U.S. election mandates Mutually Assured Survival

by Charles Stevens and Carol White

Nineteen eighty-four was the year in which the United States made a decisive shift away from the policy of Mutually Assured Destruction, a policy with the appropriate acronym MAD. The Strategic Defense Initiative (SDI) emerged as the centerpiece of a shift in U.S. military doctrine away from the 20-year-old, failed posture of "deterrence"—based on the stockpiling of offensive nuclear weapons and the false belief that general nuclear war is out of the question—and back to a classical concept of war planning that includes both the "sword" of offense and the "shield" of defense. Further, the SDI became the major issue in the U.S. presidential campaign, and internationally.

On March 27, Secretary of Defense Caspar Weinberger announced the appointment of Lt. Gen. James Abrahamson to a newly created post: director of Strategic Defense. At that time Weinberger stated that the SDI had "a very, very high priority, one of the highest priorities of the administration and of this Department."

Typically for an election year, at many points President Reagan appeared to be veering toward a deal with the Eastern Establishment defenders of MAD—Henry Kissinger, McGeorge Bundy, Robert McNamara. On each of these occasions, the polls indicated a sharp dip in the President's popularity. Independent Democratic presidential candidate Lyndon LaRouche, in many of his 15 national television broadcasts during the campaign, explained the crucial importance of the SDI and denounced the Soviet agents of influence in Washington who are trying to block it. Only after the second Mondale-Reagan debate, when the President unequivocally reiterated his support for the Strategic Defense Initiative, was the election "in the bag" for him. His landslide victory was unquestionably a mandate from the American people for the SDI.

President Reagan and Defense Secretary Weinberger have been at pains to insist, contrary to Soviet inspired propaganda, that the SDI is not a program for the defense of the United States at the expense of its allies. Weinberger reiterated this in a press conference on Dec. 19, emphasizing that the security of the United States is inseparable from that of Europe. The Strategic Defense Initiative, in fact, will make it possible to defend Europe against intermediate-range ballistic missiles, like the Soviet SS-20s. President Reagan has offered to share the technology with the whole world, Weinberger said, adding that he and the President hoped the allies would join the effort.

As we go to press, Britain's Prime Minister Margaret Thatcher is on her way to meet President Reagan, and appears to be primed to plead the Soviet case against the SDI—on behalf of herself and President François Mitterrand of France. But in opposition to this, Defense Minister Manfred Wörner of the Federal Republic of Germany called the Strategic Defense Initiative a *fait accompli,* a reality which Europeans must accept and adjust to.

One positive indication of the potential for practical cooperation in developing beam weapons among the Western allies, was the German development of tactical lasers, announced in March, which would be used to blind enemy sensors and range-finding equipment—to a range of 20 kilometers. These are scheduled for battle readiness in five years, and they will be upgraded to target helicopters and other aircraft. It is capabilities such as these which must be called upon to realize the goal of making the SDI and defensive planning a strategic reality for the whole of NATO.

The Soviet countermobilization

Over the year, the Soviet campaign against the SDI has heightened to the point of hysteria, both through Moscow's official spokesmen and through its agents of influence in the West—not least presidential aspirant Walter Mondale and his controller McGeorge Bundy. This despite ample published documentation that the U.S.S.R. has systematically violated the SALT treaties and the ABM Treaty; for example, it has five antiballistic-missile radar installations in place and one more under construction. These phased-array ABM battle management radar stations are located at various sites in the Soviet Union.

According to Secretary Weinberger, the Soviets have spent more on defensive than on offensive weapons since they signed the ABM treaty in 1972. Western intelligence estimates are that they are now at the point of deploying a new defensive system against aircraft and many kinds of ballistic missiles. While the CIA was warning of this at the start of 1984, at year's end the official estimate put off a significant Soviet breakthrough for from three to five years. General Abrahamson told the West German newspaper *Die Welt* in an interview published on Dec. 1 that he had a Soviet report in his possession, written in 1982, which surveyed the full scope of a layered laser-beam defense system, including x-ray lasers. Abrahamson concluded that the Soviet Union is ahead of the United States in at least some of these areas by now.

The United States has the capability to put in place at least a rudimentary defensive weapons system in the next two to three years. A fully effective antiballistic-missile defense would be a multi-layered system which would attack missiles at every point of their trajectory, from the boost to the terminal phase, but even a first-phase, transitional defense system could be a significant deterrent to Soviet aggression since it would add an element of incalculability to their strategic planning.

In an effort to deflect the Reagan-Weinberger momentum, actual opponents of laser defense weapons, such as High Frontier's Lt. Gen. (ret.) Danny Graham, are now claiming credit for the Reagan election victory and the Weinberger defense program. Henry Kissinger too has gotten into the act, delphically claiming to have been converted to support for the SDI—but only as a bargaining chip in disarmament negotiations. In a syndicated column published on Sept. 23 he wrote: "I was less than enthusiastic about President Reagan's 'star wars' speech when I first read it. . . . [A] foolproof defense of the civilian population that seemed implied by the speech is a mirage; even a 90% defense would still let enough weapons through to destroy an unacceptable proportion of our population. As I reflected, that argument more and more struck me as superficial. . . . Perhaps the most compelling argument is the possible beneficial effect of some missile defense on arms control. . . . This article argues that some limited defense—yet to be analyzed—coupled with a revolutionary approach to reduction of offensive forces by agreement may advance us toward the elusive goal of stability."

Kissinger's kookish physicist friends from the Union of Concerned Scientists (UCS) have maintained a more open posture of opposition to the SDI, although their so-called scientific objections to beam weapons have all been shot down. One of the authors of a UCS anti-beams report, MIT's Ashton Carter, was commissioned by the congressional Office of Technology Assessment to prepare a report for Congress attacking the SDI. This incompetent exercise in pro-Soviet propaganda was released on April 14. It has been refuted in detail by Los Alamos laboratory scientists, among others, as was reported in the pages of this magazine ("New anti-missile capabilities show 'Star Wars' foes are lying," Oct. 9).

For its dependence upon the big-lie technique perfected by Josef Goebbels, the OTA document can only be compared to the statements of Soviet scientists such as Academician Yevgenii Velikhov, the vice-president of the Soviet Academy of Scientists and head of the U.S.S.R.'s laser program. Radio Moscow featured him in a series of interviews beamed to North America, in which he said: "Is it possible to create a real defensive weapon based on some new physical principles? The conclusion is that no, this cannot be done."

Such assertions have been systematically discredited, forcing the opponents of beam defense to shift their ground. Now we are told that beam weapons are too expensive. This of course, is part of the broader fight to strip U.S. war-fighting capability by forcing cuts in the military budget. President Reagan's January 1984 budget request of $1.78 billion for the SDI (through DoD financing, the national laboratories actually get some hundred of millions of dollars more) was whittled down to $1.4 billion. The present budget calls for $3.8 billion to go to the Department of Defense for beam-weapon research.

An adequate allotment would be scaled up from $5 to $10 billion next year and $20 billion thereafter. But even without these funding levels, the program is moving ahead. Secretary Weinberger has announced that he will be contracting for feasibility studies from industry during 1985. Operationally, the laser defense program has now been unified and a Space Command has been set up directly under the Joint Chiefs of Staff and the Defense Department, doing away with overlapping commands in the separate forces. As part of this unification, the advanced early warning system has been placed under this command.

The x-ray laser

The extent of the scientific breakthroughs of the past year can be seen dramatically in the case of the x-ray laser. Until 1983, the very existence of an x-ray laser beam-weapon development program was classified "top secret"—even the words *x-ray laser weapon* were classified top secret and no one actually working on x-ray lasers was allowed to publicly pronounce them.

Then in May 1984 Los Alamos National Laboratory made public its report refuting the Office of Technology Assessment's anti-beam diatribe. The Los Alamos report, "Comments on the OTA Paper on Directed Energy Missile Defense in Space," discusses in some detail both the basic science of x-ray lasers and their potential defense deployments.

Later in the year, scientists from Lawrence Livermore National Laboratory were quoted on the public record detailing how x-ray lasers could be deployed within five years for defense against submarine-launched missiles and further developed to penetrate the atmosphere for interception of new, fast-burn ICBM boosters and for extremely long-range intercepts of missiles from deep space. Livermore also presented the details of a laboratory x-ray laser demonstration at the fall meeting of the American Physical Society's Plasma Physics Division.

These revelations have reached the point where even the leading critics of beam weapons from the Pugwash Conference circuit have been forced to admit that the x-ray laser has been demonstrated and that it has the potential of efficiently destroying the existing inventory of Soviet ballistic missiles. (The critics now argue instead that it is impossible to either further improve existing beam weapons or develop new ones which could efficiently intercept improved Soviet missiles.)

On Dec. 13, 1984, *Defense Daily* reported that Martin Marietta and Lawrence Livermore Laboratory had completed a study "about two years ago" which concluded that "the U.S. might be able to deploy an x-ray laser anti-missile system to defend against Soviet Sea Launched Ballistic Missiles (SLBMs) in five years . . . at a cost of $12.6 billion . . . with existing off-the-shelf technology in every respect" save the x-ray laser itself.

Even though the missiles carrying "pop-up" x-ray lasers are only fired into space once an offensive missile launch has been detected, they are cost effective. Dr. George Chapline, who won the 1983 Department of Energy Lawrence Prize for his work on the x-ray laser, estimates their cost at $2 million. This is probably a high estimate. In a reply to anti-beams activist Dr. Hans Bethe published in the August *Laser Focus,* Chapline wrote: "Bethe says that the cost estimate of $2 million for an x-ray laser weapon is 'complete nonsense.' He mentions that a submarine launched vehicle might cost $30 million, but fails to mention that one could put a dozen or more x-ray laser weapons on a single launch vehicle."

The success of an x-ray laser depends upon narrowing the divergence of the beam. The original bomb-powered x-ray lasers were of a low quality, with significant incoherence and a large divergence. But recently, scientists from Stanford University have built x-ray "mirrors" which can reflect up to 70% of an incident beam. Using these focusing devices allows the creation of a well-focused, coherent x-ray laser pulse at low power levels. The next step will be to amplify these by such systems as the Livermore free-electron laser amplifier, which will maintain its tight focusing and quality.

While most of the information regarding the development of x-ray lasers for defense is classified, there have been important breakthroughs in the non-classified domain which are also relevant to the development of a beam-defense capability.

Open scientific papers from Livermore Laboratory and the Princeton Plasma Physics lab have appeared recently which demonstrate that the development of x-ray lasers for diagnostic purposes is progressing rapidly. They report major scientific applications of x-ray lasers in the early stages of preparation, such as utilizing them to make three-dimensional, atomic-scale pictures of living cells (x-ray microholograms) and to probe for the first time dense thermonuclear plasmas.

Such a capability will be critical in future stages of beam-weapon development, when a missile "kill" will depend upon careful "tuning" of shots, rather than upon the delivery of a knockout blow. At that point microholography will be an essential diagnostic tool, to determine such things as metal fatigue on the microscopic level.

While previously x-ray lasing depended upon a nuclear explosion, now for the first time Livermore has reported achieving x-ray lasing by non-nuclear means. Using their Novette laser, they irradiated thin foils of Selenium and Yttrium with visible wavelength laser pulses. Princeton researchers have reported similar results. They have generated lasing from magnetically confined carbon plasmas with carbon-dioxide laser pulses.

'Conventional' lasers

In terms of both ground- and space-based laser beam weapons, the short wavelength excimer lasers are prime candidates. These lasers operate at the shortest wavelength with which ordinary optical technology—mirrors and lenses—are currently compatible. The term "excimer" refers to an excited molecule which is responsible for generating excimer lasing. Intense electron beams or x-rays can be used to generate these excimers.

Los Alamos reported the operation of a full-scale krypton fluoride (KrF) excimer laser module, and stated that construction of a full-size prototype system—consisting of 20 or more such modules—could begin in 1985 if funding were forthcoming.

Another important development is in laser pulse compression, which amplifies the power of the laser pulse, making it more lethal and reducing the problem of holding the laser onto a target, since it kills the target within a small fraction of a second. One method used is called "multiplexing." The laser beam output is amplified 20 or 30 times in power through splitting the beam into many pulses and stacking these pulses in space and time by using many correctly spaced mirrors. Full-scale demonstration of multiplexing should come in early 1985. Multiplexing can be combined with techniques of phase conjugation and Raman pulse compression to further amplify and improve the quality of excimer laser outputs.

KrF excimer lasers would be space-based, while xenon-chloride and xenon-fluoride excimer lasers are leading candidates for ground-based laser weapons operating with orbiting mirrors.

Free-electron lasers

Developments in 1984 show that "free-electron laser" (FEL) technology is becoming mature for both ground basing and possible space basing.

The Dec. 13, 1984 *Defense Daily* quotes Dr. Lowell Wood of Livermore: "One particularly interesting [non-nuclear strategic defense system] . . . involves the use of large lasers located on the ground with mirrors in space focusing their beams onto attacking missiles with lethal results. A handful of such lasers, probably having an aggregate cost of about a billion dollars, working with a small number of mirrors thrown up into space by small but powerful rockets when onset of strategic war was detected, might completely defeat even a massive attack in a highly reliable fashion. . . . Such a system could even more readily defeat attacks carried out with bombers and cruise missiles, thereby completing a robust defense against all present forms of large-scale nuclear attack."

Such a potentiality is opened up by the free-electron laser amplifier. This would allow conventional lasers to be scaled up in power by three to four orders of magnitude.

For the first time, in the fall of 1984, Livermore Laboratory demonstrated high-power amplification with a "pure" FEL system. The device was powered by their experimental test electron beam accelerator (ETA). A 30,000-watt microwave input pulse was amplified to 80 million watts. In 1985 the device will be tested on the Livermore Advanced Test Accelerator (ATA) at higher powers. The larger ATA will extend this result to infrared wavelengths (100,000 Angstroms) and 100 billion watt power levels.

The more than three order of magnitude amplification translates into a corresponding reduction in the demands made for target acquisition or optics. The normal one to two seconds that a conventional laser must remain on its target, can be significantly reduced while the tolerance for divergence allowable for the beam is increased.

Scientific breakthroughs of 1984 in beam defense

Among the highlights of the past year's developments in scientific research were:

1) Testing of x-ray lasers, which once perfected will be able to remain precisely and brightly focused for vast distances;

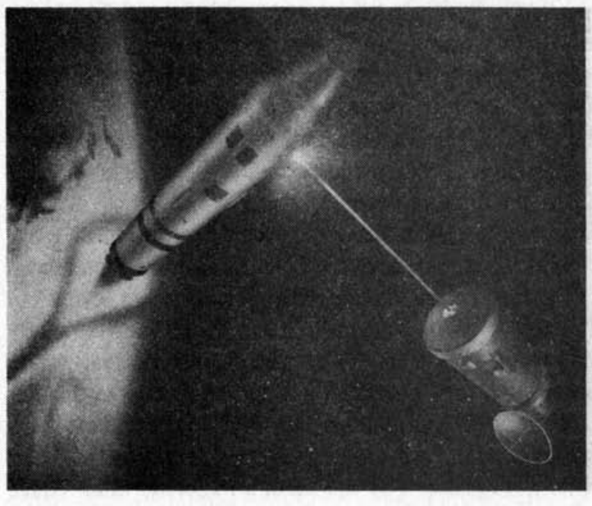
2) Demonstration of short wavelength excimer lasers, including the krypton-fluoride excimer laser module at Los Alamos National Laboratory;

3) Demonstration of two varieties of free-electron laser—one high-powered laser that could be deployed in two years. These can be "tuned" to maximize their lethality against the target;

4) Development of well-focused neutral particle beams;

5) Demonstration of high-energy elementary particle beams (muons) against nuclear warheads;

6) Demonstration of the propagation through the atmosphere of high-energy particle beams;



7) Demonstration of conventional ABMs—missile-intercept in space (HOE) and in the atmosphere;

8) Demonstration of missile protection systems—advanced infrared missile detection systems;

9) Full development of techniques for propagation of laser beams through the atmosphere (phase conjugation and adaptive optics).

Performance would be significantly increased by building betatron accelerators, specifically engineered to the free-electron laser amplifier, as opposed to the present test accelerator configurations. Utilizing advanced betatron e-beam accelerators, FEL-excimer laser systems could be built at a cost of less than $300 million, according to Livermore studies. A full-scale prototype betatron accelerator is now being completed at the Naval Research Lab.

The free-electron laser amplifies laser light by passing the light through an electron beam that is rotating at a frequency related to the laser wavelength. It is an excellent example of the harmonic relationship between light and matter.

The free-electron laser itself, as opposed to the FEL amplifier, promises to provide in one device a means for efficiently generating coherent beams of electromagnetic radiation over a wide range of wavelengths. In its full potential, the FEL promises to provide a means of tuning to any desired wavelength, at extremely high power levels and with efficiencies greater than 50%. These characteristics make the FEL an ideal fusion driver and beam weapon.

Though currently operated at low power, the FEL laser being developed at Stanford University and in France, at Orsay, has also demonstrated significant progress.

Particle beams

While lasers and microwave generators produce electromagnetic waves which travel at the speed of light, particles beams, when ionized, can be accelerated to at least one-third the speed of light via electric and magnetic force fields. Laser and microwave pulses can also be used to accelerate charged particles. Theoretically, it is possible to accelerate a single atom to such an energy that it would have the momentum of a freight train. But even at the far lesser energies now achievable, these high-energy particles appear to be the potentially most efficient of beam weapons.

Since charged particles are affected by the earth's magnetic field, it is desirable to electrically neutralize ion beams after they have been accelerated to desired energy level.

The neutral particle beam (NPB) accelerator offers a very lethal type of space-based defense against nuclear-armed missiles which could be deployed by the 1990s. In this device, electrically charged ions are first accelerated to high energy and then neutralized so that they form a lethal beam which is not deflected by the earth's magnetic field. Since there is no practical way of preventing the high-energy atomic particles from penetrating missiles—in fact these particle beams can be "tuned" in terms of their energy for penetration to any desired depth into the missile—there is no defense against them. Also, they can be extremely efficient in destroying missiles since they can deposit their energy within the electronic systems of the missile and warhead.

A recently published study by Livermore demolishes the claim of critics such as the OTA that NPBs could not be well focused. The currently utilized method of ion-beam neutralization involves passing the beam through a gas cell in which the ions are neutralized through atomic collisions. This method of neutralization always leads to a large scattering of the beam, limiting the NPB to short ranges for missile kills. But the Los Alamos study reported that this "is an important limit only to the particular means of neutralization discussed by the OTA. There are several other schemes that can produce much smaller divergences."

Electron beams

While the Livermore ETA and ATA electron-beam accelerators are important test beds for development of free-electron lasers, they are also ground-based terminal defense systems themselves. ATA has been conducting crucial experiments to demonstrate that electron beams can be shot through the earth's atmosphere and thus used to destroy any nuclear warheads which make it to the United States. The same electron beams which would be used to power FEL lasers could also be used for terminal defense.

Microwave and super-EMP

The almost continuous advances in microwave generation over the past decade achieved with microwave generators, both in terms of efficiency and power output, has led to a situation where even revolutionary developments in this field do not attract significant attention. Microwaves, which are electromagnetic waves in the range of a billion to millions of Angstroms wavelength, can be used to destroy missiles either directly through disruption of their electronics, or indirectly through utilizing them in combination with other beam weapons.

The most powerful form of microwave generation occurs with the explosion of nuclear weapons in space—the so-called electromagnetic pulse generation (EMP). Significant advances in understanding the interaction and generation of microwaves by magnetic plasmas over recent years have led to vast increases in both the power and efficiency of microwave generation. This is demonstrated in the success of the use of microwaves for maintaining electrical currents in tokamak magnetic plasmas and for various applications on magnetic mirror plasmas. Significant progress in using e-beam plasma injection for microwave generation and magnetic plasma amplification of microwave pulses has been made in 1984.

The practical implications for beam defense of these developments can be judged by the following statement by Dr. Lowell Wood, as reported in the Dec. 13, 1984 *Defense Daily*: "Even more striking prospects are being seriously studied. One contemplates the functional (and perhaps physical) destruction of entire fleets of ICBMs with a single weapon module lofted by a single defensive missile. Each of these primary prospects has significant, albeit early, experimental results behind them at the present time. They are not dreams, nor are the corresponding applications studies naive."

Conventional ABMs

Target detection and tracking are far more difficult tasks for conventional ABM systems than for lasers and particle beams. For ABM missiles to intercept offensive missiles is like shooting a bullet with a bullet, while in the case of relativistic beams, the targets are virtually standing still, since the beams travel near the speed of light—186,000 miles per second—while the missiles have a maximum velocity of 7 miles per second. The capability of intercepting ICBMs with ABM missiles, as demonstrated in the test of two systems this year (one in space and one in the atmosphere), is important mostly because it demonstrates that the targeting capabilities needed for beam weapons already exist. (The problem of aiming beam weapons over thousands of miles is still significant, but with the realization of more powerful systems which kill missiles within a small fraction of a second, this problem is greatly simplified.)

On June 11, the Army Ballistic Missile Defense program succeeded in experimentally demonstrating an actual missile intercept of an ICBM in space with the Homing Overlay Experiment (HOE). HOE utilizes an advanced, long-wavelength infrared telescope to locate and guide a missile interceptor toward an ICBM in space. The target detection, pointing, and tracking system needed for this type of intercept is far more difficult than required for beam-weapon intercepts.

While the HOE tests were being carried out, successful results were achieved with the Small Radar Homing Intercept Technology (SRHIT) at White Sands. SRHIT is the terminal defense counterpart to HOE and involves the interception of ICBMs as they re-enter the Earth's atmosphere. The pointing and tracking systems used on the F-16-launched anti-satellite intercept missile were also demonstrated in key tests in the fall. This infrared target detection and tracking system utilized is also applicable to beam systems.

All of these systems demonstrate that conventional types of ABM missile defense could be deployed today. They also demonstrate that the type of command and control and target detection, pointing, and tracking needed for beam-weapon defense either already exists or is being rapidly developed.

Laser-light propagation

Major progress has been made in the science of atmospheric propagation of laser light. This is important for using lasers within the atmosphere as well as for those ground-based systems which must travel through the upper atmosphere to reach relay and focusing mirrors orbiting in space. Many atmospheric effects, such as absorption, turbulence, and refraction, tend to defocus, distort, degrade, and deflect laser-light pulses. There are three major methods of overcoming these effects: pulse shaping, adaptive optics, and phase conjugation.

Pulse shaping changes the intensities within the light pulse so that when it interacts with the atmosphere, it either becomes a better laser pulse or it prepares the way for another pulse to traverse the same trajectory. Adaptive optics are often combined with pulse shaping.

To picture how this works, think of using a "rubber" mirror. Once one light pulse has transversed a path through the atmosphere, its distortions can be readily measured—in fact, this is an important method of measuring the distribution of physical properties of the atmosphere, such as temperature and pressure. The "rubber" mirror becomes deformed in such a way that it can effectively counter these distortions of the laser pulse which "mirror" the effects of the atmosphere.

Phase conjugation is also an important method of amplifying laser pulses. But it also removes optically introduced distortions. In general, phase-conjugation systems consist of a gas medium and a second, much smaller laser. The high-power laser pulse and the second, less powerful laser pulse are simultaneously directed into the gas chamber. The second pulse acts like a mirror traveling at the speed of light. It scoops up the first pulse and reflects it out of the chamber. The first pulse is compressed and optically "smoothed" out in the process.

Target detection, tracking, and pointing

While many of the requisite capabilities needed for beam weapons already exist, even better systems are rapidly being developed. The most powerful of these are those based on the beam weapons themselves, that is, the same lethal beam which can destroy a missile, when defocused so that it covers a huge area, can also be used to detect, locate, and track targets. Infrared lasers are particularly useful because they can be utilized like radar.

This is laser radar, called lidar. More powerful beams, such as x-ray lasers, can be used not only to see but literally "feel out" targets. In this case, the defocused laser pulse is still powerful enough to cause detectible motion of the reentry vehicle. In this way, a real RV can be distinguished from a decoy. Also, beams can be used to highlight targets, so that detectors working at other wavelengths can more easily find and track a given target.

Major advances in optical processing of information are also being realized. This will permit very small satellites to operate both as long-range detectors and battle command posts. The idea here is that, instead of electronically analyzing sensor inputs, the data is maintained as an optical image and compared with known images of desired targets. This functions very much like fitting the right shaped block into the right hole. First the sensor input is transformed to a laser pulse which mirrors the intensities of the original sensor "picture." Then the laser pulse is transformed into a "picture" which shows rotational features as opposed to linear displacements. This new picture allows the picture to be optically compared with known targets without regard to perspective. What would ordinarily take a massive computer many minutes can be accomplished through optical processing almost instantaneously.