A Fatal Flaw in the Concept of Space War

The exotic weaponry on which the Pentagon now spends more than $300 million a year would be rendered useless by a single nuclear blast in outer space

The laser weapons and particle beams that promise to turn space into the next battlefield have a critical flaw that most Pentagon planners and congressional advocates have ignored. The exotic weapons and other military satellites could easily be destroyed by a single nuclear blast in outer space.

Such a blast would instantly set up an electric pulse of up to a million volts per meter in hundreds of satellites and battle stations, disabling them and replacing the bold vision of a *Star Wars* conflict with the dreary reality of a nuclear graveyard. A 2-megaton blast just outside the earth's atmosphere would set up a pulse in objects as far away as geosynchronous orbit, some 36,000 kilometers above the earth. The effects of a larger bomb would reach even further.

Despite this apparently fatal flaw, the military's fascination with high-technology weaponry and the can-do spirit of military contractors have combined to create a laser weapons program that is now soaking up more than $300 million a year.

How did this come about? One reason is that the crippling effects of nuclear weapons in space have only recently dawned on a handful of military planners. Another reason, far more fundamental, is that these few planners are located in a relatively neglected segment of the sprawling military bureaucracy, a segment quite separate from where the exotic weapons are dreamed up.

The people who design laser battle stations work in the high-rise offices of the Defense Advanced Research Projects Agency (DARPA), just a stone's throw from the Pentagon. The people who envision the effects of nuclear explosives work in the squat offices of the Defense Nuclear Agency (DNA), off in the suburbs of Virginia. This separation of responsibilities can easily result in the neglect of important flaws in the concept of new weapons systems. "There's nobody at DARPA who addresses the problem of nuclear effects in space," says David T. Petter, a special assistant to the DARPA director. "On the directed energy stuff [lasers and particle beams], we work on the pointing and tracking, or whatever it might be. We are very much into the R & D side and haven't gotten down to the nitty-gritty."

The nuclear threat to space weapons has not been aired outside the military. Deep within the defense community, however, some military contractors have voiced concern. "It's fine to play all these games on paper," said one West Coast consultant, who asked not to be named. "But what happens when push comes to shove and we have to fight in space under realistic conditions?"

Much of the concern about war in space has been touched off by the fact that the Soviets during the past 14 years have performed several tests with killer satellites. These devices maneuver close to a target and then explode in a hail of shrapnel.

In response to the perceived threat from such satellites, the U.S. military has come up with a number of ideas. The lead project in DARPA's futuristic arsenal is an anti-satellite (A-SAT) weapon based on lasers. The Pentagon has already spent more than $1.6 billion on laser weapon development, and it is currently one of the military's most heavily funded research efforts. A laser A-SAT could sit in geosynchronous orbit, conceivably to defend a flock of unarmed satellites that are critical to U.S. national security. These satellites could include DSCS II (military communications), DSP (early warning of missile attack), NATO III C (NATO communications), and Fleet Sat Com (Navy communications). If a Soviet killer satellite started to approach, a laser death ray would flash into action, heating the skin of the target and weakening the structure until it fractured or blew itself apart. Pentagon officials estimate that 8 to 12 such battle stations could be on duty by 1995, at a cost of slightly more than $15 billion. There are no technological hurdles, say the experts. All it takes is time, patience, and money.

Such visions have won the support of the Reagan Administration and members of Congress. The Senate, in a floor amendment tacked on to the fiscal year 1982 Defense Authorization Bill, added $50 million to the Administration's request for the development of space-based laser weapons—an extra $30 million for the Air Force and $20 million for DARPA. "The language in the bill is quite clear," Malcolm Wallop (R–Wyo.) told a reporter (*1*). "It directs the Air Force to get on with it, to do high-energy laser integration and battle management."

Although it has been known since the early 1970's that satellites could be damaged by a nuclear pulse, new strategic realities are making the threat more worrisome. A nuclear blast in outer space sends out in all directions an immense number of prompt gamma rays and x-rays. On earth this radiation would be quickly attenuated by the atmosphere. When these radiations strike a metal object in space, such as a satellite, they knock out Compton electrons, creating a charge imbalance in the skin of the satellite and setting up extremely high electric fields—on the order of 100,000 to 1 million volts per meter (*2*). These surface fields induce large currents and voltages in the electronic payload, causing disruptions and burnouts. It is as if the delicate semiconductors that lie at the heart of a satellite were suddenly hit by a bolt of lightning. The whole effect is called a system-generated electromagnetic pulse (SGEMP). The distances over which it can occur are immense, an unprotected satellite suffering equipment upset from a 1-megaton nuclear blast some 25,000 kilometers away. The closer the satellite or battle station to the blast and the greater the yield of the weapon, the larger and more damaging is the pulse.

When scientists at DNA first started to realize the strategic implications of SGEMP in the early 1970's, they built machines that would simulate the pulse so they could measure the vulnerabilities of electronic equipment. The largest such machine in the world today is located just north of Washington, D.C. Called Aurora, it is more than five stories high and almost as long as a city block. Despite its size, the machine still is not powerful enough to simulate the actual radiation that would strike a satellite tens of thousands of kilometers away from a nuclear blast in space. Aurora went on

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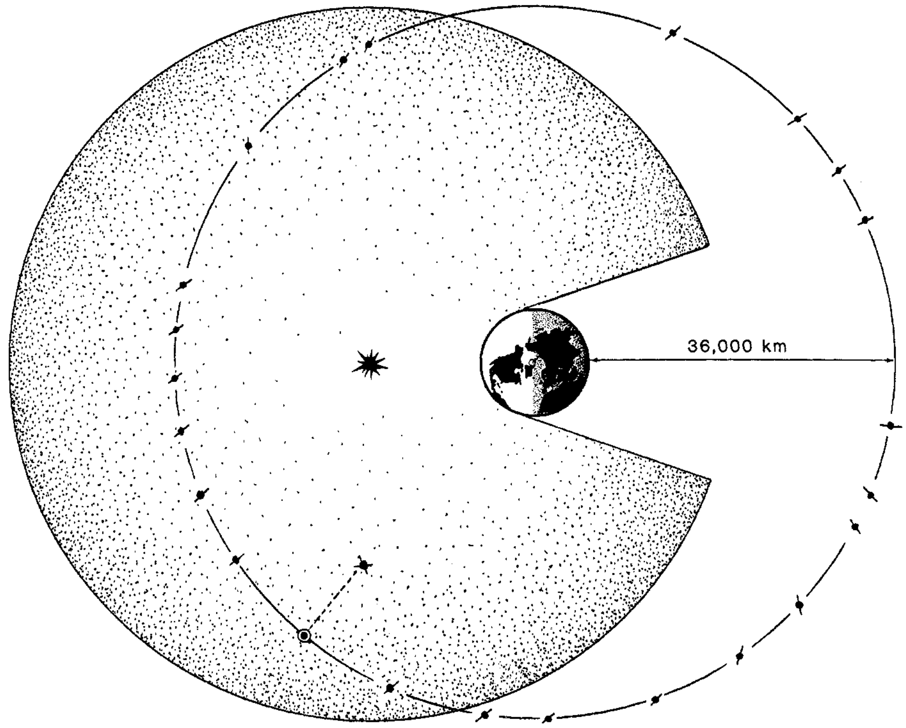
line in 1972, and ever since DNA officials have been pressing for a larger simulator.

"There is an urgent need for such a laboratory simulation facility," the director of DNA, Vice Admiral R. R. Monroe, told Congress in 1979 (3). The name of the proposed machine was the satellite x-ray test facility (SXTF), a behemoth that would cost $100 million to build. Though Congress in the past had not proved sympathetic, the new DNA director renewed the plea in April 1981 (4). "These tests," said Harry A. Griffith, "are absolutely essential if we are to have confidence in nuclear survivability of our military systems."

Then, unexpectedly, DNA itself decided late last year not to push for construction of the huge new simulator.

What happened bears some pondering, since it has implications for all of the U.S. military efforts in space. The key development was a shift in strategic thinking. In the past, it was considered likely that nuclear blasts might occur just outside the earth's atmosphere, produced by an enemy intent on disrupting land-based communications in the United States with a type of electromagnetic pulse. Easy to produce and attractive to use, this type of pulse would shut down the nation's power grid and knock out unprotected communications from coast to coast (5). Any effect on satellites would have been an accidental by-product, or "collateral," as the strategists put it. It would be worth trying to simulate the relatively weak pulses in space at the very edge of the danger area, since testing would show if satellites out in this area could be "hardened." The outer skin of a satellite, for instance, can be separated from the inner skin, setting up a barrier to high voltages. Electronic circuitry can also be designed in a way that minimizes the damage caused by surges in voltage and current.



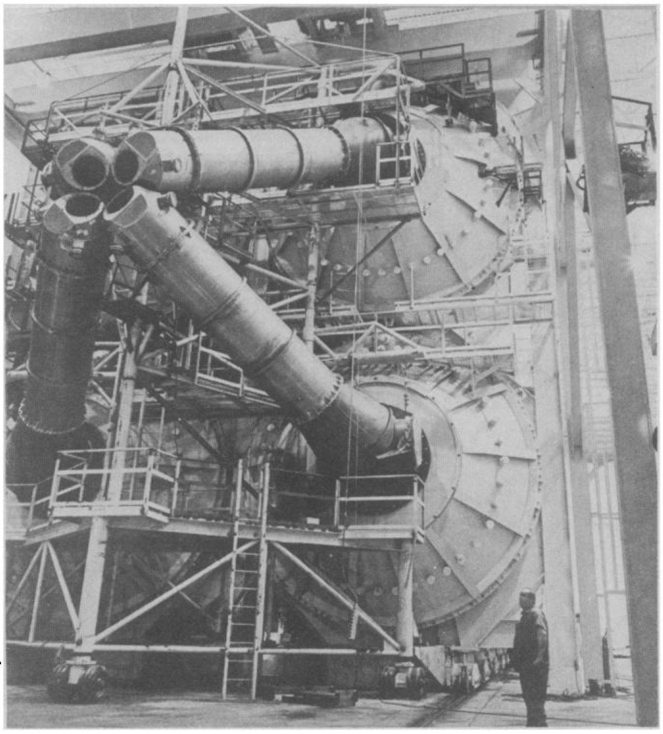
Shown is a space war scenario in which a 3-megaton nuclear bomb is detonated some 14,000 kilometers above the earth. Unprotected satellites within the shaded area would suffer equipment upset or damage, depending on how close they were to the blast. The satellites shown are in geosynchronous orbit, although many others would be closer to the earth and the blast. The extent of the nuclear threat is contrasted to a laser battle station in geosynchronous orbit, firing at a killer satellite some 10,000 kilometers away.

This protection, however, would not be sufficient against a very strong pulse. Such a pulse would be generated if a Soviet killer satellite carried a nuclear payload into space, a possibility that has profoundly disturbed the nuclear strategists. If a nuclear blast occurred far from the earth, close to the geosynchronous orbit, it would blanket a huge tract of space with powerful radiation that might cripple hundreds of satellites and battle stations. The currents might be so large that none of the nominal protections would help. Induced currents, for instance, would be set up in the inner skins of satellites, knocking out internal electronics. Proximity is the main problem. The radiation striking a satellite from a nuclear blast depends on the square of the distance between the blast and the satellite (6). Thus the damage increases geometrically as the distance decreases. "The philosophy of SXTF," says Gordon Soper, scientific adviser to the deputy director of DNA, "was for a distant burst environment." Soper continued in his explication, with bureaucratic understatement: "Weighing heavily in the decision not to proceed at this time is the fact that other levels are now envisioned."

The severity of the threat has been compounded by the development of warheads capable of turning much more of their mass into damage-producing radiation. Although neutron bombs and other enhanced radiation warheads are often depicted as being used only on the earth, they could just as well be used in space.

Technologists who still want to try to protect space hardware have not given up hope, but they paint a gloomy picture. Rather than trying to build protection into valuable satellites, the emphasis is now shifting to taking them completely out of the danger zone. A satellite equipped with special sensors and engines might be able to detect a nuclear-armed killer satellite thousands of kilometers away and kick itself into a distant orbit so as to avoid the damaging rays from the blast. From there it might still be able to perform its critical mission. Defense officials admit the concept is technologically difficult, but they also note the lack of easy alternatives.

In addition to the newly realized dangers of SGEMP, a host of other nuclear effects would vex the operation of electrical devices during a nuclear blast in space. Neutrons and gamma rays can directly penetrate satellites and battle stations, causing TREE effects (transient radiation effects on electronics). TREE would alter gate voltage thresholds in transistors, would damage the crystalline lattice of semiconductors, and would set up spurious current pulses in solid-state devices (7). Even blasts close to the earth would eventually have a serious impact on satellites. They would produce a band of trapped electrons as the bomb's fission fragments started to decay. This band would drift around the earth, damaging over the course of weeks and months electronic devices and solar cells in satellites. This type of damage, in fact, plagued the few satellites that were exposed to the aftermath of the 1962 nuclear tests conducted by the United States high above the Pacific Ocean. None of the satellites was in a position to be directly damaged by radiation from these blasts, but over the following weeks, degradation of performance was extensive. The satellites even-



U.S. Army

Aurora, the world's largest flash x-ray machine, since 1972 has been used to simulate the effects of nuclear blasts in space. Electronic parts or whole systems are placed where the four tubes come together, and an intense flash of x-rays then tests their vulnerabilities. The machine is located at the Harry Diamond Laboratories, just north of the beltway outside Washington, D.C. Even secretaries at the facility must have a security clearance of at least secret.

tually affected by trapped electrons included Transit 4B, OSO 1, Telstar 1, Relay 1, and Explorers 14 and 15.

In attempting to build in protection against some of these nuclear effects, design changes must be considered very early in the planning stages of a satellite. "If you wait until the end," says Soper at DNA, "the changes are so difficult and expensive that they are often ignored."

Nevertheless, the designers of laser battle stations and high-technology weapons apparently have a penchant for leaving the worst problems till last. "We're not looking at the overall system," says Petter of DARPA. "That responsibility belongs to the Air Force, and the Air Force would be doing that kind of thing way down the pike."

As a matter of policy, Soper and other military officials who study nuclear effects do not criticize the high-technologists at DARPA or make comments about the possible damage a nuclear blast in space would cause any specific weapon system. They speak only in generalities about satellites and space systems, and they speak in somber tones.

In promoting their projects, DARPA officials tend to ignore the nuclear side of space war. They note that space lasers could be used to shoot down Soviet ballistic missiles in the atmosphere, although critics say this idea has more flaws than warfare limited to space (*8*). Advocates of laser war also note that nuclear blasts in space are banned by the 1967 treaty forbidding "weapons of mass destruction." And it is unlikely the treaty would be broken, they say, because a nuclear blast in space would also hurt the Soviets.

Would the Soviets detonate a nuclear bomb that would knock out many of their own satellites? At first sight it might seem implausible. Yet the timing and placement of the attack could ensure that their critical satellites were shielded from damaging radiations by the earth itself or were far enough away from the blast that circuit-damaging pulses were kept to a minimum. After all, the few satellites aloft during the exoatmospheric tests of 1962 were not instantly shut down because they were on the far side of the earth, protected from prompt gamma rays and x-rays. Another consideration is that the Soviets do not rely on satellites to the same extent as the United States.

Perhaps one reason why officials at DARPA and the Air Force have ignored nuclear blasts is the magnitude of the problem they would have to confront. For one thing, a laser weapon would be huge, requiring large fuel tanks in which an especially strong surge of SGEMP would be produced and passed along to delicate electronics. For another, the space laser itself, as currently envisioned, would be dependent on a relay satellite for communications with the ground, and that satellite might easily be put out of service by the radiation from a distant nuclear blast. Lastly, even if the space laser could still function after a blast, the battlefield would have been swept clean, with little left to shoot at.

Recent changes in the defense hierarchy will not improve matters. With the release of the fiscal year 1983 budget, Defense Secretary Caspar Weinberger noted that he intends to boost the director of DARPA into a new bureaucratic role so that he also wears the hat of an assistant secretary for research and technology. One purpose of the heightened status is to speed up the pace at which new ideas are incorporated into military hardware.

In contrast to the increased prominence of the high-technology enthusiasts, the scientists and administrators at DNA have, if anything, suffered a reduction in visibility. Their $300-million-a-year research budget has not grown in real terms for nearly a decade, despite the fact that the nuclear realities they must envision and prepare for have steadily grown in scope and complexity.

The issues are indeed formidable. Rather than ignoring the flaws in the concept of space war, officials at DNA are currently looking for better ways to simulate the effects of nuclear blasts in outer space. Since machines are proving too small for the task, the focus is shifting to the underground test site in Nevada, where dummy satellites are sealed into evacuated shafts that mimic the void of outer space. At the far end of a shaft is a nuclear bomb. It explodes, sending out its lethal by-products, including an immense amount of radiation. The picture is not pretty, yet it is one that many people, not just the bureaucrats and scientists at DNA, should examine in detail.—WILLIAM J. BROAD

References and Notes

1. "Senate Directs Air Force to Formulate Laser Plan," *Aviation Week & Space Technology*," 25 May 1981, p. 52. This issue is devoted to beam weapons.
2. Samuel Glasstone and Philip J. Dolan, *The Effects of Nuclear Weapons*, third edition (Government Printing Office, Washington, D.C., 1977), p. 521–522.
3. "Statement of Vice Admiral R. R. Monroe, U.S. Navy Director, Defense Nuclear Agency, Before the research and development subcommittee Armed Services Committee, House of Representatives, Fiscal Years 1980 and 1981" (Defense Nuclear Agency, Washington, D.C., April 1979). p. 4.
4. "Statement of LTG Harry A. Griffith, Director, Defense Nuclear Agency, Before the research and development subcommittee Armed Services Committee, House of Representatives, Fiscal Year 1982" (Defense Nuclear Agency, Washington, D.C., April 1981), p. 9.
5. William J. Broad, "Nuclear pulse," *Science*, 29 May 1981, pp. 1009–1012; 5 June 1981, pp. 1116–1120; 12 June 1981, pp. 1248–1251.
6. The equation that describes the edge of the area at which damage to an unprotected satellite would start to occur is:

$$\frac{6.4\ Y}{R^2} = 10^{-5}\ \text{cal/cm}^2$$

where Y is the yield in kilotons and R is the distance from the blast in kilometers.
7. Michael A. King and Paul B. Fleming, "An overview of the effects of nuclear weapons on communications capabilities," *Signal*, January 1980, p. 64.
8. See for example Kosta Tsipis, "Laser weapons," *Scientific American*, December 1981, pp. 51–57.