January 13, 1987

TECHNOLOGY SPEEDS THE STRATEGIC DEFENSE INITIATIVE TIMETABLE

INTRODUCTION

As originally conceived, the Strategic Defense Initiative (SDI) was a "research program" to identify promising technologies for a strategic defense system. Almost four years into the SDI program, this has paid off handsomely. Technologies have been identified as very promising for use in near-term strategic defense deployment. The next step is to turn these promising technologies into reality by moving toward development and testing so that actual deployment can begin.

Among the gains so far:

** Great progress has been made in technology for intercepting ballistic missiles outside (exoatmosphere) as well as inside the atmosphere (endoatmosphere).

** Technologies exist that could be upgraded and applied to a terminal defense against both short-range and long-range ballistic missile warheads.

** Laser research has progressed to the point where scientists are talking about laser radar and discrimination capabilities being available in the early 1990s.

** An anti-missile laser prototype weapon could be available by the late 1990s.

** And research on infrared sensors has made headway in detecting and tracking ballistic missiles inside the atmosphere and in space.

The momentum of SDI research is greater than originally anticipated. What once seemed probable now seems certain. What once was possible now is probable. And what once was thought impossible is now within reach. Clearly, advances in strategic defense technologies justify a strong vote of confidence for SDI.

PROMISING NEAR-TERM STRATEGIC DEFENSE TECHNOLOGIES

One of the most enduring fallacies about SDI is that no system can be deployed for many years. Yet technologies already exist that could be used in a strategic defense system deployed either immediately or in the near future. Some of these technologies can be derived from existing air defense and ballistic missile defense systems; others are emerging from SDI research on advanced anti-ballistic missiles, radars, sensors, and interceptor systems.

The Exoatmospheric Interceptor Subsystem

The best candidate so far for a strategic defense system against missile warheads in the midcourse of their flight is the Exoatmospheric Reentry Vehicle Interceptor Subsystem, or ERIS, which is being developed by the U.S. Army. ERIS is an outgrowth of the Army's Homing Overlay Experiment (HOE) conducted at Kwajalein Atoll in the Pacific Ocean in June 1984. During this experiment a missile interceptor successfully destroyed a Minuteman ICBM warhead traveling 20,000 feet per second that had been launched some 4,000 miles away at Vandenberg Air Force Base in California. HOE's passive infrared sensor tracking system worked better than expected at acquiring, tracking, and differentiating targets from decoys. The Homing Overlay Experiment success was so encouraging that the U.S. Army's Strategic Defense Command decided to develop the HOE system, now called ERIS, over a five-year period.

The ERIS system will consist of a solid-fuel, ground-launched interceptor placed on a wheeled vehicle for mobility. The two-staged ERIS missile will be low-cost, lightweight, and capable of hitting incoming warheads at altitudes up to 1,100 miles and up to 2,500 miles down range from the launch site. A single ERIS ABM site deployed in the north central part of the United States with the appropriate radars and sensors (say, at the old U.S. ABM site at Grand Forks, North Dakota) could provide partial ballistic missile defense coverage for the entire North American continent.[1] In Europe, the ERIS system

---

1. Specific ground targets such as missile silos or cities can be picked out for preferential defense by an ERIS system. A ground-based ERIS system deployed at Grand Forks therefore could protect not only MX missile fields in Wyoming but specific urban centers in the Midwest as well. A more comprehensive system would require a multilayered defense and greater discrimination techniques than are now technically feasible.

could help defend all of NATO territory against Soviet SS-20 intermediate-range nuclear missiles.

ERIS testing will begin sometime between 1988 and 1990, with full deployment possible as early as 1993. The total life cycle cost of one ERIS site consisting of the 100 ABM interceptors permitted by the 1972 ABM Treaty would be $3.5 billion in 1986 fiscal year dollars over a ten-year period--or only $350 million annually. This price includes the cost of interceptor missiles, upgraded tracking radars, and battle management systems. The price would increase if laser radars on a space surveillance and tracking system were used to discriminate between warheads and decoys in space.

Adding terminal defenses around U.S. and NATO missile silos, military bases, and cities to supplement the midcourse ERIS defense would provide a more effective defense against an increased number of Soviet missiles. Deploying a number of advanced high altitude satellites in space, such as is envisioned in the Pentagon's proposed Boost Surveillance and Tracking System (BSTS), for tracking Soviet missiles in their boost phase would give the ERIS system early warning of a missile's projected trajectory. Developing a space-based surveillance and tracking system to discriminate between decoys and reentry vehicles in space after the ICBM has launched its payload would be required for a fully effective defense against an all-out Soviet nuclear attack. Also needed to defend against this maximum threat are space-based rockets or kinetic-kill vehicles (SBKKV) capable of destroying targets in the boost, post-boost, and midcourse phases of the missile's trajectory.

Some analysts have argued that it makes no sense to deploy ERIS until the problem of discriminating between decoys and real warheads in space has been resolved. Such a delay, however, is not warranted. For one thing, limited discrimination techniques could be developed in the near term to deal with the limited threat of an accidental nuclear launch or a possible errant missile fired by a deranged Soviet submariner. For another thing, a perfect solution to the discrimination problem may take a very long time. Perfection, however, is an unrealistic standard to set for any weapons system--or any technological development, for that matter.

The successes of the Homing Overlay Experiment and the general progress being made in space surveillance technology already demonstrate that enough real warheads could be identified and tracked in space to warrant deployment of an ERIS system to protect against a limited nuclear attack. As space surveillance technology improves, moreover, the capability of an ERIS system to discriminate between warheads and decoys will improve as well. The only serious impediment to this seems to be Congress, whose SDI budget cuts this year have forced the SDI office to scale back its space surveillance and tracking program.

The High Endoatmospheric Interceptor

If incoming missiles are not destroyed outside the atmosphere, they can be intercepted in the upper part of the atmosphere. The Pentagon is studying a new concept to do this called the High Endoatmospheric Interceptor, or HEDI. It would be the first layer of an endoatmospheric defense against those nuclear warheads that leak through the boost and midcourse layers of a space-based strategic defense system. HEDI interceptors would carry explosive or fragmentation warheads designed to destroy reentry vehicles 20 to 40 miles down range from HEDI's point of launching and at an altitude of around 65 miles.

There are many other promising technologies for intercepting incoming warheads in the upper part of the atmosphere. The U.S. can draw on the High-Acceleration Booster Experiment, or HIBEX, a modified "Sprint" hypervelocity interceptor capable of destroying warheads by crashing into them. There also are new technologies arising from the Small Radar Homing Intercept Technology (SR-HIT) developed by the U.S. Army.[2] The SR-HIT is a self-guided missile steered by radar which could knock down "maneuverable" warheads, those capable of changing their course in the terminal phase of flight. Some version of SR-HIT could be used not only against strategic missile warheads reentering the atmosphere from outer space but against tactical short-range ballistic missiles, such as the Soviet SS-21 based in Eastern Europe, that do not leave the atmosphere.

On April 20, 1986, an updated version of the SR-HIT, called the Flexible Lightweight Agile Guided Experiment, or FLAGE, was tested at White Sands Missile Range in New Mexico.[3] Using radar for guidance the 12-foot-long FLAGE hypervelocity missile destroyed a 44-inch diameter sphere that was hung 12,000 feet in the air by a balloon.[4] While the April 12 test was against a stationary target, future tests will be conducted against air-launched moving targets.

This experiment showed that an anti-ballistic missile could be accurate enough to destroy a target inside the atmosphere with a conventional explosion. This capability to hit a bullet with a bullet has been a longtime aim of ballistic missile defense research. The

2. The "Sprint" was a high-velocity anti-ballistic missile deployed in 1974 as part of the "Safeguard" anti-ballistic missile system at Grand Forks, North Dakota. The "Sprint" was nuclear-armed and intended for intercepting incoming warheads in the upper layers of the atmosphere. The "Safeguard" system was deactivated in 1976.

3. "Army Tests Guidance Accuracy of Radar Homing Device," Aviation Week and Space Technology, May 12, 1986, p. 60.

4. Ibid.

FLAGE experiment demonstrated that radar guidance software can be integrated into flight hardware to provide the accuracy required for intercepting short-range ballistic missiles. Future tests against moving targets are required to ensure system effectiveness in a real battlefield situation. Matched with space-based and airborne sensors, a FLAGE system could be used in an anti-tactical ballistic missile system in Europe or Israel and in a U.S.-based strategic defense against low-flying ballistic missiles launched from submarines at sea.[5]

The Low Endoatmospheric Interceptor

For the lowest end of the terminal defense spectrum, the U.S. is developing the Low Endoatmospheric Interceptor (LEDI) system.[6] This interceptor missile would be deployed on the ground to defend highly valued but relatively small targets such as missile silos and command and control centers which most likely would be protected in "hardened" concrete bunkers. By intercepting nuclear warheads at least 4 miles from their targets, LEDI could save a large number of "hardened" U.S. nuclear missile silos from a Soviet first strike. It also could be used to protect targets against non-nuclear warheads launched on short-range ballistic missiles.

Guided by radar, LEDI will intercept incoming warheads at an altitude of at least 4 miles above the ground. The Flexible Lightweight Agile Guided Experiment, or FLAGE, can be applied to developing LEDI by modifying the range of the interceptor to deal with threats at the lower end of the atmosphere.

Other candidates for a LEDI system include: 1) some version of the "Aegis" surface-to-air missile (SAM) currently deployed on U.S. Navy air defense cruisers; 2) a modified French-manufactured "Aster-30" SAM, a ground-launched two-stage solid propellant missile with a range of around 20 miles for use against aircraft and short-range ballistic missiles; 3) the "Patriot" air defense system, currently deployed in Western Europe by NATO, which travels at a speed of 5,000 miles per hour and can intercept aircraft at a range of nearly 65 miles. The "Patriot" could be converted into an anti-ballistic missile by modifying its radar and associated computer software, warhead, and rocket engine for use in a terminal defense

5. For a detailed study of anti-tactical ballistic missile defense in Europe, see Michael Ruehle, Preserving the Deterrent: A Missile Defense for Europe (London: The Institute for European Defence and Strategic Studies, 1986).

6. For a more detailed discussion of LEDI, see Manfred R. Hamm and Kim R. Holmes, "Anti-Tactical Ballistic Missile Defense, Deterrence, and the Conventional Defense of NATO," Washington Quarterly, Spring 1987.

against either missile warheads coming from space or short-range ballistic missiles that have a low trajectory path.

No matter which system is developed, LEDI can provide a good last minute defense of highly valued targets against not only nuclear-armed strategic ballistic warheads reentering the atmosphere from space but low-flying, conventionally armed short-range ballistic missiles as well.

Space-Based Kinetic-Kill Vehicles

Promising too in the near term are space-based kinetic-kill vehicles (SBKKV), or very small, "smart," terminally guided rockets placed on platforms in space. Deployed on hundreds of space platforms, these rockets would be shot at a missile shortly after it was launched or at a reentry vehicle flying through space. Guided by information supplied by short- and long-wave infrared sensors, these rockets would head for a target, and using homing detectors on the rocket itself, maneuver at the last minute to destroy the target by crashing into it directly or by exploding a non-nuclear warhead nearby.[7] For intercepting boosters, short-wave infrared homing devices could be employed to identify and track the hot rocket plume of the booster in the first 200 to 300 seconds of flight, or in the so-called boost phase. In the post-boost and midcourse phases, when the rocket plume has been greatly diminished or cut off entirely, long-wave infrared sensors capable of picking up cooler targets would have to be used.[8]

The space-based kinetic-kill vehicle is a very promising strategic defense technology because:

1) Space rockets can use well-established ballistic missile technologies. The major challenges thus are not scientific but rather involve such technical and economic factors as making rocket components small enough and at a low enough cost to put them in space in large numbers.[9]

2) Space kinetic-kill vehicles could be employed against missiles in the boost-phase. So doing, they could destroy a missile before it had fired its independently targeted reentry vehicles. The result is that many enemy warheads are "killed," in effect, by one U.S. shot.

---

7. Office of Technology Assessment, Ballistic Missile Defense Technologies (Washington, D.C.: Office of Technology Assessment, 1985), p. 155

8. Ibid., pp. 156-157.

9. Information provided by the Strategic Defense Initiative Organization.

3) Due to their versatility, SBKKVs could threaten targets in the boost, post-boost, and midcourse phases of a ballistic missile's trajectory.

The technical challenges posed by the space-based kinetic-kill vehicle program include the miniaturization of electronics, valves, batteries, coolers, guidance systems, and other components of conventional rocket systems. This is needed to reduce the weight of the space-based platform and to make the rockets fast and maneuverable enough to engage targets at very high speeds. The rocket also will have to be accurate enough and have sufficient fuel to change course repeatedly as it maneuvers to strike a target. A tracking and guidance system, meanwhile, will have to be devised to ensure that the space rocket actually hits the missile body in the boost phase and not the hot rocket plume that triggers the infrared sensors.

With sufficient funding, officials at the Strategic Defense Initiative Organization are confident that these technical challenges could be met and an operational system deployed by the early 1990s.[10] Pentagon officials are convinced that SBKKVs will prove to be not only cost-effective but valuable force multipliers in a multilayered strategic defense system.

PROMISING LONG-TERM TECHNOLOGIES

The Free Electron Laser

One of the most promising directed energy technologies for strategic defense is the free electron laser. This FEL is a powerful light beam produced by first detaching electrons from their orbit around atomic nuclei and then accelerating them almost to the speed of light through a linear array of magnets. The tube in which this already occurs is called a "wiggler." It is almost 10 feet long and lined with 120 electromagnets. Actual SDI applications, of course, would require a much longer tube. The magnets "wiggle" the electrons until they line up in a synchronous oscillatory motion. As the electrons decelerate, the kinetic energy of the electrons is transformed into radiation or laser light. If the wavelength of the light is small enough, the free electron laser could be aimed through the atmosphere over tremendous distances to knock down ballistic missiles or warheads in space or in the very high atmosphere.

The free electron laser is promising for a number of reasons. First, an FEL weapon could be deployed on the ground, thereby avoiding the costly task of putting the laser power source in space. Secondly,

10. Information provided by the Strategic Defense Initiative Organization.

the FEL shows the most technical promise of achieving high power at short wavelengths. A FEL has already been produced at the Lawrence Livermore National Laboratory in California, and scientists there are very much encouraged by the prospects of developing a free electron strategic defense weapon.

Great progress already has been made in three key areas of free electron laser technology:

1) Laser efficiency or the measure of how efficiently the kinetic energy of electrons is converted into laser light. The more efficient the laser, the more promising it is as a weapon. In 1985 scientists at the Livermore Laboratory produced a free electron laser, which converted 40 percent of the electrons' kinetic energy into coherent radiation or laser light. Components of the FEL now under development at Livermore Laboratory which will lead to a much more powerful free electron laser operating at shorter wavelengths by the early 1990s.

2) The free electron laser at high levels of power. Thus far a free electron laser has been created only at a low average power level, that is, by generating around one gigawatt (one billion watts) of unsustainable power instantaneously. But to create a weapon it is necessary to boost the laser beam with very high levels of average, sustainable power. The Livermore Laboratory is working on new electron beam injectors and new magnetic pulse power units which will be applied to a new FEL test facility currently under construction. These new technologies hold enormous promise for increasing the input of power required for an operational free electron laser weapon.

3) Reducing the wavelength of the free electron laser. To propel a laser through the atmosphere, it is necessary to reduce its wavelength so that it can travel through the relatively densely packed molecules of the earth's atmosphere. An experiment currently underway at Livermore Laboratory aims at lowering the free electron laser's wavelength to 10 microns.[11] The goal is one micron or below at high levels of average power. Livermore scientists are confident that with sufficient funding a free electron laser will reach these short wavelengths at higher levels of sustained power by around 1993.

The Boost Surveillance and Tracking System

The most effective way to destroy ballistic missiles is to eliminate them in the first 50 to 200 seconds or so of their flight--in their boost phase. It is far more effective to kill a missile carrying its many warheads than to wait until they have separated from the missile in space. Critical to boost-phase

11. A micron is a unit of length equal to one millionth of a meter (39.37 inches), or one thousandth of a millimeter.

interception is the ability to identify and track missiles from the moment they are launched. It is also necessary to collect data on missiles and to hand it over to space-based surveillance and tracking systems (SSTS), which can help guide laser or kinetic-kill vehicles to destroy warheads from missiles that have escaped the boost-phase defense.

Addressing this is the Boost Surveillance and Tracking System (BSTS) experiment. The Strategic Defense Initiative Organization is looking at ways to detect a ballistic missile's gaseous plume with space-based infrared sensors as soon as the missile is launched. Getting a reading on the missile's plume can be used not only to guide a laser or space-based kinetic-kill device to the missile, but to establish its trajectory and projected point of impact if it and its warheads should escape boost-phase interception.

The specific purpose of the BSTS experiment is to determine whether a satellite using infrared sensors can collect adequate data on a missile against the earth's background. Although the BSTS prototype now in the works will not be used for anti-ballistic missile defense purposes, it will tell scientists a great deal about what they can expect from more advanced versions of BSTS technology. As currently planned, BSTS will have two important spinoffs: 1) it will provide a more survivable and accurate early warning system against ballistic missile attack; and 2) it will allow the U.S. to monitor Soviet tests of multiple independently targetable reentry vehicles (MIRVs) with greater accuracy and reliability. This would improve the ability of the U.S. to verify Soviet compliance with arms control agreements.

CONCLUSION

There are many new technologies and concepts arising from SDI research. Tests show that deployment of an effective nationwide ERIS midcourse defense system could begin in the early 1990s. A terminal defense against ballistic missiles in the upper and lower parts of the atmosphere could be built on existing technologies. Much progress has been made on producing a free electron laser, which could be deployed on the ground for intercepting missiles in all phases of their trajectory. And the sensor technology for identifying and tracking missiles in the boost-phase holds promise not only for boost-phase interception but for improving the U.S. early warning system as well.

Some of these concepts could make deployment of a strategic defense system a reality within a half dozen years. Other more advanced systems show great promise in the mid- to late 1990s. No matter what the timetable for deployment, more than enough promising SDI technologies exist to confirm that strategic defense is technically feasible. Deployment options are already emerging, and more are sure to follow as SDI technologies mature.

Kim R. Holmes, Ph.D.
Deputy Director
of Defense Policy Studies