

The Strategic Offensive Initiative? The Soviets and Star Wars

Peter J. Westwick

Historians of the Cold War have paid too little attention to Soviet fears of “space-strike weapons”—that is, possible offensive uses of President Ronald Reagan’s Strategic Defense Initiative.

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In fifteen years or so, soldiers will no longer shoot rifles but will use some kind of lightning, some sort of a machine emitting a holocaustal electrical beam. Tell me, what can we invent in this line so as to surprise our neighbors? . . . Alas, we are only capable of imitating and purchasing weapons from others, and we do well if we manage to repair them ourselves.

Fyodor Dostoevsky, *A Writer’s Diary*, 1873

[Khlinov, a physicist]: “I know that he has made an important discovery concerning the transmission of infra-red rays over a distance. . . . Heat waves at a temperature of a thousand degrees centigrade transmitted parallel to each other constitute a monstrous weapon of destruction and defense in time of war. The whole secret lies in the transmission of a ray that does not disperse. So far nobody has been able to do this. Judging by your story, Garin has constructed a machine that will do it. If so it is an extremely important discovery.”

“I’ve been thinking for a long time that this invention smells of higher politics,” said Shelga.

Aleksei Tolstoy, *The Garin Death Ray*, 1927
(translated by George Hanna)

In March 1983 US President Ronald Reagan, encouraged by recent experiments with beam weapons, announced his plan to build a missile defense system, what would become known as the Strategic Defense Initiative—or, more popularly, Star Wars. Reagan’s speech set off a vocal public debate in the US over SDI’s technical feasibility and strategic implications. The subsequent literature has relied almost exclusively on the American perspective and American sources. But it takes two to tango. The program was directed at the Soviet Union, and the Soviet response helped determine SDI’s influence on the Cold War. The literature has also concentrated on the view from the White House, neglecting the science and technology involved. For a program consisting of very high technology, literally, that political focus has distorted the picture.

Including the technology and the Soviet perspective in the history of SDI yields particular insight into a basic historical question: Why did the Soviets react so strongly to SDI?

From right after Reagan announced it, they harped on it at every opportunity. The Soviets’ negotiating positions reflected their fixation on SDI, as they persisted in linking arms control to it. They did so even though Soviet scientists quickly pointed out that SDI would be very costly and difficult. And, they argued, it could likely be circumvented by counter-measures such as spinning missiles, fast-burn boosters, or decoys. If SDI would not work, why not sit back and let the Americans indulge their folly?

Soviet leaders recognized the dangers of overreaction. In March 1986 General Secretary Mikhail Gorbachev asked his advisers, “*Maybe we shouldn’t be so afraid of SDI?* Of course we cannot just disregard this dangerous program. But we should overcome our obsession with it.” As Soviet scientist Roald Sagdeev put it, “If Americans oversold SDI, we Russians overbought it.”¹ One might say the Soviet response was just propaganda aimed at Western audiences. But from a diplomatic point of view, the Soviet fixation only increased American negotiating leverage and solidified SDI’s utility as vaporware.

Western analysts suggested several reasons for what one of them called the “paradoxical” Soviet response. One stemmed from strategic calculations: If one side had an even partially effective missile defense, it might be encouraged to launch a first strike because the defensive system could mop up any missiles that survived the initial attack. Another reason was Soviet faith in American ingenuity. From the atomic bomb to cruise missiles, the US had continued to come up with new technologies, and SDI might just be another one.

There was also a sense of betrayal. After first pursuing missile defense themselves in the 1960s, the Soviets had accepted American arguments on deterrence and signed the 1972 ABM (antiballistic missile) treaty, only to see the US now turn around and reject deterrence for defense. But the main explanation offered by American analysts was prestige: The Soviets had long felt that they had earned strategic parity in 1945, only to see it snatched from their grasp by the atomic bomb. Now, having restored parity through great national sacrifices, they found the US again threatening their international status as a superpower.

Space-strike weapons

There is, however, another explanation for the Soviet response. The Soviets did not like to call SDI by its official



Edward Teller receiving the National Medal of Science from Ronald Reagan at the White House in May 1983. (Photo by Jack Kightlinger, courtesy of AIP Emilio Segrè Visual Archives.)

name. Instead, they referred to “space-strike weapons.” The Soviet military coined the term explicitly to include space-based devices that could strike targets on the ground as well as missiles in flight. That was not just rhetorical propaganda. The Soviets were deeply suspicious of the offensive possibilities of SDI, especially a new generation of space-based beam weapons that could instantly strike targets on Soviet territory at any time.

Public debate at the time and later historical accounts have almost completely ignored the potential offensive uses of SDI technologies and their role in the Soviet response. It’s high time they were brought to light. SDI was a crucial piece in the endgame of the Cold War. Some commentators have credited SDI with ending the Cold War by confronting the Soviets with a new high-tech race they could not win. Others argue that SDI aggravated tensions, undermined Soviet reformers, and actually prolonged the Cold War.

The space-strike issue demonstrates that SDI’s unsettling effect on the Soviets, whichever way it led, had a dimension unanticipated and underappreciated by the US. It suggests further that Soviet resistance to SDI lasted longer than is currently recognized. More generally, the story highlights the intersection of technology and foreign policy, and the need for scientific experts and diplomats to remain alert to the different meanings that technologies can have in different contexts.

Soviet fears derived from technological developments in beam weapons. SDI was pursuing so-called directed-energy weapons, such as lasers and particle beams, to destroy missiles or warheads in flight. The perceived offensive threat arose from the high power and precise targeting that SDI proposed to attain. An orbiting 25-megawatt laser, say, that could deliver a kilojoule per square centimeter on an ascending missile might deliver similar energy to a target on the ground, far more than enough to ignite

combustibles or kill human beings.

A particular class of directed-energy devices involved nuclear weapons. SDI coincided with talk of third-generation nuclear weapons, which promised an enormous jump in military power, comparable to that provided by the first-generation—the atomic bomb itself—and the second generation, the hydrogen bomb. These new designs would channel a nuclear blast into particular directions, delivering to a target a thousand times the energy per unit area possible with an unchanneled nuclear weapon. One weapon designer likened it to the difference between lighting a pile of gunpowder and shooting a rifle. A particular nuclear device could also maximize certain forms of energy—for example, microwaves, gamma rays, or x rays. In one scenario, a microwave beam generated by a 1-kiloton bomb in geosynchronous orbit could zap an area bigger than Moscow with

enough radiation to fry electronics.²

Even if the Soviets accepted that missile defense enhanced stability, which they did not, they could not tolerate a revolutionary new class of offensive weapons in the American arsenal. To Soviet leaders with an ingrained fear of surprise attack, the prospect of a literal bolt from the blue with a warning time of only milliseconds could not have been welcome. Furthermore, beam weapons did not fit into existing theories of nuclear deterrence. Whereas existing nuclear weapons were blunt instruments, directed-energy weapons were surgical. It might be hard to justify nuking New York because Moscow got hit by microwaves, and the Soviet strategic deterrent could be rendered worthless.

The Soviet response

Soviet scientists understood the possibilities, thanks to their own research into military laser systems, plasma physics and high-power microwaves, and the x-ray laser. The results of that research persuaded some Soviet scientists that the threat from SDI was overstated. And some were well placed to advise Soviet leaders. Among those were Sagdeev, a plasma physicist who ran the main space science institute, and Evgeny Velikhov, a plasma physicist with expertise in high-power electromagnetic fields. Velikhov had chaired for the military an early study on SDI that produced a skeptical report.

Such advice, however, clashed with the institutional interests of the design bureaus and ministries building the weapons systems. The Ministry of General Machine Building, in particular, was pushing for a vigorous space-based program to match SDI. Its Energia design bureau had designed space battle stations bristling with either kinetic or beam weapons, and one such station was designed to strike targets on the ground. The ministry’s central analysis institute, known as TsNIIMash, was a prime source of what one Soviet laser scientist called the “hotheads” who bought into

offensive speculations about SDI.³

Those speculations found a receptive audience in certain parts of the Soviet military, whose strategic doctrine had historically stressed a link between offensive and defensive systems. As one Soviet general put it, "With space-based weapons an attack could come in nanoseconds. Consequently, the Soviet General Staff would have no time to make key decisions."⁴ One of the main believers, Nikolai Chervov, was head of the general staff's department of negotiations and law, which helped prepare the final form of arms-control documents.

More evidence of those fears came from a study group chaired by Sagdeev and defense analyst Andrei Kokoshin. A 1983 draft report from the group noted that a space-based system "could be designed not only for destroying strategic missiles of the other side after their launch, but also as a direct weapon of attack, moreover precisely for dealing a first strike." The published report in 1984 devoted a chapter to space-based weapons knocking out targets on the ground. It noted, in particular, the instantaneous effect of beam weapons, which "are especially effective in a first strike for blinding the enemy's command centers and disrupting his means of communication."⁵

The upshot of all this activity was that Soviet foreign policy perceived a direct offensive threat from SDI. That perception appeared in Soviet negotiating positions, which consistently had three main goals: Ban antisatellite weapons, ban space-based missile defense, and ban weapons "designed for hitting targets in the atmosphere and on earth from space." In a letter to Reagan in June 1985, Gorbachev spelled out Soviet fears:

There is also another aspect of the program of "strategic defense," which remains as if in a shadow for the broad public. But not for responsible leaders and military experts. They talk in Washington about the development of a large-scale ABM system, but in fact a new strategic offensive weapon is being developed to be deployed in space. And it is a weapon no less dangerous by its capabilities than nuclear weapons. What difference does it make, what

will be used in a first disarming strike—ballistic missiles or lasers. If there is a difference, it is that it will be possible to carry out the first strike by the new systems practically instantly.⁶

A year later, at the Reykjavik summit meeting between Gorbachev and Reagan, Gorbachev's objections to SDI cited the potential offensive use of SDI technologies.

American perspectives

As Gorbachev suggested, US policymakers seemed not to recognize the connection between SDI and new offensive weapons. There were good technical reasons for neglecting space-strike weapons, in particular the practical difficulties of getting these large devices into orbit and then getting the beams down through the atmosphere and clouds to the ground. Nevertheless, some American reports recognized the possibilities. A letter from Edward Teller to Reagan in 1982, which helped spark Reagan's interest in missile defense, included the potential of space-based beam weapons to strike ground targets. As Teller put it, "Used against possibly very large areas of enemy territory from a region of space overhead, the effects . . . are expected to quite comprehensively devastate both civilian and military equipment." Reports from Argonne National Laboratory and the CIA likewise noted that space-based weapons could attack targets on the ground.⁷

The fullest examination of SDI's offensive aspects appeared in 1985 in a report by two analysts, Albert Latter and Ernest Martinelli, at the R&D Associates think tank. The report was firmly grounded in the strategic establishment: RDA was a spinoff from the Rand Corporation, and Latter had coauthored a book with Teller that downplayed the dangers of radioactivity and had also introduced the concept of MIRVs (rockets with multiple independently targeted reentry vehicles). Latter and Martinelli argued that beam weapons could not achieve Reagan's goal of replacing offense with defense. That "surprising possibility," as they put it, "results from the fact that the lasers can be employed in a manner not contemplated by the SDI. Specifically, they can be targeted against the same entities they were designed to protect: the cities."

Latter and Martinelli calculated the thermal energy delivered to a particular area on the ground by a certain number of satellite-based lasers, taking into account such factors as beam diffraction and atmospheric turbulence. Potential ignition points for urban fires included the clothing of individual human beings. "Would the cities burn to the ground?" they wrote. "We think the answer is almost certainly yes." A Soviet laser system powerful enough for missile defense "can incinerate our cities without warning on a time scale of minutes per city; minutes to hours for the whole country. To deter such an attack, the US could only threaten



Roald Sagdeev, now at the University of Maryland, was head of the Soviet Institute of Space Research and adviser to General Secretary Mikhail Gorbachev in the 1980s. (Photo by Space.com/Yuri Karash, courtesy of University of Maryland.)



Evgeny Velikhov is director of the Kurchatov Institute in Moscow. In the 1980s he chaired an early Soviet study group on the US Strategic Defense Initiative and advised General Secretary Mikhail Gorbachev on SDI and arms control.

to retaliate.” Far from shifting the basis for national security from offense to defense, SDI might only replace nuclear deterrence with beam-weapon deterrence.⁸

That was not a message the Reagan administration wanted to hear. The report generated no public response, and SDI’s offensive potential consistently appeared as a revelation in subsequent reports. But the combination of American analyses and persistent Soviet statements had in fact finally caught the attention of US policymakers. Gorbachev’s preoccupation with space-strike weapons at the Geneva summit conference in November 1985 made an impression on Secretary of State George Shultz, defense adviser Richard Perle, and arms-control adviser Paul Nitze. Nitze observed to Shultz that “the Soviets’ concern is not entirely misplaced. . . . We need to get at it.”⁹

The State Department had already turned to the Committee on International Security and Arms Control of the National Academy of Sciences as a way to get technical advice into the formulation of foreign policy. At the top of CISAC’s initial list of briefing topics was the offensive threat of SDI. The Latter–Martinelli report had sparked CISAC’s interest, and committee physicists Richard Muller, Charles Townes, and Richard Garwin briefed the State Department in March 1986. They judged lasers to be inefficient for starting fires and ineffective against missile silos. More likely threats were to “soft targets” such as aircraft or submarines in port. Perhaps the most potent offensive use for lasers was to cause blindness in either civilians or soldiers over large swaths of territory. This last point had troubled two referees of the briefing paper before it was circulated.¹⁰

The briefing’s general conclusion was that space-strike weapons were technically feasible but much less effective strategically than nuclear weapons. Hence, although Shultz had proposed that the US might negotiate limits on space-strike weapons while preserving SDI itself, the CISAC physicists saw no reason to pursue such a distinction: “US representatives could credibly maintain that the SDI does not contain program emphasis nor intent for offensive uses.”

The CISAC study thus only reinforced the American position. Six months later at Reykjavik, Reagan noted Gorbachev’s concern “that space-based weapons could be used

to destroy targets on the ground,” but his response followed the CISAC line: He assured Gorbachev that “this is not the purpose of SDI. . . . There are no weapons that are more reliable, more effective and faster than ballistic missiles.”¹¹

The US, in short, recognized that SDI technologies could be used offensively but saw little value in them. That position, however, assumed that the Soviets would reach the same conclusion. The CISAC physicists had stressed “the importance of making clear the difference between what is technically feasible and what makes sense,” and the conclusion of their briefing acknowledged that their position raised “‘intent vs. capability’ issues.”

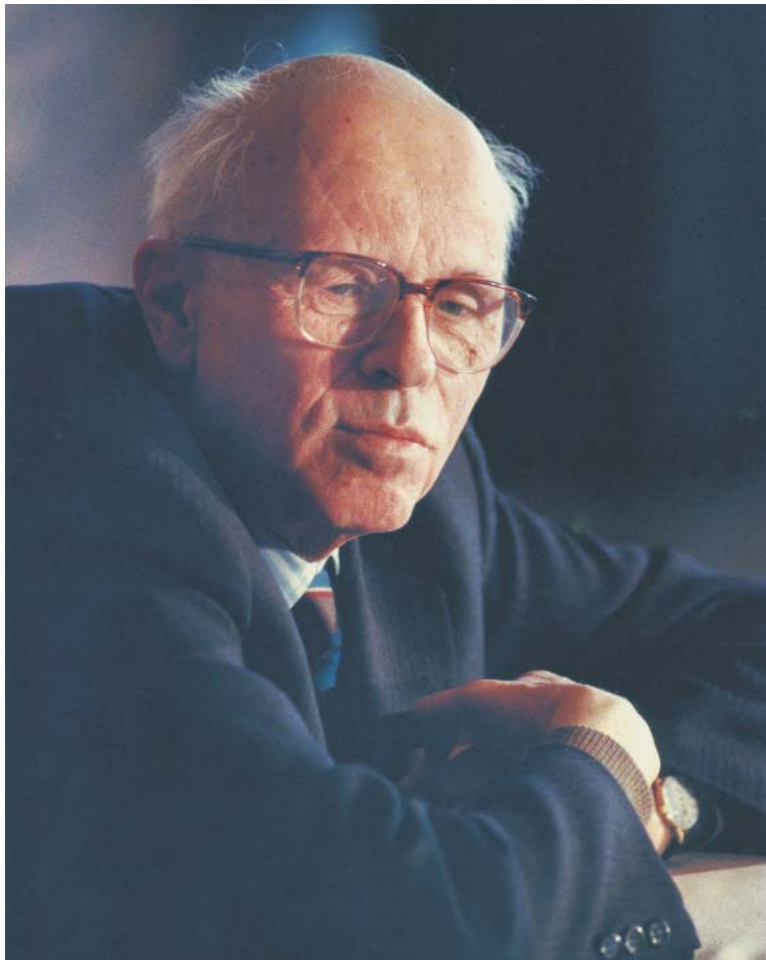
However, what makes no sense in one context may appear sensible in another, and at least some Soviet observers chose to judge American capability as equivalent to intent. Gorbachev made the point in his June 1985 letter to Reagan: “In matters affecting the heart of national security, neither side can or will rely on assurances of good intentions. Any weapon system is evaluated by its capabilities, but not by public statements regarding its mission.” Reagan’s reply noted Gorbachev’s concern and recognized “that these are matters which cannot be taken on faith. . . . However, the truth is that the United States has no intention of using its strategic defense program to gain any advantage.” The position of the Soviets at Reykjavik shows that they indeed refused to take American declarations on faith.^{10,12}

The Sakharov gambit

Four months after Reykjavik, the Soviets apparently changed their minds about SDI. That at least is the prevailing consensus, based on Gorbachev’s decision in early 1987 to decouple SDI from talks on INF (intermediate-range nuclear forces) after insisting for years that they be linked. Later that year, when Reagan declared at the Washington summit that the US intended to deploy SDI, Gorbachev replied, “Mr. President, you do what you think you have to do. . . . And if in the end you think that you have a system that you want to deploy, go ahead and deploy it. Who am I to tell you what to do? I think you’re wasting money. I don’t think it will work. But if that’s what you want to do, go ahead.”¹³

That view raises a second key question: Did the Soviets, having apparently swallowed SDI hook, line, and sinker, suddenly spit it out and swim free? Why would they retreat from their early vehement reaction? Existing accounts focus on the role of physicist Andrei Sakharov, who had been banished to internal exile in early 1980 for his political activism. Sakharov became a high-profile human-rights cause, and after years of pressure, punctuated by Sakharov’s hunger strikes, Gorbachev agreed to release him from exile in December 1986.

In February 1987 Sakharov stood up at a disarmament forum in Moscow, with Gorbachev in attendance, and criticized both SDI and Soviet insistence on linking it to strategic arms cuts. Sakharov spoke not only with the moral force of one who had suffered much for his political commitment, but also as a weapons scientist whose theoretical breakthroughs on the hydrogen bomb had made possible the Soviet strategic buildup and earned him three Hero of Socialist Labor awards. The so-called Sakharov gambit, in this telling, led to the decision by Gorbachev a few weeks later to abandon his



Andrei Sakharov (1921–89), shortly after his return to Moscow in 1986 from internal exile, publicly criticized both the US Strategic Defense Initiative and Mikhail Gorbachev's insistence on linking arms control negotiations to it. Some argue that Sakharov's "gambit" led to Gorbachev's delinking the INF negotiations from SDI. (Photo by the *Ottawa Citizen*, courtesy of AIP Emilio Segrè Visual Archives.)

fixation with SDI and to delink it from the INF negotiations.

Gorbachev may have been impressionable—but could one physicist really have impelled such a radical shift in national policy? If so, we might have something of a symmetry with the US case, in which an aging nuclear physicist with state decorations for weapons work got the ear of the national leader and persuaded him to a fundamental change in strategic course. But Sakharov, unlike Teller, was only weeks returned from seven years in exile when he made the case against SDI. And he had been out of the nuclear-weapons business since 1968—although he did carry substantial moral force.

Sakharov did not get the Soviets to quit SDI cold turkey. The focus on him and the INF negotiations ignores a Soviet preoccupation with SDI that lasted at least two more years. The Soviet test of an x-ray laser in late 1987 is one indicator of that continued obsession. The *Polyus* satellite debacle that same year is another. Also known as *Skif-DM*, *Polyus* was a test bed for a space-based laser weapon. The 80-ton spacecraft, 37 meters long, was too big to fit into the launching rocket's nose cone. It had to be strapped to the rocket's side.

At the last minute Gorbachev, apparently recognizing that a space laser demonstration would undermine his own diplomatic efforts to ban space weapons, intervened to forbid actual testing of the system in orbit. It turns out he need not have worried. Because of a faulty guidance sensor, the spacecraft was upside down when it fired its engines to enter orbit, and *Polyus* promptly plunged into the South Pacific.

Continuity in the Soviet response to SDI stemmed from internal political forces, which did not just evaporate with

Sakharov's reappearance, and from Soviet fear of offensive space weapons, which Sakharov did not address. Up through early 1986, Gorbachev was trying to appease his national-security apparatus. When the 27th Party Congress chose a new Central Committee in 1986 with only a slender pro-reform majority, he still had to build coalitions issue by issue. Only after Gorbachev cleared out the Defense Ministry in 1987 and then reshaped the Politburo in September 1988 could he operate with a freer hand. Meanwhile Eduard Shevardnadze had replaced Andrei Gromyko as foreign minister in 1985 and was similarly consolidating his influence and reducing the influence of the old guard.

The focus on delinking INF has obscured the continued Soviet criticism of SDI, including the insistence on coupling the SDI issue to the START (strategic arms reductions talks) negotiations. Only in 1989, before a meeting of foreign ministers in Wyoming, did the Soviets decisively retreat on SDI. And even then Shevardnadze acted without approval from the so-called Big Five agency heads who usually determined Soviet arms-control positions. The five included the

defense minister and the heads of the KGB and the military-industrial commission (VPK). Those three agencies were primary drivers of the Soviet response to SDI.

Several former Soviet policymakers and negotiators have since insisted that the Soviet Union was consistent in its vehement opposition to SDI up to and beyond 1989. A report to the US SDI Organization by a so-called red team confirmed that view; despite some reduction in the intensity of Soviet criticism starting in 1986, said the report, "through 1988 the Soviets appeared to be unanimous in their public opposition."¹⁴

Thus Gorbachev, at the Moscow summit in May 1988, argued against SDI on the grounds that it "opened the way to the development of space-based weapons that could hit targets on the earth."¹⁵ The eventual Soviet decoupling of SDI from START a year later coincided with cuts in the American commitment to SDI, but also with a recognition in the US that directed-energy weapons were far from realization. The latter development led to a shift in the SDI program itself from beam weapons to so-called "brilliant pebbles," small rocket interceptors that posed no offensive space-to-Earth threat.

The existing focus on INF delinkage and Sakharov has neglected important continuities in the Soviet position on SDI and the internal politics that drove them. The Sakharov story is dramatic and compelling, with the aged, charismatic, moral figure returning from exile to remove the scales from Soviet eyes. As Frances FitzGerald put it, "In mythology it is the pure of heart who slay the dragons, and so it was that in the Soviet Union Sakharov dispelled the fear of SDI."¹³ But that story is, indeed, mythology. The Soviets tempered their



Polyus, a 37-meter-long Soviet spacecraft carrying a missile-defense test bed, is the dark vehicle strapped atop an Energia rocket on the launch pad. It was launched in May 1987 but failed to reach orbit.

opposition to SDI, but they did not abandon it. And that continuity derived in part from their fear of new offensive weapons.

Lessons

The history described here adds a new dimension to the picture of SDI. Some Soviets saw no difference between the offensive and defensive potential of SDI technologies: Whatever use new beam weapons might have in defending the US, they posed an offensive threat to the Soviet Union. This issue helps bridge the logical gap in the Soviet position. They were not just getting worked up about a defensive shield that they could probably circumvent. Rather, they also feared a new offensive threat from beam weapons, including third-generation nuclear devices.

This aspect of SDI has escaped attention in part because the literature is almost exclusively written from the American perspective. Compounding the neglect has been the fact that existing histories focus on the high politics of SDI and also rely too heavily on memoirs instead of archival research, thus imposing an overly coherent post-facto view of events. Looking at the Soviet side and at the work of American defense scientists reveals the role played by possible offensive weapons. That was not the only factor in the Soviet response, but it is one almost completely absent from existing accounts.

SDI spurred both the US and USSR to increase the participation of scientists in the foreign-policy process. On the Soviet side, the Foreign Ministry created a scientific-technical council with experts from the Academy of Sciences. The council's experts could challenge technical arguments on SDI not only from the Americans but also from the Soviet military and defense industry. A similar integration of scientific expertise and foreign policy appears in the US State Department's use of CISAC.

Examining why the Soviets reacted so strongly turns the question back on the US. Why didn't the Americans recognize Soviet fears? The history of SDI seems to reveal a failure of empathy on both sides. Americans failed to comprehend Soviet suspicion of space-strike weapons, while the Soviets didn't believe American sincerity about a strictly defensive posture. As the CISAC scientists recognized, the US position amounted to a distinction between capability and intent: Yes, the capability for offensive strikes existed, but because nuclear weapons were more effective, the US would never exercise that capability.

The Soviets didn't follow that distinction. Their response reflected their defense industry's bureaucratic politics, their strategic doctrine, and their historical experience of surprise attack—not to mention a cultural legacy of writers like Dostoevsky foreseeing ruinous beam weapons. Hence their suspicion of new weapons that compressed warning times to milliseconds.

The disconnect on SDI is important to Cold War history. Soviet fears contributed to their insistence on linking SDI to arms control; Reykjavik or even Geneva might have produced much different outcomes, including radical reductions in nuclear arms. That would have greatly affected the endgame of the Cold War—and also such current issues as the security of former Soviet weapons.

The US might have done more to placate Soviet fears if it had indeed been serious about stressing defense. One way would have been to shift the focus from the ABM treaty, which generated much debate over "broad" versus "narrow" interpretations, to the Outer Space Treaty of 1967. In particular, the US might have clarified a clause in the OST banning nuclear weapons "or any other kinds of weapons of mass destruction" in space. This raised the question of what constituted a WMD and whether beam weapons qualified. Before SDI, the Soviets had raised the possibility of particle beams being WMDs, but the US declared that "most [particle beam] weapons, as currently conceived, would not be classified as [WMDs] since they are by nature point weapons."¹⁶

For the US to recognize SDI's offensive possibilities, however, ran completely against Reagan's expressed desire to halt the arms race. That suggests an unintended consequence of SDI: In trying to turn nuclear strategy from offense to defense, SDI took a new class of weapons and linked them exclusively to defensive uses—but only to American eyes. It may not be coincidence that in 1992, after a 10-year interlude, Teller began speaking again of offensive space weapons.¹⁷

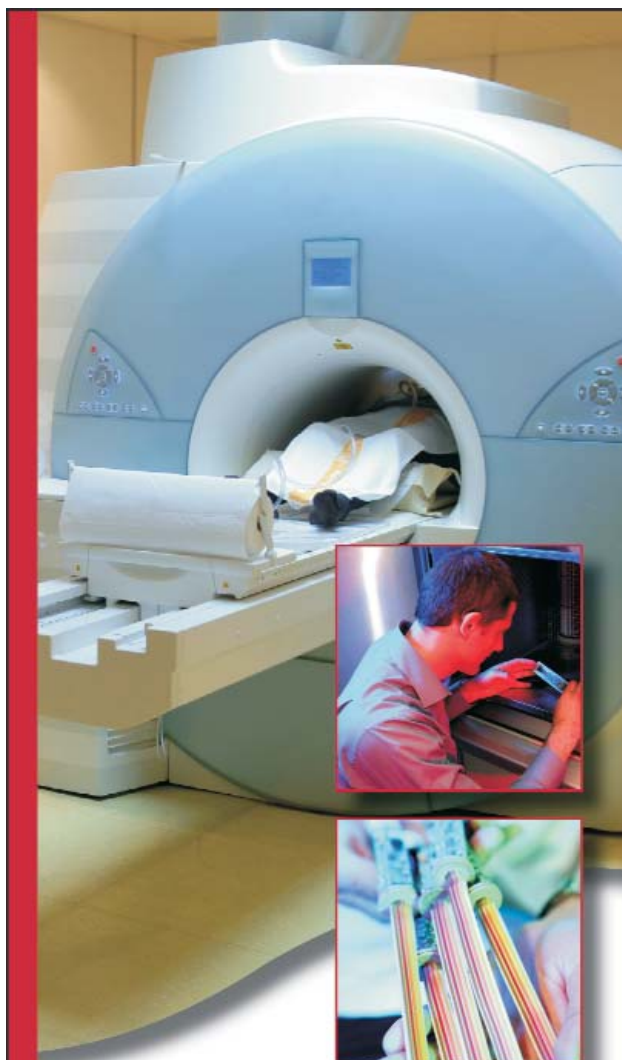
The issue remains relevant. Missile defense is still under development, and the US Space Command is pursuing "space-based strike weapons" as a new means of global engagement. Other countries, notably China, have recently joined Russia in asking the UN to ban space weapons. Meanwhile, some American defense analysts have warned that deploying space weapons would expose other crucial space assets, such as reconnaissance and communications satellites, to attack. China played on such fears in recent tests of anti-satellite weapons. The difference today, besides the strategic context, seems to be that the offensive possibilities are explicit—and are indeed a main attraction. What has not changed is the need for strategists and diplomats to grapple with all the implications of science and technology—and for

scientific experts to ponder the effects of culture, politics, and history.

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