What is the Soviet 'SDI'?

Uwe Henke von Parpart reviews what we know about directed energy weapons research and development and the space program in the U.S.S.R.

Unlike the rather detailed information available from public sources about the U.S. Strategic Defense Initiative (SDI) research programs, Soviet research and development in the area of strategic defense is shrouded in mystery. The Soviet government acknowledges existence of deployed ABM capabilities permitted by the 1972 ABM Treaty, but beyond that denies being engaged in a significant SDI-type R&D effort. Top Soviet scientists known to be involved in directed energy weapons research, for example, have not only refused to admit such involvement, but have gone to great lengths challenging the scientific and engineering feasibility of comprehensive ballistic missile defense (BMD). Such Soviet secrecy and deliberate obfuscation make it exceedingly difficult to arrive at an accurate assessment both of the overall scope of the Soviet strategic defense program and of the size and level of development of its principal components. A gross analysis of Soviet BMD research and development is nevertheless possible, based on essentially three types of information sources:

1) Elements of Western intelligence reports on Soviet BMD that find their way into official U.S. government and other Western publications.

2) Soviet and Western reports on the somewhat less well-guarded Soviet space program.

3) Soviet scientific publications, principally the *Journal of Experimental and Theoretical Physics* (*JETP*) and *JETP Letters*.

Bits and pieces of information from any of these sources are, by themselves, of limited value. However, if carefully cross-gridded and checked for scientific reliability, enough credible information comes together for the principal contours of Soviet BMD research and capabilities to emerge.

1. Brief history and summary assessment of Soviet BMD

The character of Soviet strategic defense efforts differs from comparable U.S. programs in two principal respects. First, the Soviet commitment to strategic defense is continuous and longstanding, going back to well over two decades and never experiencing any serious disruption. Soviet defector Anatoly Fedosevev, who designed anti-missile radars and fled in 1971, put it as follows: "Since the beginning of Soviet SDI . . . this project has never been interrupted or delayed. And I'm sure it never will be." ("The Secrets of Soviet Star Wars," William J. Broad, *The New York Times Magazine*, June 28, 1987, p. 24). By contrast, the United States made vigorous BMD efforts in the 1960s, but then dismantled all deployed capabilities and cut research to a minimum after the signing of the 1972 ABM Treaty. There is thus a 12-year hiatus (1972-84) on the U.S. side, which, according to Gen. James Abrahamson (Strategic Defense Initiative Organization) and Dr. Edward Teller (Lawrence Livermore National Laboratory), has given the Soviet Union a significant lead in experience with deployed BMD capabilities and in advanced research. Teller points out that many directed energy-related research results published in Soviet scientific journals in the 1970s and early 1980s were dismissed by U.S. researchers at the time, but are now being taken seriously as the results of recent U.S. advances in the same field confirm earlier Soviet work.

A second major difference between Soviet and U.S. BMD efforts results from a fundamental discrepancy in strategic doctrine and outlook. Since the 1950s, U.S. strategic thinking has been dominated by the Mutually Assured Destruction (MAD) doctrine. Strategic defense was seen to have little or no place in the MAD world of U.S. planners. The Soviet military leadership, on the other hand, has always assumed and prepared itself for the possibility of actually having to fight and win a nuclear war. Active and passive (civil defense) strategic defense is thus a significant integral aspect of overall Soviet war planning. Consequently, after 1972 they kept in place and continued to upgrade the Moscow ABM system, which by the end of 1987 will consist of 100 silo-based high-acceleration missiles. In addition, the SA-X-12 surface-to-air missile, which is now operational, has not only anti-aircraft, but also anti-missile capabilities. And both systems as well as future generation BMD systems will by the end of this decade be supported by a network of large phased-array radars (Krasnoyarsk type) for early warning, tracking, and target assessment.

Several decades of continuity of Soviet BMD research are thus matched by a similar continuity in terms of deployed capabilities. Since March of 1983 the United States has been trying to catch up with these developments in order to prevent Soviet strategic break-out in the BMD area. A principal U.S.

motivation for SDI is clearly what Secretary of Defense Weinberger stated in January 1987: "I cannot envision any circumstance more threatening and dangerous for the free world than one in which our populations and military forces remain vulnerable to Soviet nuclear missiles while their population and military assets are immune to our retaliatory forces."

U.S. concern with Soviet BMD progress is not limited to or even principally prompted by presently deployed assets. Rather the concern derives from what the Soviets have termed weapons systems "based on new physical principles" and from the rapid progress of the Soviet space program during the past decade.

The U.S. intelligence and scientific community first were alerted to relatively large-scale Soviet experimentation with exotic new weapons systems in the mid-1970s, when then-Air Force chief of intelligence Maj. Gen. George Keegan assembled a team of technical experts to investigate evidence of such experimentation emanating from the Semipalatinsk nuclear test site in Siberia. Keegan's findings and his hypothesis that the Soviets might be deploying nuclear-powered directed energy devices, were first published in *Aviation Week and Space Technology* in the summer of 1976 (No. 105, Aug. 30, 1976), but were generally dismissed by most U.S. intelligence and scientific analysts. In retrospect we may surmise that Keegan's team may well have come across early Soviet nuclear-powered x-ray laser tests. But be that as it may, it is a matter of record that the first detailed technical description of a nuclear-pumped x-ray laser in the open scientific literature appeared in the July 1981 issue of the Soviet *Journal of Quantum Electronics* under the title, "Specification for Pumping X-Ray Laser(s) with Ionizing Radiation." The article was submitted on May 28, 1981 by I.V. Bunkin, V.I. Derzhiev, and S.I. Yakovlenko of Moscow's Lebedev Physics Institute.

That Soviet physicists should have come up with advanced laser and particle beam designs for military applications should not be regarded as any real surprise. Two of the physicists honored with the Nobel Prize for invention of the laser were Russians. And the potential for lasers to play a role in strategic defense was explicitly acknowledged as early as the 1962 version of Marshal Sokolovskii's famous strategy text, *Military Strategy*:

> Possibilities are being studied for the use, against rockets, of a stream of high-speed neutrons as small detonators for the nuclear charge of a rocket. . . . Various radiation, anti-gravity and anti-matter systems are also being studied as a means of destroying rockets. Special attention is devoted to lasers; it is considered that in the future, any missile and satellite could be destroyed with powerful lasers.

We shall now turn to a more detailed and systematic account of Soviet SDI-type research as well as an evaluation of recent major advances in Soviet space-lift capability.

2. The present Soviet strategic defense research and development program

Much as in the case of U.S. SDI, Soviet research is spread over a sizable number of government laboratories and university research institutes. We will cover only those cases of research about which sufficient and relatively accurate information is available, not necessarily indicating the order of priority adopted by the Soviets themselves in their overall program.

2.1 High-energy lasers

It is estimated that the Soviet laser weapons program, if carried out in the United States, would cost approximately $1 billion per year—meaning that it is about twice the size of the present U.S. program—and that it employs up to 10,000 scientists and engineers. Both tactical (battlefield) and strategic lasers are under development. The largest lasers are of the gas-dynamic and electric discharge (rather than chemical, as in the U.S.) type, and have been scaled up to about 10 megawatts, the minimum energy required for ground-based anti-satellite (ASAT) operations. ASAT and terminal defense against re-entry vehicles appear to be the principal intended functions of such high-energy lasers now being tested at Sary Shagan. U.S. reconnaissance satellites have also detected a probable large new mountain-top laser site near Dushanbe, capital of the Tadzhik Republic. The size and electric power supply of the Dushanbe complex appear to be large enough not only for an ASAT laser, but for a laser whose signal could be relayed by a space-based mirror toward ICBMs.

Along with conventional-type lasers, the Soviet x-ray laser program is in an advanced stage of development. In congressional testimony in 1986, General Abrahamson estimated the Soviets might have a lead of up to five years in this area. It was for this reason that the U.S. government did not go along with a Soviet-initiated underground test moratorium.

The Soviet tactical laser program, in the meantime, has progressed to where "battlefield laser weapons could soon be deployed with Soviet forces" (*Soviet Military Power, 1987*, p. 112).

We thus see a broad range of Soviet laser weapons under development, covering the spectrum from tactical to most advanced strategic systems. As their systems reach relative maturity, the Soviets will not wait until they have reached a high degree of perfection. Soviet policy is steady and continuous enhancement of their war-fighting capability, and in the next few years lasers will make their appearance as an increasingly important component of the Soviet tactical and strategic arsenals.

2.2 Other directed energy weapons

Aside from laser development, the Soviet Union has over the years deployed considerable manpower and resources for research in the fields of particle beam and radio frequency weapons.

Particle beams. The key ingredients in particle beam weapons research are accelerator development and the study of beam propagation and beam interactions with the atmosphere and varieties of other materials. Soviet scientists have been leaders in these fields since the early 1960s. One example is the invention in the early 1970s of the radio frequency quadrupole (RFQ), a highly compact device used for acceleration of subatomic particles. Its compactness makes the device essential for the development of lightweight space-based particle accelerators. Since its initial development at the Institute for High Energy Physics at Serpukhov, scientists at the Los Alamos National Laboratory in the United States have developed RFQ further and regard it as the key ingredient of their own SDI-sponsored particle beam program. The Russians, of course, will not have sat on their hands in the meantime just to watch the Americans make the most of their invention.

Radio frequency weapons. In the late-1970s, Swedish scientists monitored the release of very large radio frequency energies from Soviet territory. At the same time, there were reports of radio bands worldwide being blacked out by large RF energies of unknown origin. These were the first indications of large-scale Soviet experimentation with RF energies with potential weapons applications. Since then, evidence of Soviet tactical and strategic RF weapons development has accumulated rapidly and the Pentagon's 1987 *Soviet Military Power* report (p. 112) states that "recent Soviet developments in the generation of radio frequency (RF) energy have potential applications for a fundamentally new type of weapon system that would degrade electronics or be used in an anti-personnel role. . . . In their research the Soviets have generated single pulses with peak power exceeding 1 billion watts and repetitive pulses of over 100 million watts."

As implied in the Pentagon document, RF weapons of different powers and wavelengths could be employed in numerous different strategic and tactical military roles. We will briefly list the most obvious ones:

1) space- or ground-based "chip guns," deployed to degrade or destroy the sophisticated electronics of missiles, satellites, and aircraft;

2) large-scale space-based RF generators and antennae capable of sweeping out sizable target areas on Earth and interfering with and interdicting military movements on land or sea;

3) smaller-scale RF assault weapons (the size of a large truck) deployed for limited anti-personnel, sabotage, and other irregular warfare purposes.

Since generation of very high-power RF pulses has with been a Soviet capability for almost a decade, it must be assumed that weapons systems of type 1 and type 3 either are ready in the Soviet arsenal or will become deployable in the very near term. Micro- or RF waves of the proper easiest, most painless way to frequency propagate through the atmosphere more readily than laser-generated photons, and microwave anti-satellite and anti-missile weapons may therefore, along with high-acceleration kinetic energy vehicles, come to constitute the first generation Soviet strategic defense system.

2.3 Superconductors and directed energy devices

Recent announcements in Western Europe, the United States, and Japan of the development of relatively high-temperature superconducting materials were followed a few weeks later by Soviet scientists' claims that they were already in possession of zero-resistance materials at considerably higher temperatures. As often before, such claims were met with disbelief and skepticism in the West. The skeptics should be warned, however, that it is a well-known fact that the Soviet Union for decades has maintained superconductor research programs well exceeding the combined size of Western efforts. Indirect evidence for the veracity of the recent Soviet claims is provided by their remarkable and proven success with accelerator and microwave (RF) generator development. Thus the reported very high-power Soviet microwave pulses—orders of magnitude higher than what has been achieved in the West—are difficult to conceive without the assumption that superconducting materials were used in the design of low impedance electrodes critical for compact high-power microwave generators. The acknowledged Soviet lead in particle beam development in all likelihood is also due to utilization of superconducting design elements.

Successful Soviet superconductor research, as a broad support base for specific applications in the field of directed energy weapons, underlines a point repeatedly stressed by U.S. SDI researchers best informed about Soviet SDI programs: Edward Teller, Lowell Wood, George Chapline, and others all strongly believe that Soviet theorists working in critical areas of strategic defense research are at least the equals of, and in certain fields, outshine their Western competitors.

Since higher-temperature superconducting materials are also the key to the development of a new generation of supercomputers, based on the utilization of relatively high-temperature Josephson junctions, the United States may soon lose the lead in one more essential SDI component technology—superfast computing for systems control and guidance. The undisputed U.S. lead in supercomputers and sensors—both critical to overall efficient integration and functioning of a BMD system—had, up to this point, given U.S. planners the confidence that Soviet BMD breakout could be prevented. Against some 140 U.S. installed supercomputers, the Soviet Union right now possesses only one or two of barely comparable capability. But a Soviet crash effort based on their superconductor research can be expected to close the computer gap—at least for defense applications—in the near future.

Another consideration that gives well-informed U.S. analysts pause about confidently projecting a U.S. SDI lead in the field of numerical calculations, is the unmatched brilliance of Soviet applied mathematics research. As the Soviets have demonstrated with regard to highly complicated calculations in certain areas of plasma physics, machine-executed "number crunching" can often be efficiently short-cut by analytical mathematical techniques. Excellence and success of such analytical work, for example, of the research group under V.E. Zakharov, is acknowledged worldwide.

Finally, a word about superconductors and sensing technologies: Utilization of high-temperature superconducting materials could improve the photon-capture capability of infrared photo-diodes by up to 10 orders of magnitude. Thus again—in the field of sensing as in other SDI-related research areas—we might do well to heed Edward Teller's warning in a recent radio show: The U.S., in only four years of concentrated SDI research, has made numerous and often unexpected new discoveries. The Soviets have been at it for ten years longer. So why should we expect to be ahead in the game?!

3. Soviet space-lift capability

Successful BMD requires basically three types of technology components:

1) kinetic and/or directed energy "bullets," i.e., high-acceleration missiles and projectiles, lasers, and particle beams;

2) sensors and computers for target acquisition, tracking, and overall systems guidance;

3) space-lift capability to launch elements of 1 and 2 into space, either permanently or on warning of attack, in the so-called "pop-up" mode.

We have given, so far, a characterization of Soviet capabilities with regard to areas 1 and 2, and we have concluded that the Soviets probably lead in area 1 and lag behind temporarily in area 2. Until the Space Shuttle disaster, the race between the United States and the U.S.S.R. was about even in area 3. This, however, has changed quite dramatically. Last year, the Russians were able to launch 91 rockets carrying payloads into space, compared to only 6 by the United States, and on May 15 of this year the Soviet Union launched its new* super-booster *Energia* rocket from the Baikonur Space Center. The 2,000-ton booster stands 60 meters high and can lift payloads four to five times as heavy as the U.S. Space Shuttle. The *Energia* launch was preceded by a lengthy article in *Pravda* on May 12, by Professor Markov of the U.S.S.R. Academy of Sciences, announcing major funding increases for the Soviet space and SDI research programs.

There can thus be no question that, despite the strain imposed by BMD and space research on the Soviet economy, the Soviet leadership is determined to match or exceed any effort by the United States and her allies in these two closely related high-technology military fields. The *Energia* is capable of lifting a 100-ton military space station into orbit. The West should be prepared to see this happen as soon as the relevant Soviet component technologies for space-based defense have reached their initial degree of readiness.

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* liquid hydrogen propelled