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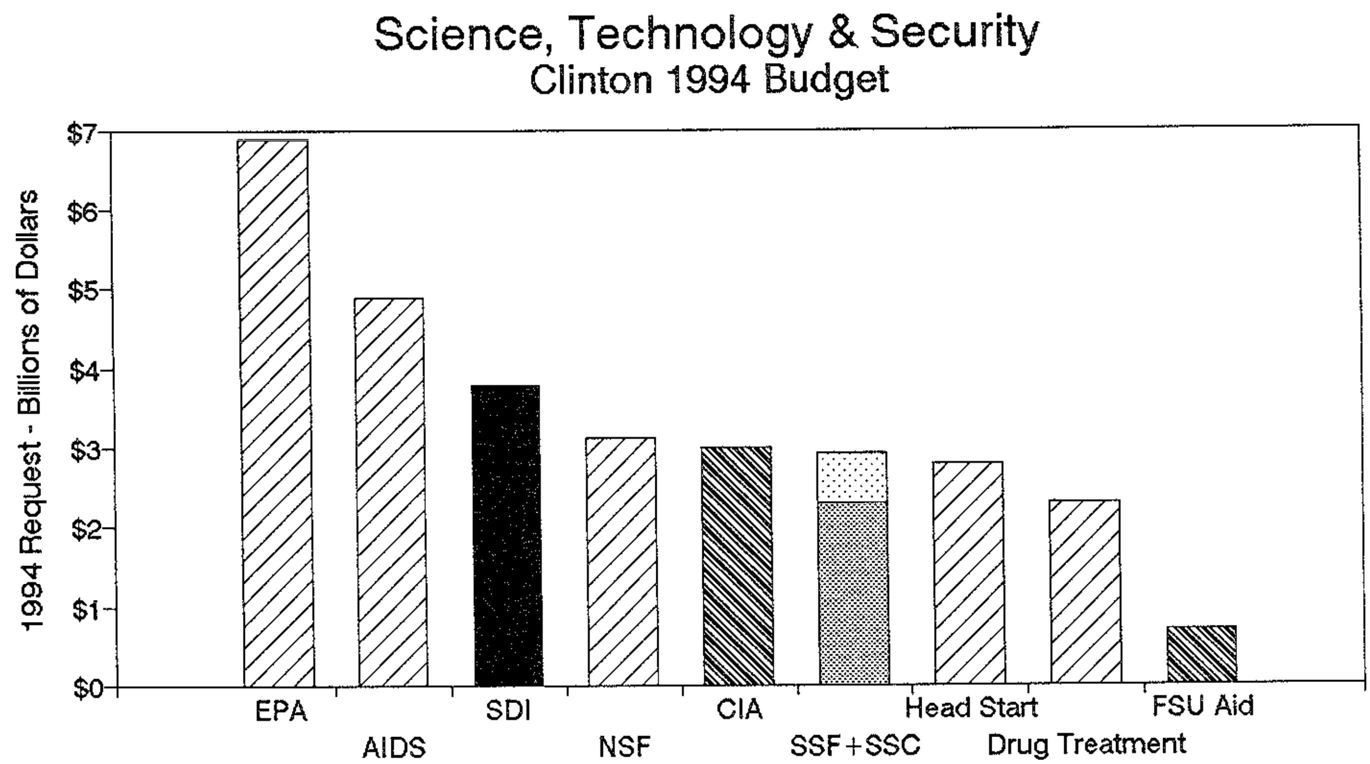
STAR WARS AFTER 10 YEARS



PROPER END TO SDI CRUSADE IS COLLABORATION

Announced a decade ago, the Strategic Defense Initiative is now entering its fourth incarnation. President Clinton has inherited, and so far accepted, a Star Wars that is largely focused on ground-based defenses against tactical and theater-range ballistic missiles.

With the end of the Cold War, the debate over antimissile systems lost some of its earlier religious fervor. Reality, perhaps no less or no more political than economic, interrupted a mass of expectations. Fingers that once moved so excitedly through a rosary of exotic strategic defenses hesitated and moved back a bead or two.

Even so, strategic defenses remain one of the central elements defining American views of national security. And though the space-based elements of Star Wars have been de-emphasized, they have not been eliminated.

During the Cold War, SDI was the preeminent incarnation of fear of an implacably resolute Soviet menace. Today, SDI incarnates all of the inchoate apprehensions of implacably hostile regional actors, and perpetuates a view of a world order primarily characterized by military threats rather than economic and cultural opportunities.

This multi-billion dollar a year program has invested itself with the icons of the Cold War. The doctrine that chemical, nuclear and missile proliferation are the major threats to American security incenses the argument that since little that can be done to stop their flow, SDI remains the only, the absolute, solution.

Proliferation of other weapons, such as strike aircraft or military space systems, is being obfuscated by the haze from candles lighted for American exports. And efforts to achieve limits on advanced weapon proliferation through unilateral restraint, multilateral arms control or international cooperative regimes have become

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IN MEMORIAM

Physicist Bernard Feld and Biochemist Robert Holley, two of America's leading scientists and longstanding supporters of the Federation, died in February.

Bernard T. Feld

Feld, a Founder of FAS who helped Enrico Fermi develop the atomic bomb, said in 1982 "I was involved in the original sin, and I have spent a large part of the rest of my life atoning." Indeed, Feld was fiercely and vocally supportive of arms control agreements, opposed to nuclear stockpiling and the arms buildup in the 1980s, and convinced that scientists should involve themselves in public policy.

In 1976, FAS awarded Feld its annual public service award, calling him the "indispensable man." In a statement to be read at the March 31 memorial service in Cambridge, Council Chairman Robert Solow, Fund Chairman Frank von Hippel and President Jeremy Stone said:

"Bernard Feld was invariably constructive, often creative and always, above all, dedicated. If, as he felt it had, his role at Los Alamos placed heavy burdens of social responsibility upon him, history will record that he amply fulfilled them."

Feld retired from MIT two years ago after a distinguished teaching career and a half-century of leadership in arms control. His death came from lymphoma at the age of 73. He is survived by his artist wife Ellen, two daughters, and three brothers.

Robert W. Holley

Holley, a Sponsor of FAS who won the Nobel Prize for unraveling the genetic code of RNA, died of lung cancer at the age of 71.

His scientific breakthrough of enormous proportion was first reported in a two-sentence journal abstract, reading "The complete nucleotide sequence of an alanine transfer RNA, isolated from yeast, has been determined. This is the first nucleic acid for which the structure is known." Isolating the RNA sample took him three years and 200 pounds of yeast. Breaking the code in a strand of RNA with 77 subunits took him another four.

The President of the Salk Institute, where Holley had been a fellow and professor since 1966 focusing on cell growth and inhibitor factors, said his "discoveries deepened our understanding of cell growth and opened new possibilities for the diagnosis and treatment of cancer and other diseases."

Holley, a resident of Los Gatos, California, is survived by his wife Anne, one son, three brothers and two grandchildren. □

The Federation of American Scientists (FAS), founded October 31, 1945 as the Federation of Atomic Scientists (FAS) is the oldest organization in the world devoted to ending the nuclear arms race.

Democratically organized, FAS is currently composed of 3,500 natural and social scientists and engineers interested in problems of science and society.

FAS's four and a half decades of work as a conscience of the scientific community has attracted the support of the distinguished Sponsors listed below.

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the province of well-versed, but less powerful, acolytes in the arms control community.

So, while the fourth stanza of the Star Wars hymn may be less fervent in tone, and Bill Clinton may find himself comfortable with the lyrics, the refrain is the same: How much will it cost? Is it needed? Will it work? And what about arms control?

How Much Will It Cost?

The costs of currently contemplated anti-missile systems are modest compared with the trillion dollar fantasies of a decade ago. But the roughly four billion dollars that is proposed for anti-missile systems each year for the remainder of this decade is real money, even by Washington standards.

Clinton's proposed SDI budget exceeds that of the National Science Foundation. It exceeds the combined budgets of the Space Station and Superconducting Super Collider. It is more than that of the CIA. It is more than what is proposed to be spent on productive domestic programs such as Head Start and Drug Rehabilitation.

Is It Needed?

The case for deploying theater missile defenses with capabilities beyond those of the improved PAC-3 Patriot has not been made.

There is little prospect within the foreseeable future that the United States or its allies will be threatened by Third World ballistic missiles that cannot be addressed just as well by new generations of Patriot as by an SDI consisting for the most part of fixed ground-based systems. And even if one were to concede that such Third World ballistic missiles are, or will be, a threat, counterforce strikes against their launchers may be a more cost-effective response.

Moreover, air-breathing systems such as cruise missiles—an equal if not greater threat—would not be countered by dedicated anti-ballistic missile systems.

Will It Work?

Intercepting tactical and theater ballistic missiles poses the same challenges to system effectiveness as those faced by strategic defense. The experience of the Patriot deployed in Desert Storm confirmed the long-standing apprehensions of those skeptical of SDI: Performance of anti-missile systems is easily degraded by the difficulties of discriminating real targets from decoys, and by the unreliability of software.

The more advanced systems of SDI obviously remain untested in combat, but simulated testing has to date produced mixed results and no measurable increase in the confidence level.

And What About Arms Control?

Notwithstanding the fact that America and Russia will, for the foreseeable future, retain large arsenals of strategic offensive forces aimed at each other, reductions in nuclear force now underway on both sides confirm the original logic of the ABM Treaty. Reductions in offensive forces require strict limitations on anti-ballistic missile systems and mandate definition of treaty-compliant anti-tactical ballistic missile systems.

The Bush Administration engaged the Russians in negotiations aimed at loosening or eliminating Treaty restrictions. The Clinton Administration should reverse course and focus on more restrictive limitations.

Money Better Spent Elsewhere

We have very little to show for the $32 billion spent on SDI over the past ten years. And we will have even less to show for spending another $32 billion on it over the next eight years. Only two rationales remain for spending any amount. They are the threat of Third World missile proliferation and the effects of political instability in the former Soviet Union.

Both of these problems largely result from the dissolution of the former Soviet aerospace complex. It would be better to keep Russian aerospace workers on the job than to see them moving to work on Third World missile projects, or taking to the streets to demand a return to the old system. But the amount of money allocated for direct aid to Russia is negligible, compared to either the magnitude of the problem or to the proposed SDI budget.

It would be far more prudent to redirect much of the proposed SDI budget into an aid program targeted at stabilizing the former Soviet aerospace complex. Such a program, patterned after the one already enacted to deal with the former Soviet nuclear weapons complex, would have an immediate impact—both on promoting Russian democracy and on discouraging missile proliferation.

Paradoxically, SDI has been at the forefront of developing cooperative projects with the Russian aerospace complex. This was the lure in the Bush Administration's strategem of gaining Russian support for the program. The Clinton Administration should build on this experience, taking it one step further and in a different direction, and greatly expand the scope of civil space cooperation recently begun by NASA.

Such cooperation would reduce potential threats arising from instability in the former Soviet Union and from ballistic missile proliferation—providing economies in our space effort almost immediately and even greater economies in defense over time.

—John E. Pike ■

RECOUNTING THE HISTORY, DISCOUNTING THE CLAIMS

Since President Reagan first unveiled his Strategic Defense Initiative on 23 March 1983, the program has been marked by shifting goals and uncertain plans. The past decade has witnessed three major phases in the evolution of SDI.

Each new phase was marked by less ambitious performance goals that were to be met by less ambitious technical means. The inevitable trend of the evolutions, however, has been to confirm the observations of those who have questioned both the need for and feasibility of anti-missile systems.

The Magic Peace Shield

At its outset, SDI was to offer a perfect defense against a very large missile strike by the Soviets. When this proved unworkable, it evolved to a less-than perfect-defense against a large attack. Later, it returned to claims of perfection, but this time protecting against a small attack. However, at no point was SDI able to find something it could do that was worth doing.

The vision that President Reagan initially presented for his Strategic Defense Initiative was a world in which nuclear weapons were rendered "impotent and obsolete." Although this was a somewhat vague and indefinite notion, it was generally taken to mean that the SDI would lead to a virtually perfect defense of populations. Certainly the exuberant rhetoric that was used in support of the program would have been difficult to sustain in support of less exalted goals, such as defense of retaliatory forces.

But this ambitious goal was generally thought to require an implausible level of technical perfection. While Reagan's goal of an impermeable shield over Western Civilization was attractive, there was little reason to expect that it was attainable. Obvious Soviet countermeasures, such as massive numbers of decoy warheads, coupled with the predictable unreliability of battle management computer software, guaranteed that the goal of perfection would stay just beyond our grasp.

Finding Out What Wouldn't Work

Perhaps the greatest accomplishment of the first four years of the SDI program consisted of learning what technologies would not work. At its beginning, the program contemplated an investigation of a bewildering array of devices that might be of some use in shooting down missiles and warheads.

Most of these gadgets, such as railguns, space-based lasers, and particle beams, were weighed in the balance and found wanting. By 1987, the negative appraisal led to erosion, even abandonment, of support for unpromising technologies.

This loss of support was a blessing in disguise. The Congress demonstrated a stubborn unwillingness to grant the program more than about $4 billion in annual appropriations. And Congressional rejection of the Administration's attempt to reinterpret the ABM Treaty further constrained the prospects for testing or deploying exotic systems.

Phase One: Validating What Would Work—Sort Of

The fading dream of technological perfection left in its shadow a lowering of ambitions. In August 1987, the SDI Organization received approval from the Defense Acquisition Board, the Pentagon's highest committee dealing with procurement matters, to proceed with demonstration and validation of those anti-missile technologies that could be deployed in the mid-to-late 1990s.

It was anticipated that an actual decision to deploy the system would come this year—1993, and that initial operational capability of the system would be achieved in 1997. The system was to include up to 2000 ground-based interceptors and 4000 space-based interceptors, at a cost of over $70 billion.

One mission defined for the system was the protection of American land-based missiles. Specifically, the requirement was that the system demonstrate the ability to intercept fifty percent of the Soviet's force of 308 SS-18 ICBM's—the core of Soviet counter-silo capability and our window of ICBM vulnerability.

An umbrella capable of keeping out only half the rain is clearly a leaky one. It was also a case of too much, too late.

The Scowcroft commission had nearly closed the window in 1983 by noting that missile silo vulnerability had limited significance when compared to the other two legs of the triad—the bomber and submarine, both of which had continuing viability. The long-running MX/Midgetman debate would have closed the window long before SDI could, at a fraction of the cost. Too, the window of vulnerability was wearing thin as a compelling rationale for new weapons systems.

Then, in late 1989, the Berlin Wall cracked, effectively marking the end of the Cold War and largely eliminating political anxieties over the prospects of impending nuclear combat with the Soviet Union.

Maybe Global Protection Against Limited Strikes?

In 1990, growing disenchantment with the technical and military prospects of an anti-missile system oriented toward the declining Soviet threat led Congress to endorse, for the first time, significant cuts in the SDI budget (as opposed to reductions in what had been requested), and to call for a major restructuring of the SDI program.

But the end of the Cold War did not mark the end of SDI. By late 1990, the Strategic Defense Initiative was reoriented into Global Protection Against Limited Strikes (GPALS) to defend against tactical and theater missile threats, as well as up to 200 long-range ICBM or SLBM warheads aimed against the United States. Plans for the components of the operational Strategic Defense System underwent significant changes, with a new generation of systems replacing those that were the focus of activity in the 1980s.

This new system would be deployed in three stages: a Transportable Protection Against Limited Strikes (T-PALS)—an air-transportable system to defend against theater missiles, a Continental US system (C-PALS) of Brilliant Eyes sensors and ground-based interceptors deployed at multiple sites, and the global system (G-PALS) with space-based Brilliant Pebbles interceptors.

All of these systems were inherited without modification from earlier plans for more massive defenses oriented against the Soviet Union. The order-of-magnitude reduction in the number of warheads that would turn a "strategic" attack into a "limited" one did not translate into a comparable reduction in the size of the defensive system: The 1000 space-based components are about 25 percent of the previous number, and the 1000 ground-based interceptor are 50 percent of what had been determined necessary for a "strategic" system. The total estimated cost of deploying the GPALS system was in the range of about $40 billion.

Desert Storm Fever Hits And Runs

In the wake of the Gulf War, and the perceived success of the Patriot, the Congress responded by passing the Missile Defense Act, which called for deploying a ground-based system covering the United States by 1996 and restored the funding cuts imposed the previous year.

However, this Congressional enthusiasm was short lived. By mid-1992 it was apparent that Patriot had been much less successful than originally claimed. Whistleblower Aldric Saucier raised disturbing questions about the technical judgement and management of the SDI program. The Pentagon itself admitted that there was no prospect of meeting the 1996 deployment target. 2002, said the military, was a more realistic goal. So, in 1992 the Congress eliminated the target dates and, further, declined to increase the program's budget.

Debate Gets Down to Earth

The first eight years of the Star Wars debate were marked by zealous disputations unsullied by concrete evidence. Like strategic nuclear war, there was (fortunately) no actual combat experience to constrain the speculations of the SDI "theologians." Then, in early 1991, the Patriot engaged Iraqi missiles during Operation Desert Storm.

Proponents of SDI immediately embraced the Patriot as vindicating their claims for the utility of anti-missile systems. President Bush and others immediately claimed that Patriot had given the virtually perfect performance that had long been the goal of the Star Warriors. And enthusiasm for limited anti-missile systems was rejuvenated.

Conflicting Claims For Patriot Performance

The Pentagon asserted that at least 81 Scuds were fired during the conflict; independent sources count as many as 89. Against these eighty-odd missiles, 158 Patriots were fired against 47 to 51 of them (again, the number is uncertain), an average of three Patriots fired at a single Scud through the mid-point of the conflict and four fired at each incoming missile thereafter. The three or four-to-one firing sequence, of course, made it impossible to test the 70-90 percent single-shot kill probability SDI advocates had promised.

It was initially claimed that of the 47-51 Scuds fired at, 45-50 were successfully intercepted. Such was not the case.

Subsequent analysis by the Army, as well as analysis of the pattern of damage in Israel and of commercial television coverage, suggested a less optimistic conclusion on Patriot's success. As the excitement of the war cooled, it became increasing apparent that actual performance had fallen far short of the initial claims of near-perfection. Given government and industrial secrecy and the paucity of reliable data, how far short may be unknowable. But it is clear that the number of missiles intercepted, rather than being "virtually all," actually ranged somewhere between "some" and "none."

Instead of fulfilling the promises by SDI advocates, the performance of the Patriot system during Desert Storm confirmed the initial concerns of skeptics that the perform-

THE BASIS FOR CHOOSING WHAT TO FUND

In earlier debates over SDI, it was generally accepted that if the cost of intercepting a missile was greater than the cost of the missile to the attacker, deployment of anti-missile defenses would stimulate a spriraling competition between offensive and defensive systems in which the cost advantage of offensive systems would make them the winner. The ABM Treaty avoided this competition between the superpowers.

Generally speaking, applying any such metric is manifestly unfavorable to defense and in many ways denies its proper rationale. The Nitze criteria illustrated how the offense-defense game can be transformed into simple economic warfare, with the weaker economy the loser. With roughly matched economies, as once was the case with the United States and Soviet Union, such a contest can continue for some time, though at enormous costs. The greater the inequality in economic resources, the more quickly the contest will be decided.

For example, Israel is clearly disinclined to pay the full costs of the Arrow program, fearing a ruinously expensive arms race with its regional adversaries. In principle, the United States, with an economy that dwarfs that of Israel's antagonists, could pay for defenses of Israel that would outmatch Arab missile forces. In practice, however, the American government has been properly reluctant to accept such an open-ended commitment. This caution is all the more appropriate, given the likelihood that no prospective anti-missile system would manifest the level of perfection necessary to contribute much to resolving Israel's dilemmas. ■

ance of anti-missile systems would be degraded by the problems of discriminating decoys from real targets, and by the abiding unreliability of computer software.

Flaws In Scuds Create Inadvertent Decoys

Target discrimination was hampered by design flaws in Iraq's modification of Scuds to Al-Husayns. Structural weaknesses broke the missiles up into several pieces, thereby inadvertently approximating the effects of deliberate countermeasures. Most Al-Husayns seem to have disintegrated at fairly low altitudes, after they had been detected and tracked by the Patriot units. Therefore, Patriots were launched at what was presumed to be a single target and were then faced with two or more targets.

On 17 January in Saudi Arabia, 28 Patriot interceptors were fired at 5 Scud missiles, because pieces of disintegrating Scuds were discerned by Patriot fire units as distinct threatening objects. On 25 January in Israel, more than 27 Patriot interceptors were fired at 7 Al-Husayns under similar circumstances.

In the first example, US satellites reported 5 Scud launches. As the missiles approached Dhahran, Patriot radar detected 14 objects and launched two interceptors at each target. This demonstrates the challenge to successful missile defenses posed by technical aberrations, much less deliberate countermeasures.

Surgical Precision Lacking In Software

Even a simple system like Patriot, which is managed by a relatively modest several-million-line computer code, can have software errors that result in a complete failure of the system to perform its basic functions. This was demonstrated in the case of the Scud that killed 28 Americans in a barracks in Saudi Arabia in the closing days of Desert Storm.

A programming error in the tracking software generated a timing error that increased the longer the computer ran without being reset. Over the course of 100 hours of operation, an error of just over a third of a second was sufficient to cause the Patriot unit to malfunction. Radar operators observed no return or track from the missile as it passed through the search pattern. The missile was not detected and, thus, not engaged.

Campaign Against Launchers Had Chilling Effect

A third lesson from Desert Storm relates to the relative effectiveness of counterforce versus active defenses—sometimes referred to as shooting the archer versus catching the arrows. In the conduct of Desert Storm it appeared that the air campaign against Iraqi missile launchers was a massive effort that produced dis-proportionately small results. However, this negative assessment rests on too narrow a definition of success.

While it is true that only a few Iraqi launchers were destroyed from the air, the campaign induced frantic Iraqi efforts to avoid detection and destruction. The result was a missile force that was for the most part too preoccupied with its own survival to mount sustained fire against Israel or Saudi Arabia. And though Iraq was occasionally able to fire as many as 10 Scuds in a single day, the fact remains that fewer than 90 missiles were launched during the 42 days of combat—stark contrast to the more than 400 that theoretically could have been fired.

The air campaign succeeded in inflicting a 75 percent virtual attrition rate against Iraq. Early proponents of SDI asserted that the boost-phase layer of the defense was the most highly leveraged, since it could engage missiles before they deployed multiple warheads or countermeasures. Some wags responded that the most highly leveraged layer of the defense was the pre-boost phase, otherwise known as preemptive counterforce, attacking the missiles before they are launched. Desert Storm confirmed the importance of pre-boost phase engagement. □

During the 1992 campaign, Bill Clinton made several statements related to Star Wars and the ABM Treaty, statements that were a refreshingly realistic appraisal of the issue, reflecting an appreciation of the lessons of Desert Storm and a recognition of the end of the Cold War.

In July 1992, Clinton stated:

"We should focus the SDI program on three more concrete goals connected to hard-headed analysis of the real threats that the United States might face in the future."

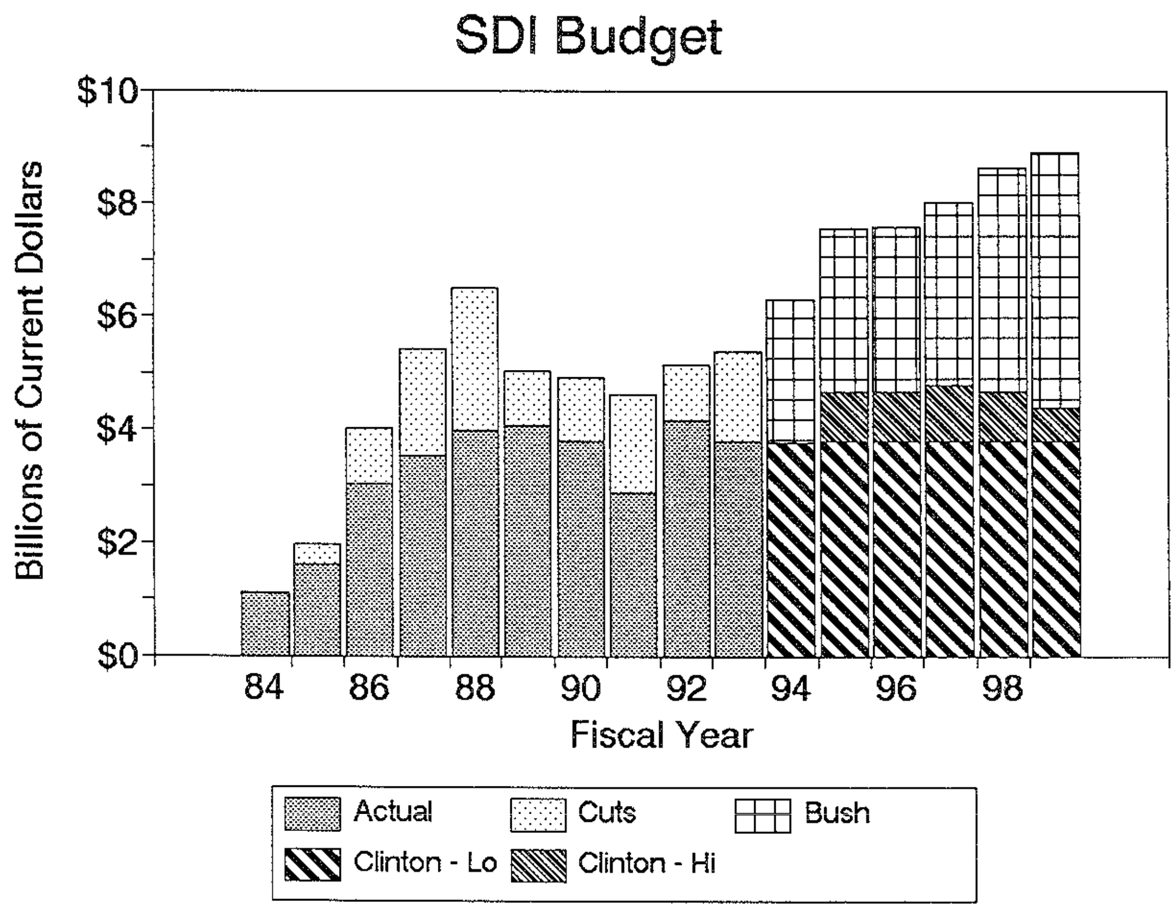
"First, we would develop and deploy theater-based defense systems—like Patriot and its successors—to defend US troops and allies against the existing threat of short-range missile attack."

"Second, we should focus strategic defense research on a limited defense of the United States against the possibility of new ICBM threats. Such threats have not yet and may never emerge—the CIA says there will be no new ICBM threat for at least a decade. But, it is prudent to be in a position to deploy a limited defense should the need arise."

"Third, we should support a prudent research program on more advanced follow-on anti-missile technologies. This would ensure American technological leadership in the field, as well as preserve the option to deploy more capable systems in the future, should the need arise."

Not surprisingly, these statements by Clinton, the candidate, were of a general nature.

The question now is how President Clinton will translate his general goals into specific action. In the absence of affirmative decisions on the part of the new Administration, the multitude of existing SDI programs will likely continue, outliving the outdated political and strategic assumptions from which they arose. ■



The present budget is heavily weighted in favor of investments in active defenses against ballistic missiles, while potentially more rewarding investments in defenses against air-breathing threats and counterforce systems are relatively poorly funded.

Even so, the costs of the Patriot can at this juncture be more easily justified than those projected for deployment of more expensive systems of a scaled-back Star Wars. The Patriot at least has the advantages of actuality, a modicum of performance on which to build and a demonstrated threat to counter. The more capable systems now proposed appear to be based on optimistic assumptions that may never be actualized and threats that may never be encountered. Furthermore, upgrades to Patriot build on existing investments in support infrastructure; more capable systems require major new investments.

Patriot Anti-tactical-missile Capability (PAC-1/2/3)

From the beginning of its development in the mid-1960s, the Patriot anti-aircraft missile was intended to also have an anti-missile capability. The first phase of Patriot Advanced Capability (PAC) consisted of software upgrades to enable Patriot radar and the fire control system to engage high-angle missile targets. This system was declared operational and entered service in 1988 as a limited self-defense capability for US and German forces.

The second phase (PAC-2) provided the Patriot missile with a warhead that produces larger fragments (700 grains) and an improved fuse to increase the interceptor's effectiveness against ballistic missiles. Initial deliveries of the PAC-2 system began on 30 August 1990, just in time for use during Desert Storm.

The Advanced Tactical Patriot, or Patriot PAC-3, will incorporate an active radar seeker on the missile itself and employ a more sensitive ground tracking radar. Other improvements increase its range, improve communications links to permit launchers to be fired by radars up to 30 kilometers away, and reduce the complexity of the system to facilitate rapid deployment. Testing of the PAC-3 started in 1992, and will be completed this year.

Extended Range Interceptor (ERINT)

In contrast to the Patriot, the Extended Range Interceptor (ERINT) uses a millimeter-wave radar in the nose of the interceptor itself for guidance, rather than the ground-based radar used in systems such as Patriot, destroys its target by direct impact and is smaller (a Patriot launcher could carry 16 ERINTs in place of 4 Patriots).

While the direct-impact capability might provide enhanced lethality against missiles, ERINT would be less effective than Patriot against aircraft, since the small mis-

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sile could pass harmlessly through an airplane's wing. During 1993, ERINT will participate in a competitive fly-off with Patriot PAC-3 to determine which of these interceptors will be approved for production.

Theater High Altitude Area Defense (THAAD)

The Theater High Altitude Area Defense system is a 5-year, multi-hundred million dollar effort to develop an integrated two-layer, wide-area defense against ballistic missiles with ranges up to 3000 kilometers. If successful, THAAD will be capable of engaging such targets at distances of up to 200 kilometers, at altitudes in excess of 150 kilometers.

The THAAD, the first-layer interceptor missile, will be larger than either Patriot or ERINT, though smaller than the Israeli Arrow. ERINT will be the second-layer interceptor in the system. As with the HEDI endo-atmospheric interceptor (previously developed), THAAD would use an infrared homing kill vehicle.

Initial testing of this interceptor is anticipated by 1994, with tests continuing through 1996. Unlike ERINT, which will take advantage of existing Patriot infrastructure, the larger THAAD will require all-new launch and support equipment, greatly increasing the overall cost of the system.

Arrow (Chetz)

The Arrow (Chetz) is a medium range anti-missile interceptor intended for defense against ballistic missiles with ranges up to 1000 kilometers. There is considerable confusion in the public record over almost every feature of the Arrow. However, it is clear that this two-stage solid-fueled missile, which uses infra-red homing guidance (as with THAAD) and an explosive shrapnel warhead (as does Patriot), is substantially larger and more expensive than its American counterparts.

A range of technical problems has emerged in the program. The system's radar has an inadequate scan area. Better command and control equipment is needed. And many elements need to be miniaturized. The first three tests of this interceptor failed, with only the fourth, in February 1993, finally succeeding. Although the project is jointly financed by America and Israel, both governments have stated that they have no plans to finance the deployment of this system, suggesting that each thinks the other should shoulder the costs.

Ground-Based Interceptor (GBI)

SDI plans include continued work on strategic ground-based interceptors that would intercept missile warheads during the mid-course phase of flight, just before they reenter the atmosphere over North America. This effort extends the approach used in the Homing Overlay Experiment (HOE), which successfully intercepted a warhead in 1984, and the Exo-atmospheric Reentry-vehicle Interception System (ERIS), which incorporated a much smaller and lighter kill vehicle.

The relative progress among these three generations of interceptors is indicated by the mass of the kill vehicle, which dropped from near 1200 kilograms with Homing Overlay, to less than 200 kilograms with ERIS, to about 25 kilograms with GBI-X.

Competitive development of the operational Ground Based Interceptor Experiment (GBI-X), a smaller and more sophisticated version of the ERIS, was awarded in mid-1990. Under these plans, testing of the GBI would begin about 1995, with deployment at one or more sites in the 2002-2004 time-frame. Award of the contract has been delayed, pending a review of the program by the Clinton Administration.

Boost-Phase Sensors (BSTS and FEWS)

Early detection of missile launches can significantly improve the performance of defenses against both tactical and ballistic missiles. During the 1980s, SDIO spent several hundred million dollars on developing the Booster Surveillance and Tracking System (BSTS).

When the anti-missile mission requirement for BSTS was eliminated in 1990, the program went back to the Air Force. Renamed the Follow-on Early Warning System (FEWS) to reflect improved early warning of missile attack and enhanced intelligence collection and verification capabilities, its proponents are once again stressing its potential in a theater missile defense. But given the performance of the Defense Support Program warning satellites during Desert Storm, it is far from clear that the greater sensitivity of the FEWS sensors would improve tracking or interception capability.

Mid-Course Sensors (GSTS/GBR/PAVE PAWS/Brilliant Eyes)

When the SDI program first began, there was considerable optimism that sensitive thermal sensors could detect minute differences in the heat emitted from real warheads and decoys and would enable the system to attack the first and ignore the latter. Although subsequent work on using laser radars to detect slight differences in the vibration patterns of warheads and decoys showed some promise, over the years the mid-course discrimination problem seemed to grow increasingly intractable.

By 1992, a total of four mid-course sensor systems were under study by the SDI Organization.

The Ground-based Surveillance and Tracking System (GSTS) would use long-wavelength infrared sensors for tracking and discrimination. GSTS probes would be lofted into space on ballistic trajectories upon warning of an attack, remain in space for tens of minutes—long enough to discriminate and transmit data before falling back to earth.

The Ground Based Radar, based on earlier SDI work on the Terminal Imaging Radar, would provide late mid-course discrimination and tracking. This program was divided into two related projects. A GBR-TMD (Theater Missile Defense), using technology similar to the Patriot's, is to be tested at White Sands starting in 1994. And a larger GBR-SMD (Strategic Missile Defense) that uses X-band technology to track ICBM and SLBM reentry vehicles before they reenter the atmosphere is under development.

The SDIO has also evaluated upgrades to existing PAVE PAWS early warning radars that would enable them to support anti-missile operations. Upgrades to PAVE PAWS radars promise to provide the least costly option for a national missile defense, should such a need arise.

The most ambitious sensor is the Brilliant Eyes constellation of 50 to 80 spacecraft orbiting at altitudes of somewhat less than 1000 kilometers. Each spacecraft would be equipped with a combination of long-wavelength infrared, visible light and laser radar sensors, for tracking targets in mid-course. This large constellation of satellites would be capable of covering only 20 percent of the Earth's surface at any one time, and would have to rely on other sensors, such as the DSP satellites, for warning of missile launches.

Again, based on the Desert Storm experience, none of the sensors, with the possible exception of the Tactical Ground Based Radar, would appear needed for defending against existing threats.

Third World Threats

Recent estimates of the number of prospective ballistic missile states—ranging from 15 to 25 by the year 2000—have been used by advocates of SDI oriented defenses to win support for their position. Missiles to be held by these nations generally fall into three categories:

- Short-range, conventionally armed missiles deployed by Third World countries, including Scuds and Scud-derivatives;
- Long-range missiles currently deployed by nuclear powers, including the states of the former Soviet Union; and
- Longer range or more sophisticated missiles that are supposed to be under development by various Third World countries, including space launch vehicles that could be converted into long-range missiles.

The first category can be adequately addressed with Patriot or ERINT.

The second category, an abiding Cold-War fact of life now parsed in terms of rogue commanders and accidental launch, poses no new case for deploying SDI. The American intelligence community continues to believe that, despite instability in CIS republics, controls on the former Soviet nuclear arsenal remain adequate. In any event, the current internal problems will have been resolved long before an SDI defense would be ready.

There are only a few missile programs in no more than a handful of Third World states—North Korea, Iran, Iraq, Syria and Libya— and each of them is under intense international scrutiny. Yet, it is the third category that is at the heart of the call for more ambitious anti-missile systems.

Considering the range of options available to counter this actual or supposed threat, a major investment in proposed anti-missile systems beyond Patriot appears the least attractive. A strengthened Missile Technology Control Regime, economic assistance to the states of the former Soviet Union, more stringent international export controls on missile-usable materials and components, and the confidence building that is inherent in US-Russian force reductions would seem more productive and more consistent with post-Cold War goals.

Do Missiles Make Good Terror Weapons?

A review of the War with Iraq suggests that the primary result of the Iraqi missile campaign against Israel lay more in the fear created in the minds of the threatened population than in actual destruction, which was relatively minor.

Still, there are those who contend that the use, or potential use, of conventionally armed ballistic missiles as weapons of terror against civilian populations mandates the deployment of SDI. In the absence of such defenses, it is said, other countries might be reluctant to join American-led coalitions against regional actors, or otherwise be subject to untoward political pressures of some sort.

But neither the ballistic nor the tactical/theater missile is a unique agency for such political pressure. Nor will prospective anti-missile systems resolve such concerns. As the recent bombing of the World Trade Center suggests, no country is beyond the reach of a determined terrorist organization. The cost of maintaining the capability, even a worldwide network, to use incendiary devices against public facilities or commercial airliners is negligible compared to that of developing and deploying either Scud-type or long-range ballistic missiles.

Since it is the fear of attack that is at issue in terrorist threats, a system to protect against the use of ballistic missiles as terrorist weapons must be thoroughly reliable, which is to say essentially perfect. If only a few missiles penetrate a defensive screen, the terrorist achieves his goal. And no prospective anti-missile system can guarantee a contrary outcome.

He Who Has Missiles Has Countermeasures

The probability of countermeasures could prove just as stressful to the performance of tactical and theater defenses as it would be to that of strategic defenses. There are a range of relatively simple countermeasures that could readily defeat the even the most capable systems currently planned by SDIO. Such countermeasures are not beyond the reach of most countries capable of building their own ballistic missiles.

For example, one measure would be to replace the unitary warhead used on Scud-derivative ballistic missiles with multiple bomblets (similar to mortar shells). Instead of a single 1000 kilogram warhead, such a multiple warhead missile might be armed with eight 100 kilogram bombs, or dozens of 10 kilogram bomblets. Or the missile could carry dozens of canisters loaded with chemical or biological agents.

If the goal were simply to overwhelm the defense, a precision dispensing mechanism might not even be needed. While such errant submunition warheads would likely be too small and their impact too random to be of significant military value, they would still be effective as a weapon of terror.

The challenge of gaining access to the boost-phase of strategic ballistic missiles which has bedeviled Star Wars for the past decade is recapitulated at the tactical and

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theater level. Just as SDI found no plausible solution to this problem for strategic defenses, solution at the theater and tactical level will prove equally elusive.

The availability of such countermeasures substantially vitiates the case for deploying longer range interceptors such as THAAD. Although THAAD could intercept missiles at nearly ten times the range possible with Patriot, it could not gain access to the boost phase of ballistic missiles, before the deployment of multiple warheads.

Defense of Military Assets: Questions and Answers

What role is played in the opponent's strategy by a missile attack on the target set? Attacks on some of these target sets may figure more prominently in the opponent's strategy than others, and thus may be more likely to occur. If this is the threat that is forecast to emerge, using conventional techniques to conceal or harden the targets may make a greater contribution to deterrence than an anti-missile defense system.

Are there other threats to the target? In most instances, these targets can be attacked by means other than ballistic missiles. Strike aircraft are much more widely proliferated than ballistic missiles, and may pose a more challenging threat to defense.

Are there adequate counters to these other threats? Air defense capabilities may not be adequate to deny the success of an attack. If so, anti-missile systems may not necessarily improve the situation.

Can anti-missile systems "successfully" defend the target set against the baseline threat? Some of these attacks are much easier to counter than others. *Do excursions from the baseline threat stress the effectiveness of the defense?* If proliferation of offensive weapons or other countermeasures can negate the missile defense, its utility can be reduced or eliminated.

Are other means available to enhance the survivability of the targets? In some instances, other means, such as mobility, can make a significant contribution to survivability. *In terms of costs, do anti-missile defenses compare favorably to the alternatives?* The technical complexity of these defenses may result in very high costs when compared with alternative survivability approaches.

Russians Are Split On SDI Issue

Both the American and Russian stances toward anti-missile systems and arms control underwent significant evolution in 1991. The Missile Defense Act called for deploying an anti-missile system that would be "cost-effective and operationally effective and ABM Treaty compliant." However, deployment of significant strategic anti-missile systems would require revision or elimination of the 1972 Anti-Ballistic Missile Treaty. Under the terms of the Treaty, any operationally effective system would be a violation, and any Treaty compliant system would not be operationally effective.

Some SDI advocates claim that the Russians have reversed their opposition to the deployment of missile defenses. In fact, at least two approaches to anti-missile issues are now contending for dominance in Moscow.

The traditional skeptics at the Foreign Ministry and Academy of Sciences retain their prior support for the ABM Treaty and skepticism toward anti-satellite weapons, while accepting the possibility of jointly operated warning systems. But the new enthusiasts on the General Staff and in the aerospace industry are now free to openly advance a more hospitable approach, calling for joint development and operation of space-based interceptor systems.

Although both of these approaches offer a more positive attitude toward anti-missile systems than was to be found in initial Soviet reactions to SDI, neither constitutes an endorsement of the Bush Administration approach. In their support for the ABM Treaty and their opposition to large scale anti-missile deployments, the traditional skeptics propose less than the Bush Administration wanted. On the other front, the new enthusiasts have sought more than the Bush Administration offered and conditioned their support on a new Russian/American condominium.

Taking Clinton Beyond His Word

In March 1992, Clinton stated:

"The ABM Treaty has well served US security interests since it was ratified 20 years ago. I would only consider modest changes in it that clearly enhanced US security interests and were negotiated in good faith with Russia after full consultations with our NATO allies. At present, such changes are not needed."

But the actions and inactions of the past twelve years have created a situation that demands more than a determination not to pursue the wholesale revision of the ABM Treaty proposed by the Bush Administration. A decade of Star Wars has vitiated the ABM Treaty regime, and even the programs that the Clinton Administration appears committed to support raise new challenges to the Treaty.

The technology required to intercept high performance aircraft is not unlike that needed to intercept ballistic missiles. This led to concerns in the United States that Soviet anti-aircraft missiles could form the base for a ballistic missile defense system. Unfortunately, improved technology has increasingly blurred the technical distinctions between air defense and ABM systems.

Article VI(a) of the Treaty dealt with this emerging problem by prohibiting either side from giving air defense (or other) missiles, launchers, or radars the capability to counter strategic ballistic missiles or their elements (reentry vehicles) while in flight, and not to test them "in an ABM mode."

At the time the SALT 1 agreement was signed, the shortest-range "strategic" ballistic missile covered by that treaty was the Soviet SS-N-6 SLBM, with a range of approximately 2500 kilometers, and a reentry velocity of slightly over 4 kilometers per second. This was well below the 7 kilometer per second reentry velocity of intercontinental systems with ranges of 10,000 kilometers.

Internal Defense Department guidance at the time defined anti-tactical missile systems, which would be clearly permitted by the Treaty, as those capable of intercepting targets moving at speeds below 2 kilometers per second (nearly twice as fast as high performance combat aircraft.)

Under these circumstances, there was a large buffer zone between the capabilities of tactical and strategic defenses.

With the advent of the START agreements, the SS-N-6 and other intermediate range missiles were to be eliminated, prompting a call to redefine the tactical/strategic threshold at 5 kilometers per second. This would mean that a system capable of intercepting missiles with ranges of several thousand kilometers, such as the CSS-2 deployed by Saudi Arabia, would be permitted under the ABM Treaty. The THAAD is an example of such an interceptor.

Although the PAC-3 Patriot is probably consistent with the provisions of the ABM Treaty, the more capable, longer range systems such as THAAD are not so obviously compliant. Redefining the parameters to include THAAD would fly in the face of prior American practice.

ATBM Concerns On Both Sides

During two decades of the ABM Treaty, the United States has repeatedly expressed concerns about Soviet development and testing of anti-aircraft interceptors, including the SA-5 and SA-10, as well as the SA-12B anti-tactical missile system.

A comparison of the intercept envelopes of these Russian systems with that of THAAD clearly indicates that THAAD is far more capable than these systems, which in the past the United States has regarded as being of questionable compliance with the Treaty. Now, Russia is actively promoting sales of even more capable SA-12 systems, and the proliferation of such systems is only a matter of time.

It will become more difficult for the United States to object to Russian actions in the face of an expanding American program. At a minimum, the absence of mutually accepted standards will be a source of increasing friction in coming years.

The transfer of some anti-missile components to third countries may raise questions concerning compliance with the Article IX undertaking "not to transfer to other states, and not to deploy outside its national territory, ABM systems or components limited by this Treaty."

Concerns about compliance with this provision of the Treaty are likely to increase in the future, given the proliferation of ATM systems, continuing improvements in the capabilities of ATMs, and the current lack of definition of the distinction between permitted anti-tactical systems and Treaty-constrained strategic interceptors. American Administration concern over Russian actions in this field will only grow if these systems are exported.

Definitions And Thresholds Essential

New definitions of what constitutes ABM "capabilities," and a focus on thresholds rather than categorical bans, could resolve this problem. Devices with capabilities above a certain threshold would be subject to the testing and deployment limits of the Treaty, while those with inferior capabilities would not.

Similarly, there are questions about what is an ABM "component" or what constitutes "development," terms that are central to the ABM Treaty, but which lack sufficiently precise definition. Threshold limits would provide a less ambiguous operational definition for the "development" of an "ABM component" which has "ABM capabilities" or has been "tested in an ABM mode."

In particular, it is essential that a precise definition of the distinction between Treaty-accountable strategic systems, and tactical systems that are not constrained by the Treaty, be reached. Such definitions should provide an ample margin of safety to avoid concerns about creeping breakout. □

A PRUDENT PROPOSAL FOR MISSILE DEFENSE

The Clinton Administration's initial request for 1994 SDI funding will be $3.8 billion, of which approximately half will go for Theater Missile Defense programs. This funding level is equivalent to that provided by Congress for 1993. It also represents the average budget appropriated each year by Congress since 1987.

While Clinton's SDI budget is modest by the extravagant standards of the Reagan era, which contemplated annual budgets exceeding $10 billion, it is a mark of misplaced budget priorities to speak of a "mere" $3.8 billion for SDI.

$3.8 billion is over half the total budget of the Environmental Protection Agency. It is a significant fraction of all federal spending on AIDS.

At a time when both the Space Station Freedom (SSF) and Superconducting Super Collider (SSC) are the focus of great political controversy, and numerous cost-conscious groups clamor for their elimination or postponement, the Clinton SDI funding request exceeds the combined budgets of these projects.

The Reasonable Approach

A more reasonable anti-missile research program would consist of five projects, which would require funding of only about $1.25 billion from 1994 through 1996, and funding of about $1 billion in subsequent years.

1. Based on upcoming competitive testing, either the Patriot PAC-3 or the Extended Range Interceptor (ERINT) should be developed and deployed. Most analyses have concluded that Patriot would be equally effective in defending most target systems as the longer range sys-

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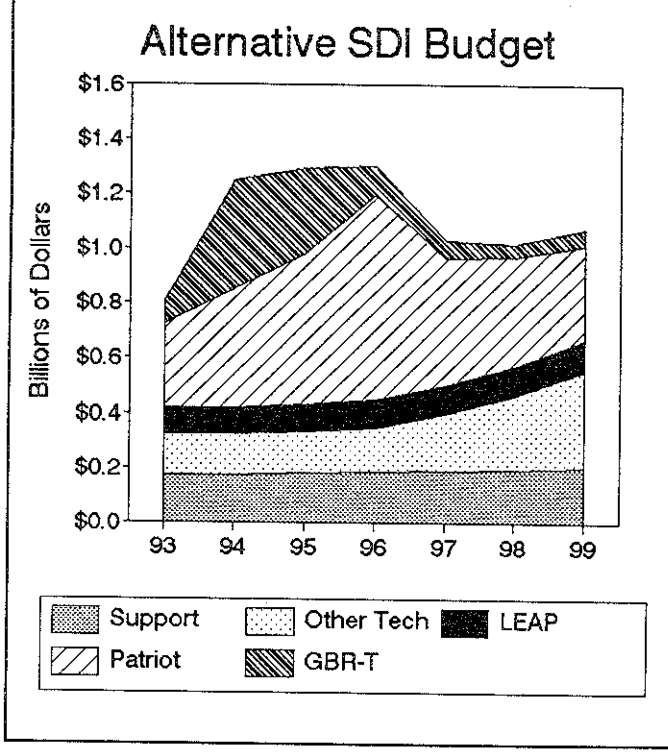
tems, such as THAAD. The attractiveness of Patriot is further reinforced by the use of the existing investment in Patriot support infrastructure, as well as its dual capability against air-breathing targets.

2. The Ground-Based Radar—Tactical (GBR-T) should be developed and deployed to extend the coverage of Patriot. This radar is distinct from the GBR proposed for the national missile defense system, which would be terminated.

3. The Lightweight Exo-atmospheric Agile Projectile (LEAP) kinetic kill vehicle test program should be continued. This would provide the technology base for the deployment of a defense of the continental United States, should such an unlikely requirement emerge in the next century. Surplus ballistic missile motors from ICBMs and SLBMs dismantled under the START agreements could be used as launchers. Existing PAVE PAWS early warning radars could be upgraded to support such a deployment, with existing Defense Support Program early warning satellites providing initial launch detection.

4. Other follow-on technologies, notably those relatively low-cost efforts that could make important contributions to developing technologies relevant to other civil applications (the Midcourse Sensor Technology Integration—MSTI), scientific projects (the Clementine asteroid probe), or maintaining relations with the Russian aerospace complex (Topaz space reactor).

5. A modest support effort would be required to manage these projects. This should include a reorganized and renamed replacement for the existing Strategic Defense Initiative Organization, which would ensure the continued visibility and coordination of these projects.



The immediate termination of all other SDI projects not included in this program would free $2.5 billion dollars for other purposes in 1994, and greater amounts in later years. This program would provide a cost-effective response to foreseeable ballistic missile threats, while preserving the option of responding to future threats, should they emerge. □

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