arms-race cycle all over again. In this way, U.S. technological innovation has ended up diminishing rather than enhancing Western security.

The vicious circle can be broken. The factors that have made for the spiraling arms race also hold the seeds for a fundamental U.S.-Soviet agreement on arms reduction--a trade-off of U.S. quality for Soviet quantity. Such a political compromise is the real hope of current negotiations. But achieving it will require that U.S. weapons scientists and technologists give up the false hope of attaining technological superiority once and for all.

In this country, the creation of a new weapons system generally begins when scientists in arms laboratories or military officials in close contact with them start to champion new technical possibilities in the government bureaucracy. The nuclear-powered submarine was largely the product of one such technical entrepreneur--Hyman Rickover. Starting in the mid-1940s as an unknown navy captain with a background in engineering, Rickover persuaded his superiors at the Atomic Energy Commission and the navy's Bureau of Ships to support the development of nuclear propulsion for submarines. His efforts attracted the backing of influential members of Congress and eventually earned him the rank of admiral and the title of "father of the nuclear navy."

Similarly, the nuclear physicist Edward Teller was the patron behind the development of the hydrogen bomb in the early 1950s. While working on the Manhattan Project, Teller was preoccupied with the idea of a "superbomb" based on nuclear fusion rather than fission. After the war, he successfully lobbied Congress to establish a second nuclear weapons lab in Livermore, Calif., claiming that scientists at Los alamos opposed hydrogen weapons. Even before coming up with the major design breakthrough for the H-bomb, Teller was already trying to interest air force officials and lawmakers in the weapon. Thus began a long and remarkably successful career of influencing U.S. military policy through contacts in the Pentagon, Congress, and the military-technical community.

Sometimes, scientists will advocate a particular arms system as an alternative to weapons they oppose. Tactical nuclear weapons were developed in the early 1950s largely because some U.S. scientists, J. Robert Oppenheimer among them, disagreed with the prevailing policy of strategic bombing and Teller's plans for the H-bomb. At the height of the Korean War, Oppenheimer and his colleagues thought tactical warheads for actual use in combat were more relevant to U.S. military requirements. Ultimately, the

United States developed both weapons.

Once a particular system gains the backing of enough civilian or military technologists, their enthusiasm can often keep it going under private sponsorship, even when high-level government officials try to eliminate it. In 1949, the air force decided to cut back on the Convair Corp.'s research on ballistic missiles--weapons that threatened to undermine the Strategic Air Command's preferred reliance on bombers. But Convair simply continued research with its own funds until the air force resumed sponsorship of the program in 1951. The project eventually became the Atlas intercontinental ballistic missile (ICBM). (See also "Money, Politics, and the B-1 Bomber," April 1988.)

Such low-level initiative in the absence of high-level support has subsequently been institutionalized in the U.S. military research and development community, at a cost to taxpayers of several billion dollars a year. Under the Pentagon's Bid and Proposal (B&P) program, private corporations can charge the costs of preparing unsolicited proposals for additional new weapons as overhead on their Defense Department contracts. The Independent Research and Development (IR&D) program allows firms to recover the research-and-development costs of projects that they have initiated, without a prior government contract or any congressional oversight.

Building Consensus and Countering Threats

Once a new technology is identified, its designers actively promote military applications by "consensus building." Creating a consensus around a weapons system starts with the military-technical community and gradually reaches to top military officials, members of Congress, and usually officials in the executive branch. Sometimes, it can take years or even decades.

Consider the neutron bomb, a weapon that kills primarily with neutron radiation rather than with the blast, heat, and gamma radiation of standard fission and fusion weapons. The major conceptual breakthrough for the bomb occurred in 1958, a result of the work of physicist Samuel Cohen at the Rand Corp. Over the next 20 years, Cohen, Teller, and other supporters went from the air force to the navy to the army in search of support for the weapon--at first with little success.

In 1973, however, when Congress turned down an army request for the development of a new nuclear artillery shell, the service somewhat reluctantly came to support the development of neutron warheads, in the belief that championing a new kind of tactical nuclear weapon was the only chance to get a new artillery shell. Five years later, President Carter ordered production of a neutron-bomb warhead for the Lance missile. And in 1984, Congress finally approved a program for a neutron-bomb artillery shell--in an obscure amendment attached to the Defense Authorization Bill and passed without a roll-call vote.

Consensus-building has an important influence on the design of U.S. weapons systems. For one thing, many related programs are often pursued at the same time so as not to exclude any potential supporters for a given technology. This leads to redundancy in weapons produced. The classic example is the development of intermediate-range ballistic missiles (IRBMS) in the 1950s. Both the army and the air force worked on the weapons, ultimately producing two virtually identical systems--the army's Jupiter and the air force's Thor.

A second common method for creating consensus is to incorporate all the technical features or capabilities desired by potential supporters into a system. The result is weapons of greater technical sophistion than is necessary or desirable for a given military mission. The F-111 aircraft was the unhappy product of such a logrolling consensus. Promoters designed the plane with variable-sweep wings on the theory that it could fulfill a variety of missions for both the navy and the air force, including air-to-air combat, close-air support of ground troops, and long-range bombing. But because of persistent technical problems with this advanced design, the F-111 fulfilled none of these missiones well and cost far more than anticipated.

Of course, as the neutron bomb example suggests, not all proposed weapons immediately win military or government approval. Often one branch of the military resists a particular innovation that it fears will jeopardize its own organizational traditions or mission. So, promoters of new weapons systems emphasize the inability of current weapons systems or organizational structures to deal with foreign threats. For example, the air force's interest in intermediate-range missiles during the mid-1950s was evidently triggered by concern that the army's IRBM program would yield a system that could replace aircraft in many important combat missions, such as deep interdiction attacks against major air bases and supply depots. Yet both services justified their programs by exaggerating the danger of a Soviet ballistic-missile threat.

Once a weapon has received sufficient support from the services and from key congressional committees to enter advanced R&D, promoters frequently look for events to justify producing a prototype. The classic example is the Soviet Union's October 1957 launching of Sputnik. Although the Soviets had already tested an ICBM the previous August, the Sputnik satellite was a more dramatic demonstration of the technical capacity for launching long-range ballistic missiles. It spawned fears of a "missile gap" and transformed the U.S. ICBM from a project supported mainly by the air force and its contractors into a top-priority crash program.

This is not to say that factors like Sputnik actually cause the development of new weapons. Rather, they speed up a process already well underway. In fact, the weapons promoted as responses to such threats are often unsuited to them or unnecessary. In the case of the missile gap, President Eisenhower was confident that U.S. strategic bombers could adequately counter any emerging Soviet missile capability, and no crash program to mass-produce U.S. ICBM was required. Nevertheless, the fear of a missile gap was used by the military services, arms manufacturers, and Democratic presidential candidates in 1960 to push for ICBM development and deployment. The Kennedy administration's missile buildup confirmed Eisenhower's worst fears and led to a major acceleration of the arms race.

Typically, U.S. weapons systems receive high-level political endorsement only at the final stage of the innovation process. Promoters seek wide public and congressional support so as to secure full funding for large-scale production of the weapon. Often under greater scrutiny than during earlier stages, the program generally must be justified with reference to a more specific threat or opportunity. But because promoters of the new weapon have already amassed considerable bureaucratic backing, their rationales need not be too realistic. President Kennedy's decision in early 1961 to accelerate deployment of 1,000 Minuteman missiles, even after it became obvious that the missile gap was clearly in favor of the United States, constitutes a prime example.

At first glance, the most recent U.S. attempt at a major weapons innovation, the Strategic Defense Initiative (SDI), would seem to contradict the process outlined here. Surely, the argument goes, SDI was launched from the very top in President Reagan's March 1983 speech, at a time when the relevant technologies were immature at best. Pressure for strategic defenses had, however, been building up from the bottom for many years before the president's speech, and research was already proceeding at the rate of about $1 billion per year.

As with tactical nuclear weapons and the neutron bomb, the initiative for Star Wars came from physicists and weapons designers associated with government laboratories. Once again Edward Teller played a central role, as did some of his proteges at the Livermore Laboratory--most notably Lowell Wood, leader of the "O Group," which invented the nuclear-pumped X-ray laser. Starting more than a year before the Reagan speech, Teller promoted the laser and other defense technologies in meetings with members of Reagan's "kitchen cabinet" and with the president himself. What is different about the SDI case is that the scientific and military proponents of the system gained access to top political leaders before the process of consensus building in the military-technical community was complete.

Churning Out Missiles

"Like Sausages"

The Soviet Union enjoys a high level of scientific talent and devotes more resources to military R&D than any other country in the world, with the possible exception of the United States. In many respects, however, the Soviet pattern of arms development reverses the U.S. pattern. There is little technological innovation until the later stages of the development process, when foreign events spur high-level political intervention to pave the way by restructuring priorities.

This contradicts the conventional wisdom that the Soviet military's privileged status protects it from the shortcomings of the rest of the economy and makes it an island of innovation, employing the country's top scientists. But recent memoirs and descriptions by Soviet emigre scientists and engineers who have worked in military R&D suggest that the system's centralized, secretive nature, which is strongest in military research, acts to inhibit innovation.

For example, the secret nature of the work means that military scientists are not allowed many civilian advantages such as contact with foreign colleagues and the ability to publish articles and books in the open press. And even though salaries are sometimes higher in the military sector, they cannot be supplemented in the way that civilian salaries can--by fees from consulting, tutoring, writing, and lecturing. Therefore, the most ambitious and capable scientists often seek employment in the civilian sector.

Secrecy also severely inhibits how Soviet weapons labs function. Security personnel--members of the so-called First Department--rather than scientists and technologists determine work procedures and access to information. For instance, a researcher at a Soviet military design bureau who wants to visit a colleague at another establishment where classified work is conducted faces a daunting set of security procedures. To obtain permission for the trip requires considerable preparation and paperwork, the constant issuing and verifying of passes, and the filling out of forms. Upon arriving at the colleague's institute, the researcher faces the same security practices as at the home institute, including the ban on retaining any notes. Notes must be written into prenumbered notebooks and presented to the First Department. The department then sends the notebooks by special mail to its conterpart at the home institute, where they are deposited in the researcher's classified portfolio.

This stultifying atmosphere shapes the Soviet innovation process. At first, Soviet weapons scientists devote some resources to keep up with research in a particular area, especially by monitoring foreign developments. Then, depending on events abroad, weapons labs and research bureaus may start to prepare a broad technological background that might prove useful later, should efforts ever be accelerated in response to an identifiable foreign threat. But in the absence of explicit political direction, work on particular weapons systems goes no further.

Consider tactical nuclear weapons. As early as 1946, when they first learned of the existence of the atomic bomb, some officers studying at Soviet military academies expressed interest in the impact of nuclear weapons on the battlefield. Yet while there was a widespread published discussion of this issue in the United States, Stalin's policy of strict nuclear secrecy did not even allow teachers to broach it in class. The Soviets focused instead on strategic uses for nuclear weapons.

Only after the United States deployed short-range atomic weapons in Europe in 1952 did the Soviet political and military leadership decide to reassess its priorities. In the short term the Soviets restructured their air defense forces to respond to nuclear attack and began instructing soldiers in the effects of nuclear weapons. Then in 1953, Soviet leaders initiated programs to develop both tactical nuclear weapons and the delivery vehicles to carry them. They hedged their bets by ordering development of all the systems that they knew the Americans were working on--missiles, artillery and aircraft.

Such a chain of events is typical ofthe Soviet system. In the final stages, when the Soviet leadership endorses an all-out effort to pursue a particular innovation, the change in priorities that allows the system to overcome its usual inertia becomes especially evident. To promote the development of missiles in the postwar period, Soviet leaders established a new network of research institutes, plants, and design bureaus. By 1948, some 13 scientific institutes and 35 major factories were involved in designing and manufacturing missiles, under the direction of Soviet rocket expert Sergei Korolev.

Although the specific character of new Soviet weapons programs is, to a certain extent, shaped by existing military organizations and technologies, the top leadership still retains the ability to intervene in the process of carrying out an innovation. In the late 1950s.

Soviet leader Nikita Khrushchev canceled production of the expensive and technically unsuccessful "atomic cannon" in favor of an emphasis on missiles, and, to a lesser extent, aircraft. In the United States, by contrast, large atomic artillery pieces continued to be produced, despite serious criticisms of their capabilities.

The Soviet innovation process concludes when a particular weapons system moves into mass production. This normally corresponds to the first public evidence of a change in policy. In the case of ballistic missiles, Khrushcev announced in January 1960 that the Soviet Union believed a future war would inevitably be fought with nuclear missles and that assembly lines at Soviet aircraft factories had therefore all been converted to missile production. Later the same year he announced the formation of a new military Branch--the Strategic Rocket Forces--and boasted that the Soviet Union was churning out missiles "like sausages."

The False Hope of Technology

Khrushchev was bluffing when he made his claims about Soviet missile superiority. Yet in the wake of the Kennedy administration's buildup and Soviet humiliation during the Cuban missile crisis, Khrushchev's successors were determined to overtake the United States in the major quantitative indicators of strategic nuclear power--most notably intercontinental missiles. The Soviets had barely caught up when the United States inaugurated another key phase of the arms race by deploying the multiple, indpendently targetable reentry vehicle, or MIRV, that allowed a single missile to carry several warheads.

Adding MIRVs to U.S. missles increased the number of deliverable strategic warheads from a couple thousand in the early 1970s to nearly 10,000 by the end of what Ronald Reagan has called the "decade of neglect" in U.S. military policy. But the Soviets eventually developed MIRVs as well and placed 10 warheads on each of their 308 "heavy" SS-18 missiles, thus posing the theoretical first-Strike threat that has been a major source of concern among U.S. military panners and politicians ever since. The MIRV, which had once appeared to be kind of technical panacea, is now understood, even by former proponents such as Henry Kissinger, to be perhaps the most dangerous and potentially destabilizing development in the Soviet-American arms race to date.

This patter of escalation characterizes not only the past but possibly also the future of Soviet-American arms competition. We are now at a point where recent U.S. innovations such as cruise missiles, deep-strike conventional weapons, and SDI present the Soviets with crucial choices about how to respond. Certainly, they are capable of matching these innovations--whether through emulating U.S. initiatives or developing effective countermeasures to them. Either response would serve to diminish the security of both sides.

When the United States developed advanced cruise missiles during the 1970s, their promoters described them as another technical solution to the West's security problems, especially well-suited for negating Soviet quantitative advantages in air defense. But now the Soviets have developed their own cruise missiles. Unless restricted by verifiable arms-control agreements, they could be mass-produced and deployed on virtually any Soviet fishing trawler or commercial airliner--rendering any U.S. security gain chimerical.

The Soviets have also closely followed U.S. developments in the area of deep-strike weapons, ever since the relevant echnologies--especially remote sensors, information-processing and target-acquisition systems, and cluster munitions--appeared during the Vietnam War. Prominent military figures such as Marshal Nikolai Ogarkov have argued that nuclear parity magnifies the importance of these high-tech systems for conventional warfare. Some Western observes believe that Gorbachev's economic reforms are specifically geared toward preparing the Soviet Union to compete in the realm of advanced military technology into the next century. If the Soviets develop deep-strike weapons in large quantities, and incorporate them into offensive military strategies, NATO's security will surely suffer.

Potential Soviet responses to a U.S. strategic defense system are already well known and need no further elaboration here. Whether the Soviets eventually try to create a defensive system of their own or simply offset any potential U.S. system by deploying countermeasures, SDI will render the United States less secure than it was before the program was ever proposed. SDI also poses an immediate threat to potential arms-reduction agreements. Without a U.S. commitment to abide by the 1972 Anti-Ballistic Missile (ABM) Treaty and refrain from deploying large-scale strategic defenses, the Soviets would be unlikely to carry out extensive reductions of their MIRVed ICBM force--the best SDI countermeasure they have.

Trading Quality for Quantity

The elements of a grand compromise to avert the next spiral in the arms race have been evident virtually from the moment Ronald Reagan announced the Strategic Defense Initiative in March 1983. SDI would be employed as a "bargaining chip" to get the Soviets to agree to substantial reductions in their force of MIRVed SS-18 missiles. Such an agreement would require each side to make sacrifices in its primary area of strength--for the United States, the ability to initiate technoligical innovations; for the Soviet Union, the ability to imitate those innovations and produce them in large quantity. Put another way, the arms-control deal that has received so much attention entails U.S. restraint in the next major technological innovation, strategic defense systems, in return for Soviet cutbacks in the previous major innovation, multiple-warhead ICBMs.

What appears to observers to be an ideal compromise may be perceived by the protagonists as giving up their sole source of strength--as Ronald Reagan's unwavering commitment to SDI suggests. However, the treaty eliminating shorter- and medium-range missiles, signed in Washington last December, is in a sense just such a trade of comparative advantages, of quality for quantity. The SS-20 represented the Soviet Union's first successful, large-scale deployment of a technology--solid-fueled MIRVed missiles--that the United States had mastered years earlier. The new U.S. missiles, by contrast, are state of the art. In particular, the Pershing II is considered the world's most accurate ballistic missile. The treaty is largely the result of the Soviet Union's willingness to trade its numerical advantage in medium-range missiles in exchange for the United States relinquishing its technological advantage.

Gorbachev's recent initiatives suggest a preference for an alternative to the competition in military technology with the United States. During the mid 1980s, the Soviets took a number of actions intended to persuade the United States to agree to arms limitations. They maintained a unilateral moratorium on nuclear testing for over a year and a half, while the United States exploded more than 25 nuclear devices. They halted deployment of SS-20 missiles targeted against Europe and withdrew some 35 of them, even as the United States continued deploying Pershing II and cruise missiles. They refrained from testing antisatellite weapons (ASATs), and they allowed unprecedented measures of on-site inspection to verify compliance with arms agreements. U.S. scientists were even permitted to set up seismic monitoring equipment adjacent to Soviet nuclear test ranges. The treaty removing missiles from Europe entails even more intrusive measures of verification, including monitoring of missile factories.

Soviet leaders seem to realize that although their nation has been able to match U.S. innovations and produce them in large numbers, these actions have served to justify new U.S. weapons developments. U.S. officials should recognize that unilateral U.S. advantages--especially in the realm of technology--are short-lived and provide no guarantee of security. In acknoledging the counterproductive nature of the technological arms race, both countries would open the way to cooperative agreements aimed at ending it.

How can this mutually advantageous outcome be achieved" In the tradition of the Soviet system, the initiative comes from the top. It clearly bears the mark of Gorbachev and his main advisers. In the United States, where the scope for low-level initiative has always been much greater, recent developments suggest that scientists are stepping in to promote serious measures of arms control despite the reluctance of their government.

The U.S. side of the agreement to monitor the Soviet nuclear test moratorium, for example, was a private initiative, organized by the Natural Resources Defense Council and funded by private donations. American scientists have been major participants in the movement to preserve and strengthen the ABM Treaty. Many of them have signed pledges refusing to conduct SDI-related research. scientists have also put pressure on Congress to limit funding for ASATs so long as the Soviets maintain a moratorium on testing theirs. These efforts have contributed to averting a counterproductive and potentially dangerous ASAT race.

This is hardly the first time that scientists have taken a stand against an unconstrained technological arms race. The ABM Treaty itself testifies to past initiatives. Yet there remains much to do. Efforts to secure a comprehensive nuclear test ban should continue, in hopes that the next administration will reaffirm the longstanding formal U.S. commitment--broken only by the Reagan administration--to this goal. In addition, U.S. scientists could work with their Soviet counterparts to develop means of verifying limitations on sea-launched cruise missiles. Otherwise, these weapons threaten to open an enourmous loophole in the European missile treaty as well as in any potential strategic weapons agreement.

The importance of such actions at the present time lies in the enhanced prospects for success. The international atmosphere has finally improved, and the increasingly frequent superpower summits suggest that U.S.-Soviet relations are on the way to normalization. The current leadership in the Kremlin recognizes the futility of the arms race and has made real concessions to demonstrate a serious intent to end it. All that remains is for the next American administration to demonstrate comparable flexibility and political will.

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